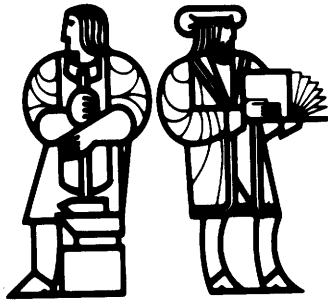


Reports to the President

1983-84

Massachusetts Institute of Technology



Reports to the President

1983-84

Massachusetts Institute of Technology

Reports in this book were submitted for publication in final, camera-ready form by MIT departments, laboratories, and centers.

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President

The idea of MIT began in the mind of one man -- William Barton Rogers -- and took root in a fertile setting: in nineteenth-century America, in Boston. It was an idea that captured the imagination and intellectual energy of those citizens who saw the need for a new kind of education which would emphasize, in Rogers's words, "...the value of science in its great modern applications to the practical arts of life, to human comfort, and health, and to social wealth and power." The founding idea was accompanied by an impulse, a spirit, which was just as revolutionary as the idea itself: the spirit of inventing the future. Rogers was not bound by the traditional ways of organizing and seeking knowledge; his entrepreneurial spirit and willingness to take risks in pursuit of an exciting idea are the MIT tradition.

As MIT has grown, it has embraced and invented a host of intellectual domains. Our departments and academic programs reflect in their names and in their activities the remarkable ability of the faculty to anticipate and shape the future. Scores of interdepartmental research laboratories and centers constitute perhaps an even more sensitive barometer of the ways in which MIT transcends the boundaries of tradition in both organization and style.

Today, our fields of study and scholarship include management, urban planning, humanities and the social sciences, as well as the natural sciences, architecture, and engineering. MIT has become more than an institute of technology in the nineteenth-century sense of that phrase. To use the words of James R. Killian, Jr., first spoken in 1949, MIT is "a university polarized around science, engineering, and the arts." And yet the founding idea of MIT continues and is central to our future, for we are now and must remain the strongest science-based research university in the world. Our historic commitment to scientific and quantitative methods remains at the core of our approach to learning; it permeates the whole spectrum of our degree programs, and is a touchstone of common interest and purpose for all who study, teach, and work here.

Given this foundation, MIT's current mission can be stated succinctly: to provide the highest quality programs of education and research in each of those areas of study and investigation in which we have developed strength and competence, and to do so with a strong commitment to public service and to a diversity of backgrounds, interests, and points of view among the faculty, students, and staff.

How does this mission translate into programs and plans for MIT today and in the decades to come? The insistence on the highest standards for all that we do -- in education, in research, and in the services necessary to support this academic endeavor -- is taken for granted. The faculty, students, and staff of MIT set extraordinary standards for themselves -- and surpass them more often than not. Combined with, and in many ways derived from, this insistence on the best has been the variety of interests and perspectives among the people of MIT. Indeed, this diversity has long been a source of great strength. We have welcomed students from all economic circumstances, many of whom have been the first generation of their families to pursue higher education. And for over a century, we have enjoyed and benefited from a cosmopolitan, international student body and faculty. Indeed, few U.S. colleges or universities are better known overseas.

Within the last two decades, we have seriously begun to broaden the gender and ethnic diversity of our population. Our efforts on this score have been only partially successful. While we have made some progress, to be sure, the representation of women and most minority groups among the undergraduates is at about half of the number that would be expected on the basis of their distribution in the population of this country. In the graduate school, their representation is even lower, and in the faculty it is lower still. This situation will not change quickly, but deserves our continued and heightened attention if we are to succeed in making MIT more attractive and hospitable to minorities and women. My own sense is that we might make progress faster in today's environment if we were to focus more intensively on specific, short-term goals for each year, try very hard to realize them, and then move on to set new ones. Such an approach may help give an immediacy and a greater sense of priority to these important objectives.

Diversity of interests and points of view extends to our goals for the educational program as well. All undergraduates at MIT are expected to obtain a solid base in the natural sciences and in quantitative methods of learning, on the one hand, and in the social sciences, humanities, and arts, on the other. In practice, this symmetry is less than complete. Our undergraduates are indeed exceptional young men and women, many of whom have a wide range of interests -- interests which

could equally well be satisfied and developed at a general university. If judged by their choice of major, however, the focus of their interests has narrowed in recent years to a handful of engineering and science departments. In fact, one department -- Electrical Engineering and Computer Science -- now enrolls more than a third of all undergraduate majors.

This profusion of academic majors in a few departments has several unfortunate consequences. First, it places painful pressures on the faculty in those departments simply to keep up with the extraordinary demand for teaching and advising, making it much more difficult to spend time on curriculum development and scholarly renewal. Such pressures, if not checked, could well lead to a decline in the quality of the educational programs of those very departments now so much in demand by the students. Concentration in a few departments also means a dispiriting decline in the number of students majoring in other departments. In the face of a student culture that devalues certain areas of study, it is becoming harder for MIT undergraduates to maintain a serious academic interest in fields other than science and engineering. We run the risk of attracting principally those students whose interests are much narrower than the resources we have to offer. The quality of our education will erode and the intellectual climate both inside and outside the classroom will suffer if these trends are allowed to continue.

The quality of an institution depends on the standards and the vision it sets for itself. It depends, also, on the ability to make the most out of its resources and its potential. As a science-based university, even as an institute of technology, we must come to terms with the challenge and the responsibility to educate our undergraduates liberally. This is a challenge because many in our society have come to equate college education with professional preparation. Certainly we have an interest, even a stake, in preparing students for contributions to society. And many, indeed most, MIT undergraduates express a passionate interest in moving swiftly toward their professional objectives. If we become the champions of early preprofessional training at the expense of a broader academic vision, however, our graduates will become increasingly specialized in their skills and limited in their fields of vision. At the undergraduate level, it is our responsibility to help students understand the many ways of seeing, knowing, and understanding the world. The liberating quality of education develops precisely through our ability to explore the natural and social orders from a variety of perspectives and to integrate, easily and unselfconsciously, knowledge gained through our feelings and our intellects.

MIT's brand of liberal education must include those ways of perceiving, understanding, and communicating that at any time and in any place allow access to the world in which we live. In contemporary post-industrial society, a liberal education must encompass the arts, engineering and technology, humanities, science and mathematics, and social science. It is up to us to organize and to present that array in judicious balance. The educated will find imaginative ways of reassembling it as they come to terms with the worlds within and around them. Some will focus on those studies which seem most relevant to their professional interests. Others, including some who are more conscious of the likelihood of future changes in interest and career, will choose a broader path through the curriculum. But all of our students will spend their professional lives working under circumstances in which the linkages among science, technology, and human affairs bear directly on their work and in which the ethical and moral consequences of their work will be more easily questioned and more frequently called upon for discussion and defense. The education we provide must enable our alumni to meet and engage their professional and personal worlds as fully and as responsibly as possible.

The challenge of providing a liberal and liberating education for the extraordinary young people who come here as undergraduates is in no way inconsistent with our historic mission or our present strengths. The intellectual diversity and innovative spirit of the Institute -- present in Rogers's founding proposition that education must meet the spirit and the needs of the times -- is nowhere more evident than in the activities of the faculty. These men and women have the ideas, inspiration, and energy to reshape whole fields of intellectual inquiry and to invent new ways of organizing and applying knowledge for practical purposes. A few examples drawn from the events of the past year will illustrate the way in which the insights, instincts, and entrepreneurial spirit of the faculty continually shape the course of MIT's development.

- Professor Erich P. Ippen of the Department of Electrical Engineering and Computer Science, working with his graduate students in the Research Laboratory of Electronics, made scientific history by generating and measuring the quickest flashes of light ever produced. These laser-generated pulses have a duration of about sixteen femtoseconds (16×10^{-15} seconds). The techniques for generating and observing these very short pulses were created during the course

of a research program aimed at developing high-speed, optical information processing systems -- systems which may one day permit computers to operate at speeds higher than those imposed by the limits of electronic devices. These short light pulses are also useful in studying the behavior of molecules and crystalline materials because they can "freeze" events which occur at atomic and molecular time scales, just as the strobe lamp, invented more than fifty years ago by Institute Professor Emeritus Harold E. Edgerton, is able to freeze events which occur on the time scales of the macroscopic world.

- Project Athena, which was described in this report a year ago, has taken the first steps toward operational reality. This large-scale educational experiment is aimed at developing and appraising ways in which convenient access to networked computer work stations can influence the structure and content as well as the teaching and learning associated with the educational programs of the Institute. The Project is well under way, with computers and cables being installed in academic buildings and libraries throughout the Institute. Last spring, in the first two rounds of grants for curriculum development, just over \$1 million was awarded to faculty members for 49 projects, and a score of experiments in the classroom and laboratory are scheduled to begin during the fall term. With such a massive experiment in teaching and learning taking place in every corner of the Institute, we need to understand and to assess the changes which are taking place not only in individual subjects but in the general academic culture of MIT. Toward that end, I am designating \$250,000 -- the major portion of this past year's Sustaining Fellows Fund -- for the support of faculty initiatives to understand the educational impact of Athena in specific subject areas as well as on learning styles and on the ways we communicate with each other more generally.
- Within the past year, the Sloan School of Management has embarked on a number of programs aimed at encouraging broader, more innovative uses of new computer and communications technologies in its educational and research activities. The management science faculty within the School, for example, has proposed a re-design of a major portion of the core curriculum in the master's program around an integrating theme of decision support systems, which would make heavy use of personal computers and related capabilities. These and other changes being proposed by the master's program committee are seen as necessary responses to changes in discipline-based knowledge and to technological innovations that may reshape some dimensions of management practice. Such initiatives offer exciting opportunities to strengthen the currency and impact of the School's educational and research programs, and are, once again, examples of the way in which MIT faculty look to the future to inform the present.
- Work in the Center for Cancer Research and the Department of Biology has led this year to several significant advances in efforts to understand, at the molecular level, the mechanisms which cause cancer and the ways in which the body's immune system eliminates cancerous cells. Professor Robert A. Weinberg and his colleagues have recently identified the precise molecular difference between the gene which causes human bladder cancer and the corresponding normal growth-control gene. The difference between the normal gene and the oncogene is extraordinarily small; just one nucleotide or molecular unit of the DNA (which is composed of about 5,000 units) is out of sequence. This understanding of the genetic basis for a cancer cell may lead to insights into the ways in which carcinogens operate. Also this year, Professors Susumu Tonegawa and Herman N. Eisen and their associates have described the complete structure of the receptor on T cells that is believed to account for the recognition of antigens by these cells. These T cells seek out and destroy cells foreign to the body, including cancer cells. This new knowledge sheds light on an important piece of the immune system puzzle; it may lead to enhancement of T cells' ability to attack cancer cells and to the possibility of suspending T cell activity so that transplants are not rejected.
- The Whitehead Institute for Biomedical Research, a separate research organization affiliated with MIT, has occupied its new building in Kendall Square. Established in 1982 with funds provided by Edwin C. Whitehead, this nonprofit research institution is directed by Nobel laureate David Baltimore, American Cancer Society Professor in our Department of Biology. Several members of the faculty, including Professor Weinberg, who have appointments in

the Whitehead Institute, have moved into the new facilities. Members of the Whitehead Institute teach as professors at MIT, and some of our graduate students do their research at the Whitehead Institute. This novel arrangement greatly enhances the strength of biological research and education at MIT.

- Last fall, the School of Architecture and Planning announced the establishment of a Center for Real Estate Development, made possible by the generous support and intensive personal involvement of Charles H. Spaulding. By focusing on specific management and policy issues attendant to real estate development, the Center contributes to the larger issue of shaping the physical environment that we will bequeath to the future. Interest in the Center, and in the associated master's program which begins this fall, has greatly exceeded our expectations. Also during the year, the new interdisciplinary Media Laboratory was formally established within the School. Under the direction of Professor Nicholas Negroponte, the Laboratory's activities address the invention and creative use of new media and will be housed in the Arts and Media Technology facility, now nearing completion. This year saw the beginning of an intensive and collaborative period of program development among the various groups that make up the Laboratory.
- Another example of the way in which research centers bring together faculty and foster synergism among different intellectual areas is found in the Center for Cognitive Science. The Center draws together faculty from Psychology and from Linguistics and Philosophy to work on problems of perception, cognition, and language. This year saw intensive development of the Center's Multi-User Laboratory, which provides the cognitive science community at MIT with computational facilities for data analysis, simulation, text processing, information management, and on-line control of experiments -- another illustration of how advances in information processing technologies are helping to support and advance fields throughout the Institute.

These are but a few of the notable achievements and initiatives undertaken by individual faculty members and by groups of faculty working together to define and contribute to the world of knowledge and practice.

At the institutional level, the department heads and deans, along with other members of the administration, have invested much time and effort over the past two years in the development of five-year plans for every area at MIT. The Provost has convened and chaired an Institute Planning Group to oversee these efforts. The overall objective of this planning activity is to put in place a process to review, renew, and extend each year a set of long-range strategic plans for the Institute. This process will encourage the anticipation of critical decisions about alternatives and the forecasting of resource needs. The planning is intended to serve as a normative framework, subject to review and change, and not as a set of rigid constraints.

Academic planning at MIT -- indeed at any institution in which the future is strongly influenced by unforeseen intellectual developments and by the unpredictable outcomes and new opportunities generated by research -- is, of necessity, a delicate business. It must originate in the departments and laboratories, it must be guided with a light hand, and it must be employed in a manner which recognizes the inevitability of surprises. At the same time, planning encourages a self-conscious approach to choices between alternative uses of resources and paths of development, and it enables assessment of both resource limitations and future resource needs. This is especially important at a time when constraints on money and space are major considerations affecting the future of the Institute. I am convinced that this planning activity, which has required the investment of much energy by people throughout MIT, is of great benefit to us, now and in future years.

The planning activity has given immediacy and a greater sense of priority to our future resource needs -- needs which have long been present but which have been less explicitly defined.

Jerome B. Wiesner, the thirteenth president of MIT, has said that when he was a young member of the faculty, the most important quality of the Institute for him was the fact that every assistant professor could do exactly what he or she wished to do. All it took was a solid idea and the initiative and persuasiveness to convince one or two others. The necessary resources of money, space, and equipment would somehow be found. This ready access to support for compelling ideas is, regrettably, no longer universally the case, largely because of constraints on funds, both internal and external.

How have our circumstances changed? The modern development of MIT was paced by the postwar involvement of the federal government in the support of graduate education and research. In the period up to 1968, the rapid growth in that support saw the MIT faculty more than double in size, the graduate students match the undergraduates in number, and a great expansion in the size of the physical plant as well as the budget.

For several years following 1968, there was a decline in real terms, and then a levelling off, in federal support of basic research at colleges and universities. For the past eight years, there has been growth again, but at MIT this growth has not been steady.

At the same time, the costs of education and research have steadily increased, fueled by a decade of high inflation and the introduction of new techniques and instruments which are both more effective and substantially more expensive. These increases are now reflected in the Institute's tuition, which is among the highest in the nation, and in the cost of its research programs. While the latter is harder to quantify in terms which permit ready comparisons with other universities, there is a pervasive sense that research at MIT costs a fifth or so more than at most of the research universities with which we compete for research support, for the strongest students, and for the most talented faculty.

While these cost differences do not presently seem to affect either the quality of work done here or the underlying strength of the faculty, it is clear that they do make it more difficult for faculty to obtain research funding and to develop and sustain evolving research programs. The principal consequence of these cost differentials is to raise the "intellectual overhead" which faculty must spend in seeking and sustaining research support. We are very much concerned about the corrosive long-term effects of this problem.

At the student level, there is no definitive evidence that the cost of our educational programs has caused any decline in the quality of those who apply. Demand, as measured by the number of students who apply and who accept our offer of admission, remains strong. In fact, at the undergraduate level and in many areas of graduate study, these measures have increased. But we recognize the crucial importance of financial aid for both undergraduate and graduate students in sustaining a student body of the highest quality, and here, too, we are concerned that increasing costs may place serious constraints on our ability to enroll the most promising students regardless of their economic circumstances.

We have, during the past three years, undertaken a comprehensive review of operating budgets which has enabled us to reduce ongoing operating expenses by about \$11 million per year (in 1984 dollars). Nearly all of these reductions were achieved in support areas. While academic budgets have also been reduced in most departments, these recaptured funds have been allocated to those departments which have experienced significant increases in enrollment; consequently, the net change in aggregate academic budgets over these three years is very small.

The budget reductions have had a beneficial effect both on the operating budget and on the research indirect cost rate. This past year, we were able to achieve a small surplus (\$0.8 million) in the operating budget -- a result due in large measure to the remarkable efforts to contain costs which were made by people throughout the Institute. They deserve thanks for a job well done.

The future financial and academic integrity of MIT, however, cannot be secured by a steady diet of budget reductions. In fact, both the quality of our programs and the spirit of this community would wane if we were to rely only on cost containment efforts in order to meet our funding needs.

Even when annual gifts reach close to \$50 million, as they did this past year (nearly matching the prior year's record level), they cannot address the chronic and fundamental need for a larger endowment. Endowment plays a special, critically important role in the operation of a university. It underwrites the basic academic activities and provides, as well, the venture funds or seed money required to launch new activities and to explore promising new areas of inquiry. It supports the educational activities of students through scholarships and fellowships. It moderates cost pressures on tuition charges and on the price of research. By providing a stable base of support for faculty, it mitigates the relentless pressure of searching for outside research funding.

During these past four years, I have become completely convinced that not only is the Institute's endowment presently too small by a substantial margin but that, as a corollary, this capital base must be greatly expanded if we are to secure MIT's future as the premier science-based university in the world.

This is, of course, not the first time a president has seen the needs of the Institute in such terms. Almost a century ago, President Francis Amasa Walker wrote in his annual report:

"In this effort to make the Massachusetts Institute of Technology second to none in the world, the Corporation have succeeded -- thanks, largely, to the zeal, learning, and sound judgment of a devoted and self-sacrificing body of professors and instructors....But I think no one can know much of this school without having a strong conviction that the full time has now come, when it requires for its greatest usefulness, for the maintenance of its high character among the scientific institutions of the world, and for its security against disaster and business depression, large, very large, additions to its permanent investments....The needs of the Institute are so great, because the Institute itself is so much needed...."

How much more true are those words today. When we look at our achievements and the role of MIT in the world, when we look at our aspirations and our long range plans, we cannot help but conclude that the needs of MIT are so great because MIT itself is so much needed!

PAUL E. GRAY
October 1984

In Special Recognition

Every year there are occasions which remind us of the uniqueness of individuals who collectively mold the character of the Institute. This past year several key leadership roles at the Institute have changed, and those transitions were occasion for special recognition.

In the fall of 1983 Stuart H. Cowen asked, for health-related reasons, to be relieved of his responsibilities as Vice President for Financial Operations. During his 10 years as Vice President, Stuart Cowen's exceptional talents as financial analyst and manager, skillful negotiator, and academic colleague have combined to make the Institute a leader in the development of policy governing the relations between research universities and the federal government, and his standing among university financial officers is without peer. Under his stewardship, the Institute has maintained a steady financial course during increasingly difficult times. His determination, his courageous spirit, and his unyielding will are an example to us all.

After nearly 11 years of service, Harold J. Hanham, Dean of the School of Humanities and Social Science, announced that he would be leaving the deanship at the end of August 1984. During his term in office Dean Hanham nurtured scholarship and educational excellence in the School of Humanities and Social Science and was also responsible for guiding through a major revision in the Humanities, Arts, and Social Sciences Requirement. His term of office will also be noted as a period when the graduate programs in economics, linguistics, philosophy, and political science consolidated their position among the best in the country. Dean Hanham plans to devote the 1984-85 academic year to writing, following which he will assume new responsibilities as Vice-Chancellor of the University of Lancaster in England.

Ann F. Friedlaender, Head of the Department of Economics, was appointed Dean of the School of Humanities and Social Science, effective September 1, 1984. A gifted economist and teacher, Professor Friedlaender is widely known for her work in the field of public finance, with a specialization in transportation studies. She came to MIT in 1972 as a visiting professor, and in 1974 was appointed professor in the Department of Economics and the Department of Civil Engineering. She became Head of the Department of Economics in 1983.

The special character of MIT is also seen each year in the achievements and honors of its faculty. While it is not possible to take note of every such distinction, there are some highlights which deserve mention.

In the spring the National Academy of Engineering elected as a member Joseph L. Smith, Jr., Department of Mechanical Engineering. This election brings to 72 the number of MIT faculty and staff who are members of the NAE. Ralph Landau, Life Member of the Corporation, was elected to another four-year term as Vice President of the Academy.

Also in the spring Peter A. Diamond, Department of Economics, was elected to the National Academy of Sciences, and Vera Kistiakowsky, Department of Physics, was elected a Fellow of the American Association for the Advancement of Science.

Mildred S. Dresselhaus, Abby Rockefeller Mauze Professor of Electrical Engineering and Physics, was elected President of the American Physical Society, serving as President-Elect in 1983 and President in 1984.

Eight members of the MIT faculty were among the 73 Americans elected to the American Academy of Arts and Sciences this year. New MIT members are: George B. Benedek, Alfred H. Caspary Professor of Physics and Biological Physics; B. Clark Burchfiel, Schlumberger Professor of Geology in the Department of Earth, Atmospheric, and Planetary Sciences; Gerald R. Fink, Professor of Genetics in the Department of Biology and at the Whitehead Institute for Biomedical Research; William D. Kingery, Kyocera Professor of Ceramics in the Department of Materials Science and Engineering; Hamish N. Munro, Adjunct Professor of Physiological Chemistry in the Department of Nutrition and Food Science; K. Barry Sharpless, Professor of Chemistry; Lester C. Thurrow, Gordon Y. Billard Professor of Economics and Management; and Susumu Tonegawa, Professor of Biology.

Former Presidential Science Advisor and MIT Corporation Member, Edward E. David, Jr., and Professor Kenneth M. Hoffman of the Department of Mathematics served as Chairman and Executive Director, respectively, of the National Research Council's commission to assess the state of mathematics in the United States. The commission's findings and recommendations were contained in a report, "Renewing U.S. Mathematics," published by the National Academy Press.

In the summer of 1983, Alfred A. H. Keil, Professor of Ocean Engineering, Emeritus, and former Dean of the School of Engineering was accorded a rare honor when he was inducted as a corresponding member of the 127-year-old Association of German Engineers. The occasion marked the first time the association has inducted foreign corresponding members since 1869.

Jerrold R. Zacharias, Institute Professor Emeritus, was awarded the 1983-84 medal of the International Commission for Physics Education.

In the late spring Samuel A. Goldblith, Vice President for Resource Development and Professor in the Department of Nutrition and Food Science, was awarded the Second Class of the Order of the Sacred Treasure by the Emperor of Japan. Professor Goldblith was selected to receive this award for his promotion of friendly relations and mutual understanding between the United States and Japan.

John S. Waugh, Arthur Amos Noyes Professor of Chemistry, was named a co-recipient (along with Professor Herbert S. Gutowsky of the University of Illinois at Urbana and Professor Harden M. McConnell of Stanford University) of the 1984 Wolf Foundation Prize in Chemistry and received the prize from Israeli President Chaim Herzog at a special meeting of the Israeli Knesset. This year's prize was given for the independent research pursued by these scientists in magnetic resonance spectroscopy as applied to chemistry.

In the spring Robert A. Weinberg, Department of Biology, received the seventh annual Bristol-Myers Award for Distinguished Achievement in Cancer Research.

In the winter Richard B. Melrose of the Department of Mathematics received the Bocher Prize of the American Mathematical Society "for his solution of several outstanding problems in diffraction theory and scattering theory and for developing the analytical tools needed for their resolution."

Two MIT faculty members were the recipients of MacArthur Prize Fellows awards given by the John D. and Catherine MacArthur Foundation to recognize and give certain talented individuals the financial freedom to pursue their interests. The recipients were Professor Heather N. Lechtman, whose research in anthropology and archaeology combines the physical sciences and the humanities, and Professor Michael J. Piore, an economist known particularly for his concept of the "dual labor market" in industrial societies.

In April, Institute Professor Philip Morrison was selected by faculty colleagues to be the 1984-85 recipient of the James R. Killian, Jr., Faculty Achievement Award. The Award recognizes extraordinary professional accomplishments and service to the Institute. The committee's citation reads, in part, "No one has better demonstrated, or rather embodied, what it means to the human soul to perceive or recognize a new scientific discovery or a new theoretical insight. Scientific knowledge and understanding is not a purely cerebral affair; it is soaked with emotion, excitement, and nervous tension, as everyone knows who has ever heard Philip Morrison talk."

In May, Associate Professors Joshua Cohen of the Department of Linguistics and Philosophy and Jae S. Lim of the Department of Electrical Engineering and Computer Science were co-recipients of the Harold E. Edgerton Faculty Achievement Award. The Award recognizes young faculty members for outstanding achievements in research, scholarship, and teaching.

Several changes in senior posts in the academic administration were announced this past year. In December 1983, Steven R. Lerman, Department of Civil Engineering, was appointed director of Project Athena. Other changes in the academic administration during the year included H. Kent Bowen, Director of the Manufacturing Systems Program; Arthur P. Mattuck, Head of the Department of Mathematics; Gordon H. Pettengill, Director of the Center for Space Research; Charles H. Spaulding, Director of the Center for Real Estate Development; and J. Kim Vandiver, Head of the Experimental Study Group.

Several changes in the Institute's central administration also were announced during the year. These include the selection of James J. Culliton as Vice President for Financial Operations, succeeding Stuart H. Cowen. Mr. Culliton assumed his new responsibilities June 1, 1984. Mr. Culliton had been Assistant to the Vice President in the Office of the President and Director of Personnel since 1978. Joan F. Rice, Manager of Personnel Services and Development, succeeded Mr. Culliton as Director of Personnel on June 1. D. Hugh Darden was appointed Assistant Treasurer for Planned Gifts and Legal Affairs.

At Lincoln Laboratory, John A. McCook became Assistant Director on July 1, 1984, upon the retirement of Henry W. Fitzpatrick, who served the Laboratory since its inception over 30 years ago. In May 1984, Peter H. Richardson, Director of Admissions, announced his decision to retire from the post in September. A search has been launched to select his successor.

The Institute was saddened this year by the deaths of several longtime friends and colleagues. We miss their presence among us and are grateful for their contributions to this community.

Gordon Y Billard, a graduate of MIT who became a major supporter of the Sloan School of Management, died in September 1983 at the age of 83. During his career he served as a financial consultant, engineer, economist, investment banker, and corporate director of many companies.

In February 1984 Evers Burtner, Professor of Naval Architecture and Marine Engineering, died at the age of 90. Upon his retirement from MIT, he was one of the last two faculty members to have begun teaching at "Boston Tech" before MIT moved to Cambridge.

Samuel C. Collins of the Department of Mechanical Engineering, internationally known as the father of practical helium liquefiers and founder of the MIT Cryogenic Engineering Laboratory, died in June 1984 at the age of 85. Professor Collins and his colleagues built what became known as the Collins Helium Cryostat -- a device which revolutionized cryogenics and made the practice of that science possible in many universities.

Nathaniel H. Frank, former Head of the Department of Physics, died at the age of 80 in February 1984. Though his professional fields of specialization were theoretical physics and metallic conduction, Nathaniel Frank was particularly interested in physics education and worked to restructure physics curricula in the nation's high schools.

Mason Haire, formerly a Professor at the Sloan School of Management and a pioneer in the application of psychology to the problems of management, died in June 1984 at the age of 68. Known for his innovative methods for looking at the way people relate to organizations and organizations to the world, he made important contributions to a vital area in the Sloan School.

In December 1983 Robert S. Harris died at the age of 79. Known for his research on the roles of vitamins, minerals, fats and proteins in the metabolic process, he served as a member of the faculty in the Department of Nutrition and Food Science for 41 years.

Kevin A. Lynch, internationally known for developing the field of urban design and for his pioneering work in establishing the basic theories of how cities are perceived and organized by those who live in them, died in April 1984 at the age of 66. His career spanned 35 years of research, teaching, and practice, largely focused at MIT where he was Professor of City Planning in the Department of Urban Studies and Planning, which he joined in 1949.

Retired Chairman of the Board of T. Rowe Price Associates, Inc., and a member of the MIT Corporation, E. Kirkbride Miller died at the age of 66 in June 1984. A distinguished leader in investment banking, he was also a devoted alumnus who participated in the activities of both the Alumni Association and the Corporation.

In October 1983 Robert B. Newman died at age 73. He was an internationally known acoustical consultant and lecturer who served as a member of the faculty in the Department of Architecture for 27 years and was a co-founder of Bolt Beranek and Newman, Inc., of Cambridge.

Stephen M. Paneitz, Assistant Professor in the Department of Mathematics, died at the age of 28 in September 1983. After receiving his Ph.D. in June 1980 from MIT, he was a Miller Fellow at Berkeley, returning to MIT in September 1982 as a member of the faculty.

Ithiel de Sola Pool, Ruth and Arthur Sloan Professor of Political Science and an authority on the social impacts of modern communications systems, died in March 1984 at the age of 66. A pioneer in the field of communications research, he combined a grounding in classical political theory and humanistic historical perspective with rigorous quantitative social science methods. He joined the MIT faculty in 1953 and was instrumental in founding the Political Science Department, turning it into a major department with an international reputation.

In February 1984 James F. Thomson, Professor Emeritus of the Department of Linguistics and Philosophy, died at the age of 62. A specialist in mathematical logic and computation theory, James Thomson was instrumental in establishing the philosophy program's strength in analytic philosophy.

B. Alden Thresher, former Director of Admissions at MIT and long considered the "dean" of admissions officers in the United States, died in January 1984 at the age of 87. He held the position of Director of Admissions from 1936 to 1961, and made outstanding contributions to the theory and practice of his profession.

In February 1984 Harold C. Weber, Professor Emeritus of the Department of Chemical Engineering, died at the age of 88. In 1922 he was appointed Assistant Professor of Chemical Engineering and served on the faculty until his retirement in 1960.

Robert S. Woodbury, Professor Emeritus of the History of Technology, died at the age of 76 in September 1983. With the exception of six years' service in the Navy (1940-1946), he was on the teaching staff of MIT from 1929 until his retirement in 1972.

Statistics for the Year

The following paragraphs report briefly on various aspects of the Institute's activities and operations during 1983-84.

Registration

In 1983-84 student enrollment was 9,577, compared with 9,475 in 1982-83. This total comprised 4,602 undergraduates (compared with 4,619 the previous year), and 4,975 graduate students (compared with 4,856 the previous year). Graduate students who entered MIT last year held degrees from 381 colleges and universities, 227 American and 154 foreign. The international student population was 2,106, representing 12 percent of the undergraduate and 31 percent of the graduate population. These students were citizens of 97 countries.

Degrees awarded by the Institute in 1983-84 included 1,169 bachelor's degrees, 1,162 master's degrees, 72 engineer's degrees, 415 doctoral degrees -- a total of 2,818.

In 1983-84, there were 2,066 women students (1,090 undergraduate and 976 graduate) at the Institute, compared with 1,977 (1,048 undergraduate and 929 graduate) in 1982-83. In September 1983, 259 first-year women entered MIT, representing 24 percent of the entering class.

In 1983-84, there were 1,107 minority* students (914 undergraduate and 193 graduate) at the Institute, compared with 968 (817 undergraduate and 151 graduate) in 1982-83. The first-year class entering in September 1983 included 270 minority students, representing 25 percent of the class.

Student Financial Aid

During the academic year 1983-84 the student financial aid program was again characterized by increases in the overall need for financial aid and in the aggregate amount of grants made available.** There was an increase in the amount of MIT loans awarded. Federally guaranteed loans obtained from commercial sources showed a significant decrease.

A total of 2,662 undergraduates who demonstrated the need for assistance (58 percent of the enrollment) received \$14,748,000 in grant aid and \$2,418,000 in loans. The total, \$17,166,000, represents a 16 percent increase in aid compared with last year.

Grant assistance was provided by \$3,831,000 in income from the scholarship endowment, by \$1,712,000 in outside gifts and federal allocations to MIT for scholarships, and by \$3,219,000 in direct grants to needy students. Scholarship assistance from MIT's own operating funds was provided to the extent of \$5,871,000 (a 46 percent increase over last year's level and the largest allocation ever). The special program of scholarship aid to minority group students represented an additional \$115,000 from specially designated funds. An additional 610 students received grants from outside agencies, irrespective of need. The undergraduate scholarship endowment was aided by the addition of \$2,227,227 in new funds, which raised the principal of the endowment to \$35,913,417.

*Minority students include 319 Blacks (non-Hispanic), 21 native Americans, 199 Hispanics, and 568 Asian Americans.

**Scholarship and fellowship figures differ slightly from those reported in the Treasurer's Report because of differences between academic and fiscal year accruals.

Loans totaling \$2,418,000 were made to needy undergraduates -- a one percent decrease from last year. Of this amount \$484,000 came from the Technology Loan Fund and \$1,934,000 from the National Direct Loan Fund. Not included in the foregoing summary is an additional \$5,982,000 obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources. This represents a two percent decrease in the use of these programs over last year.

Graduate students obtained \$1,632,000 from the Technology Loan Fund, \$304,000 of which was loaned to international students and did not qualify for the federal interest subsidies and guarantees available under the Guaranteed Student Loan Program. In addition, \$228,000 was loaned by MIT under the Guaranteed Student Loan Program. The total, \$1,860,000, represents a 39 percent increase over last year's level. Graduate students obtained \$3,011,000 from outside sources under the Guaranteed Student Loan Program -- 13 percent below last year's level. The total loaned by MIT to both graduate and undergraduate students was \$4,278,000, a 13 percent increase over last year's level.

Career Services and Preprofessional Advising

Employment opportunities for graduating students were distinctly better in 1983-84 than during the previous year. There was a great increase in the number of job offers reported by companies and by students, even though the number of employers making recruiting visits rose hardly at all, from 405 in 1982-83 to 407 in 1983-84. The number of student interviews also changed very little, hovering near 9,700.

The demand for graduates in electrical engineering and computer science was pervasive. In the spring term alone nearly 300 separate employers asked to see electrical engineers; more than 200 asked for students in computer science. The firms looking for electrical engineers and computer scientists were in almost every industry, from computers and communications to aerospace, chemicals, oil, paper, railroads, and banking.

Fortunately, the vitality of the electronics and computer industries is creating a new demand in other disciplines as well. In 1981-82 more than a third of the Institute's graduates in mechanical engineering joined electronics firms. In 1982-83 the electronics industry was the destination of a quarter of the Institute's chemical engineers and a third of the master's graduates at Sloan. Figures are not yet available for 1983-84 but it is likely that they will tell the same story, probably even more emphatically.

There was a small increase in the number of MIT applicants to medical school, chiefly stemming from an increase in the number of alumni applicants. A total of 105 candidates filed applications, compared with 101 in 1982-83. They included 69 seniors, 3 graduate students and 33 alumni. Preliminary returns indicate that 55 seniors, all the graduate students, and 19 alumni were accepted.

Thirty-seven MIT candidates applied to law school. As in previous years the majority were alumni (21 out of 37).

Finances

As reported by the Vice President for Financial Operations and the Treasurer, the total financial operations of the Institute, including sponsored research, amounted to \$658,611,000, an increase of 12 percent over 1982-83. Education and general expenses -- excluding the direct expenses of departmental and interdepartmental research, and the Lincoln Laboratory -- amounted to \$270,180,000 during 1983-84, compared with \$255,541,000 in 1982-83. The direct expenses of campus departmental and interdepartmental sponsored research increased from \$149,478,000 to \$156,811,000; and direct expenses of the Lincoln Laboratory's sponsored research increased from \$183,683,000 to \$231,620,000, largely because of increased subcontracts and equipment purchases.

Current revenues used to meet the Institute's operating expenses totaled \$651,932,000, augmented by \$6,679,000 in unrestricted revenues. After meeting these expenses, a surplus of \$805,000 in current unrestricted gifts was held.

The construction program of the Institute continued to make progress in 1983-84, with the book value of educational plant facilities increasing from \$288,392,000 to \$298,895,000.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, students' notes receivable, and amounts due from educational plant, had a book value of \$605,378,000 and a market value of \$771,319,000. This compares to book and market values of \$514,808,000 and \$767,228,000 last year.

Gifts

Gifts, grants, and bequests to MIT from private donors decreased slightly in 1983-84 to a total of \$49,122,000, compared with \$50,025,000 in 1982-83. The Alumni Fund reported gifts of \$9,434,000 for the year, a new record.

Physical Plant and Campus Environment

One new building, the EG&G Education Center, was completed and occupied during the year. This five-story, 20,000 square foot facility, located between the two wings of the Sherman Fairchild Electrical Engineering and Electronics Research Building, contains a 325-seat lecture hall, four conventional classrooms, a student lounge, an undergraduate teaching laboratory, and a multi-use departmental conference room. Opening of the Center, designed exclusively for teaching and conference purposes, completed a plan conceived more than a decade ago. The building was dedicated on October 7, 1983, in honor of Esther M. and Harold E. Edgerton, Pauline S. and Kenneth J. Germeshausen, and Dorothy J. and Herbert E. Grier, whose joint efforts made the facility possible.

Other projects completed during the year included renewal of the undergraduate chemistry teaching laboratories on the fourth floor of Building 4, renovation of 175 Albany Street to accommodate the Nuclear Magnetic Resonance (NMR) Facility and additional Plasma Fusion Center activities, renovation of the first floor of Building 11 to house the Joint Computer Center and Project Athena and of the basement to accommodate the Graphic Arts Copy Center, renovation of the upper floors of the Sloan Building (E52) for the Sloan School and Department of Economics, and installation of new kitchens and dining areas in the East Campus and Senior House dormitories.

Major projects under construction and scheduled for completion this fall are the Arts and Media Technology facility on Ames Street and the Microsystems Research Laboratories in Building 39 on Vassar Street. The latter facility, scheduled to be made available to the research staff in December, will require up to another year for installation of complex research equipment.

Smaller projects scheduled for fall completion include the Center for Real Estate Development on the top floor of the old Armory Building (W31) on Massachusetts Avenue, the Mechanical Engineering Design Center on the fourth floor of Building 3, portions of the second and third floors of Building 2 for chemistry research laboratories, and a relocation of Amherst Alley on the West Campus between Danforth Street and Burton-Connor House to move the road away from the student residences and create a more attractive and safe environment.

Two major changes in the dining commons program were implemented during this past year. First, East Campus and Senior House residents are no longer required to participate in the program because they now have kitchen and dining facilities within their residences. Second, a la carte service was offered in place of commons at 500 Memorial Drive in response to a student proposal to the Dining Advisory Board. Both of the above changes seem to have been well received by the students in those houses.

For the past several years, the telecommunications industry has been undergoing substantial changes, which are reflective of new technology, increased usage of networked computers, and regulatory actions. Because of these changes, we have undertaken an evaluation of the telecommunication services for the Institute community. Our analysis indicates that the Institute would be better served by a state-of-the-art digital switching system than by the present Centrex system provided by the telephone company. As a result, we released a request to selected vendors in May 1984 asking for proposals to replace the Centrex system with a coherent and integrated telecommunications system, capable of transporting all forms of messages (voice, data, video, and facsimile). If we implement one of these proposals, the new system would begin operation in the latter half of 1986.

* * *

Personnel Changes

CORPORATION

DEATHS

W. Van Alan Clark, Jr.
Life Member

George J. Leness
Life Member Emeritus

E. Kirkbride Miller
Member

David A. Shepard
Life Member, Emeritus

CHANGES OF APPOINTMENT

Frank T. Cary
Life Member

Edward E. David, Jr.
Life Member

ELECTIONS

Donald J. Atwood
Member

E. R. Kane
Member

Margaret E. Mahoney
Member

Robert L. Mitchell
Member

Arlene F. Roane
Member

Mitchell W. Spellman
Member

Raymond S. Stata
Member

Clifton R. Wharton, Jr.
Member

T. A. Wilson
Member

MEMBER EX-OFFICIO

Mary Frances Wagley
President
Alumni Association

TERMS EXPIRED

Herman R. Branson
Member

Paulette Coleman
Member

S. James Goldstein
Member

Maurice F. Granville
Member

Joe F. Moore
Member

Barbara W. Newell
Member

J. Paul Sticht
Member

Emily V. Wade
Member

FACULTY

DEATHS

Ithiel De Sola Pool
Department of Political
Science

RETIREMENTS

W. Carlisle Barber
Department of Physics

Richard Beckhard
Sloan School of Management

Horacio Caminos
Department of Architecture

Robert M. Fano
Department of Electrical
Engineering and Computer
Science

Louis N. Howard
Department of Mathematics

Thomas H.D. Mahoney
History Section
Department of Humanities

Robert E. Ogilvie
Department of Materials
Science and Engineering

William H. Pinson, Jr.
Department of Earth,
Atmospheric, and Planetary
Sciences

Frederick Sanders
Department of Earth,
Atmospheric, and Planetary
Sciences

Eli Shapiro
Sloan School of
Management

Kenneth R. Wadleigh
Department of Mechanical
Engineering

RESIGNATIONS

Professors

Kurt W. Forster
Department of Architecture

Paul V. Kiparsky
Department of Linguistics and
Philosophy

Erik L. Mollo-Christensen
Department of Earth,
Atmospheric, and
Planetary Sciences

Barry Spacks
Literature Section
Department of Humanities

Associate Professors

Henri Brunengraber
Department of Nutrition and
Food Science

David R. Clarke
Department of Materials
Science and Engineering

John Dittmer
History Section
Department of Humanities

Michael D. Meyer
Department of Civil
Engineering

David F. Noble
Program in Science, Technology
and Society

Christos Papadimitriou
Department of Electrical
Engineering and Computer
Science

Assistant Professors

Timothy C. Aarset
Music Section
Department of Humanities

Montgomery M. Alger
Department of Chemical
Engineering

Robin Becker
Assistant Professor of
Exposition and Rhetoric
in Writing Program
Department of Humanities

Alan Bleier
Department of Materials
Science and Engineering

Ellen W. Chu
Writing Program
Department of Humanities

Susan J. Dickman
Literature Section
Department of Humanities

A. Thomas Ferguson
Department of Political
Science

John R. Freeman
Department of Political
Science

Barbara Gastel
Writing Program
Department of Humanities

Ira M. Gessel
Department of Mathematics

Carolyn D. Heising
Department of Nuclear
Engineering

George A. Huff, Jr.
Department of Chemical
Engineering

Emma L. Jackson
Department of Political
Science

Jama Lazerow
History Section
Department of Humanities

David Lee
Department of Architecture

Carolyn Moyer
Department of Nutrition and
Food Science

Stephen M. Paneitz
Department of Mathematics

Kenneth R. Sloan
Department of Architecture

Robin Yates
History Section
Department of Humanities

PROMOTIONS

To Professor

Klaus-Jurgen Bathe
Department of Mechanical
Engineering

Ned J. Block
Department of Linguistics
and Philosophy

Chryssostomos Chryssostomides
Department of Ocean
Engineering

Stephen L. Erdely
Music Section
Department of Humanities

James G. Fox
Division of Comparative
Medicine

Bennett Harrison
Department of Urban
Studies and Planning

J. Karl Hedrick
Department of Mechanical
Engineering

Richard O. Hynes
Department of Biology

Robert L. Jaffe
Department of Physics

John D. Joannopoulos
Department of Physics

Paul C. Joss
Department of Physics

Marc A. Kastner
Department of Physics

Steven R. Lerman
Department of Civil
Engineering

Margaret L.A. MacVicar
Undergraduate Research
Opportunities Program, Office
of the Provost

Peter H. Molnar
Department of Earth,
Atmospheric, and
Planetary Sciences

Ernest J. Moniz
Department of Physics

Ronald L. Rivest
Department of Electrical
Engineering and Computer
Science

Sean C. Solomon
Department of Earth,
Atmospheric, and
Planetary Sciences

Lawrence E. Susskind
Department of Urban
Studies and Planning

Daniele Veneziano
Department of Civil
Engineering

To Associate Professor

A. Julia Alissandratos
Foreign Languages
and Literatures Section
Department of Humanities

Samuel M. Allen
Department of Materials
Science and Engineering

James G. Branson
Department of Physics

Richard J. Cohen
Department of Physics and
Harvard-MIT Division of Health
Sciences, and Technology

Rick L. Danheiser
Department of Chemistry

Randall Davis
Department of Electrical
Engineering and Computer
Science

Charles C. Eriksen
Department of Earth,
Atmospheric, and
Planetary Sciences

Sy David Friedman
Department of Mathematics

David M. Halperin
Literature Section
Department of Humanities

Neville Hogan
Department of Mechanical
Engineering

Mel Horwitch
Sloan School of
Management

Ravindran Kannan
Department of Mathematics

Harry C. Katz
Sloan School of
Management

Timothy J. Kehoe
Department of Economics

Alexander M. Klibanov
Department of Nutrition
and Food Science

Andrew B. Lippman
Department of Architecture

Stephen M. Meyer
Department of Political
Science

James B. Orlin
Sloan School of
Management

Harilaos N. Psaraftis
Department of Ocean
Engineering

L. Rafael Reif
Department of Electrical
Engineering and Computer
Science

Mary F. Roberts
Department of Chemistry

William R. Roush
Department of Chemistry

Warren P. Seering
Department of Mechanical
Engineering

Michael F. Sipser
Department of Mathematics

Brian H. Smith
Department of Political
Science

Frank S. Spear
Department of Earth,
Atmospheric, and
Planetary Sciences

Michael S. Triantafyllou
Department of Ocean
Engineering

George C. Verghese
Department of Electrical
Engineering and Computer
Science

M. Anthony Wong
Sloan School of
Management

Paul C. Xirouchakis
Department of Ocean
Engineering

To Assistant Professor

William M. Goldman
Department of Mathematics

Christopher J. Guzy
Department of Chemical
Engineering

Robert J. Hansman, Jr.
Department of Aeronautics and
Astronautics

Jama Lacero
History Section
Department of Humanities

CHANGES OF APPOINTMENT

David L. Akin
Rockwell International
Assistant Professor
in Department of Aeronautics
and Astronautics

Lalit Anand
Esther and Harold E. Edgerton
Assistant Professor of
Mechanical Engineering in
Department of Mechanical
Engineering

Emilio Bizzi
Director of Whitaker College
of Health Sciences,
Technology, and Management and
Eugene McDermott Professor in
the Brain Sciences and Human
Behavior

William F. Brace
Head Department of Earth,
Atmospheric, and Planetary
Sciences and Cecil and Ida
Green Professor of Geology

James D. Bruce
Director of Information
Systems
and Professor in Department of
Electrical Engineering and
Computer Science

Elzbieta E. Chodakowska
Thomas Meloy Associate
Professor in Rhetoric in
Writing Program
Department of Humanities

Fernando J. Corbato
Acting Associate Head for
Computer Science and Professor
of Electrical Engineering in
Department of Electrical
Engineering and Computer
Science

Peter S. Eagleson
Edmund K. Turner Professor
of Civil Engineering in
Department of Civil
Engineering

Stan N. Finkelstein
J.W. Kieckhefer Associate
Professor in Technological
Assessment in Health Care in
Sloan School of Management and
Harvard-MIT Division of Health
Sciences and Technology

Jerome I. Friedman
Head, Department of Physics
and Professor of Physics
Department of Physics

Jeffrey Goldstone
Cecil and Ida Green Professor
in Department of Physics

John H. Harbison
Class of 1949 Professor in
Music Section
Department of Humanities

Joseph H. Haritonidis
Esther and Harold E. Edgerton
Assistant Professor in
Department of Aeronautics and
Astronautics

Philip B. Herr
Adjunct Professor in
Department of Urban Studies
and Planning

Arthur K. Kerman
Director, Laboratory for
Nuclear Science and Professor
of Physics Laboratory for
Nuclear Science

Jeffrey H. Lang
Esther and Harold E. Edgerton
Assistant Professor of
Electrical Engineering in
Department of Electrical
Engineering and Computer
Science

Robert S. Langer
Dorothy W. Poitras Associate
Professor in Medical
Engineering in Department of
Nutrition and Food Science and
Whitaker College of Health
Sciences,
Technology, and Management

Steven R. Lerman
Director of Project Athena and
Professor of Civil Engineering
Project Athena

James D. Litster
Director of Center for
Materials Science and
Engineering and Professor of
Physics

Fred Moavenzadeh
William E. Leohard Professor
of Engineering in Department
of Civil Engineering

Ernest Moniz
Director and Professor of
Physics
Bates Linear Accelerator

Alan C. Nelson
W. M. Keck Assistant Professor
of Biomedical Engineering in
Department of Nuclear
Engineering and Whitaker
College of Health Sciences,
Technology, and Management

Anthony T. Patera
Rockwell International
Assistant Professor of
Mechanical Engineering in
Department of Mechanical
Engineering

Norman C. Rasmussen
McAfee Professor of
Engineering in Department of
Nuclear Engineering

Salil K. Roy
Visiting Associate Professor
in Department of Materials
Science and Engineering

Richard J. Samuels
Mitsui Career Development
Associate Professor in
Department of Political
Science

John G. Sclater
Visiting Professor in
Department of Earth,
Atmospheric, and Planetary
Sciences

Dietmar Seyferth
Robert T. Haslam and Bradley
Dewey Professor in Department
of Chemistry

Alvin J. Silk
Erwin H. Schell Professor of
Management and Associate Dean
in Sloan School of Management

Denis F. Simon
Ford International Assistant
Professor in Sloan School of
Management

Marvin A. Sirbu, Jr.
KDD Career Development
Assistant Professor of
Management in Sloan School of
Management

Lester C. Thurow
Gordon Y. Billard
Professor of Management and
Economics in Sloan School of
Management

Donald R. Uhlmann
Cabot Professor in Department
of Materials Science and
Engineering

James M. Utterback
Director of Industrial Liaison
Program and Associate
Professor of Engineering

Tomasz Wierzbicki
Professor of Applied
Mathematics
in Department of Ocean
Engineering

NEW FACULTY APPOINTMENTS

Professors

Nelson Yuan-Sheng Kiang
Eaton-Peabody Professor of
Communication Sciences in
Whitaker College of Health
Sciences, Technology, and
Management and Department of
Psychology

Richard S. Lindzen
Department of Meteorology and
Physical Oceanography

Isadore M. Singer
Department of Mathematics

George Stephanopoulos
Department of Chemical
Engineering

Associate Professors

Olivier J. Blanchard
Department of Economics

John S. Carroll
Sloan School of Management

John C. Cox
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Provost

Center for Cognitive Science

During the academic year 1983-84, the Center for Cognitive Science has continued its program of interdisciplinary research on human cognition. Specific elements include the development of the Human Subjects Laboratory, the visiting scientist and postdoctoral fellow programs, the affiliate program, the member program, the seminar and colloquia series, the Occasional Paper Publication program, and the financial support program for research initiatives within the Center. Each of these activities is the responsibility of a separate subcommittee to the central policy-making group of the Center; namely, the CCS Working Group. A brief description of the activities of each of these subcommittees follows.

THE MULTI-USER LABORATORY

Since 1981, the Multi-User Laboratory of the CCS has provided the cognitive science community at MIT with computational facilities for data analysis, simulation, stimulus preparation, text processing, information management, and on-line control of experiments on perception, cognition and language. The central facility in 20C-131 contains a PDP 11/44 running under UNIX, two LSI 11/03 minicomputers dedicated to real-time control of experiments, subject testing stations equipped with video screens, headphones, and so on, and associated peripherals such as printers, plotters and tape drives. In addition, the Multi-User Lab maintains two satellite labs in the Psychology Department (E10), each with an LSI 11/03 subject testing station and hardwired connections to the central computer in Building 20. Software has been developed that allows programs for the real-time control of experiments to be written easily; in addition, 3-D graphics and acoustic signal processing software is currently being developed. The Laboratory is the principal experimental research facility for graduate students and faculty in linguistics and in human experimental psychology, and in addition serves the large number of visiting scientists and postdoctoral fellows in residence at the Center and the Psychology Department each year.

The 1983-84 year was a period of intensive development for the laboratory. The two satellite stations in the Department of Psychology were set up, involving hardware interfaces and software for a random-access projection tachistoscope and high-speed medium-resolution graphics screens. The main computer was switched over from AT&T UNIX Version 7 to Berkeley UNIX 2.9, resulting in greater speed and greater compatibility with other UNIX installations at the Institute. A 300 megabyte disk was installed. And a set of 50 personal microcomputers was purchased and installed, providing the Department of Linguistics and Philosophy, the Center for Cognitive Science, and much of the Department of Psychology with full-scale word processing and communications facilities for the first time.

Despite several setbacks (a head crash on the largest disk drive, an unreliable connection to the campus-wide CHAOSnet, and impending personnel changes), during the past year the Center Laboratory has begun to approach the end of its development phase, and has already become an indispensable facility for graduate training in psychology and for externally funded research in psychology and linguistics.

RESEARCH

During the past academic year two major research initiatives have been launched in the Center. The first is a two-year program in comparative syntax. This program, under the supervision of Professor James Higginbotham, will bring to the Center a number of scholars with expertise in a wide variety of languages. The purpose will be to assess the most recent developments in Government and Binding Theory from a comparative point of view. The end result of this project will be the publication of a volume devoted to this two-year study.

A second major initiative is the Lexicon Project. This project, under the supervision of Professors Ken Hale and Samuel Jay Keyser, is supported by a grant of \$750,000 from the System Development Foundation. This project is concerned with the question of the proper format for a lexical entry. It is presently engaged in developing lexicons for a wide variety of languages, including Winnebago, Berber, Warlpiri and English, and expects to add Hopi to the list of lexicons under active development. Various dictionary handling programs are also being developed and implemented to facilitate the use of these lexicons as research tools.

THE RESEARCH PROPOSAL REVIEW COMMITTEE

Projects approved by this committee for the past academic year included support for ongoing research projects, including funding for human subject experimentation, special equipment purchases and the running of a workshop in Cognitive Neuropsychology. Among the recipients of Center support were postdoctoral fellows Larry Parsons and Martha Farah, research associates Nancy Etcoff, Neal Cohen, Janet Sherman and James McClelland, and faculty members Jerry Fodor, Merrill Garrett, Richard Held, Steve Pinker and Susan Carey.

THE VISITOR SELECTION COMMITTEE

During the academic year 1983-84, the Center supported seven postdoctoral fellows: one in psycholinguistics, two in semantics, one in speech perception, one in neuropsychology, one in visual perception, and one in spatial-visual cognition. It also hosted two visiting scientists: one in psycholinguistics and speech perception, and one in psycholinguistics and speech recognition.

THE AFFILIATE PROGRAM

In addition to the visiting program, the Center also maintains an affiliate program which provides formal status for individuals associated with Center research but not in residence at MIT. These affiliates include researchers working actively in the field and observers of the field who wish to have Center affiliation. At present there are 17 affiliates.

THE MEMBER PROGRAM

Recently, the Center has inaugurated a Member program designed to bring people in the MIT community into formal affiliation with the Center. This is done because of significant overlap in their interests and is deemed useful in supporting the intellectual goals of the Center. Currently, eight individuals have been designated Members of the Center, including Professors Ned Block, Jerry Fodor and James Higginbotham of the Department of Linguistics and Philosophy, Professors Emilio Bizzi, Jeremy Wolfe, John Hollerbach, and Dr. Neal Cohen of the Department of Psychology, and Professor Judah Schwartz of the School of Engineering.

SEMINARS AND COLLOQUIA

The Center supports three kinds of seminars. The first is a bi-weekly seminar, The Center for Cognitive Science Seminar Series. This series is open to the Cambridge community at large and is devoted to papers on a variety of topics relevant to the Center. The format involves selecting a paper and a commentator or set of commentators. Each paper is distributed to the seminar participants prior to the meeting. At the seminar itself, the commentator offers a presentation on the paper, followed by comments from the author. The paper is then thrown open for general discussion from the floor. In addition to these seminars, lunch time talks sponsored jointly by the Center and the Department of Psychology, are held in the conference room of the Psychology Department. Four talks were held last year. Finally, a number of special purpose seminars take place each year, depending on the research interests of Center members and visitors. Last year, for example, the Lexicon Project conducted a year-long seminar on the theory of lexical entries, drawing on a wide variety of languages, including Warlpiri, Winnebago, Berber, and English.

THE OCCASIONAL PAPER PROGRAM

The series of Occasional Papers distributed by the MIT Center for Cognitive Science attempts to inform fellow workers in the field of important current research undertaken at the Center. During the academic year 1983-84 three new Occasional Papers were published: "Cognition in Infancy" by Elizabeth Spelke of the Department of Psychology at the University of Pennsylvania (Occasional Paper No. 23); "To Be Is To Be A Value of A Variable (Or To Be Some Values of Some Variables)" by George Boolos of the Department of Linguistics and Philosophy at MIT (Occasional Paper No. 24); and "The Neurological Basis of Mental Imagery: A Componential Analysis" by Martha J. Farah of the Center for Cognitive Science (Occasional Paper No. 25).

PUBLICATIONS

By making its resources available to visiting scientists, postdoctoral fellows, predoctoral fellows, and to affiliated faculty, the Center for Cognitive Science has supported a variety of publications. As of the end of the academic year 1983-84, a total of four books and 38 articles has been published as a result of Center support since its inception in February of 1979.

SAMUEL J. KEYSER

Center for Materials Research in Archaeology and Ethnology

The 1983-84 academic year was the seventh year of operation for the Center for Materials Research in Archaeology and Ethnology (CMRAE). Activities focused in three areas: graduate education of students from the seven participating universities; doctoral research among students from both Center-affiliated and non-Center universities; and the third offering of the month-long Summer Institute course.

Dr. Frederick M. Wiseman joined the Center staff as principal research scientist. An expert in palaeoecology, Dr. Wiseman is establishing a unique biological research laboratory at CMRAE. The new archaeoenvironmental laboratory will investigate ways in which prehistoric societies managed their environments.

The Center established its first postdoctoral fellowship with a grant from Asarco, Inc. and its two affiliates, Industrial Minera México and Southern Peru Copper Corporation. The CMRAE-ASARCO Fellowship in the Prehistoric Metallurgies of the Americas was awarded to Dorothy Hosler, who is completing her doctoral research at the Center. The fellowship runs for two years.

A special agreement of international scope was signed by CMRAE and the Banco Central del Ecuador for joint participation in a research project to investigate the origins and development of the mining and metallurgical technologies of Ecuador in the PreColumbian era. Professor Heather Lechtman, director of CMRAE, represented MIT at the formal ceremony which took place in Quito, Ecuador. The agreement between the two institutions is a model of the way in which research among colleagues in the Americas about the Americas may be organized and conducted. The Center's responsibility during the duration of the project includes not only the design and execution of the more technical aspects of the research but the training of students and personnel within the Ecuadorian museums of art and archaeology operated by the Banco Central.

Two graduate subjects ran concurrently during the year. Professor Lechtman (MIT, Anthropology/Archaeology, and Materials Science and Engineering) offered a one-semester class in Materials in Ancient Societies: Metals. Professor George Cowgill (Brandeis, Anthropology) taught a full-year subject on Mathematics and Computers in Archaeological Data Analysis. Both subjects were easily accommodated in the Center's Graduate Laboratory (MIT, Bldg. 20) and were well attended by graduate students from the participating institutions.

Four graduate students at the Center, one from the University of California at Santa Barbara, one from MIT, one from Boston University, and one from Brandeis University engaged in full-time research toward the doctoral degree. Of the two students supervised by Professor Lechtman, one is studying the prehistoric development of copper metallurgy in west Mexico and its relation to Andean metallurgies, and the other has begun an investigation into the PreColumbian metallurgy of Ecuador. The latter student, who will receive her Ph.D. at MIT from the Department of Materials Science and Engineering, is that Department's first student to combine materials science and archaeology in the dissertation topic. The third and fourth students are supervised by Professor Suzanne De Atley (MIT, Anthropology/Archaeology). One is concerned with the ceramic materials fundamental to iron smelting technologies in east Africa during the iron age; the other is exploring the standardization and control of ceramic production in the ancient Mexican capital of Teotihuacán. All four carry out their laboratory analyses and experiments in the CMRAE Graduate Laboratory.

The Center established a Summer Institute in 1981-82, conceived as a mechanism through which scholars at non-Center institutions could benefit from the highly specialized and often unavailable education in laboratory-analytical skills in which the Center is expert. The aim is to provide individuals across the nation in such professions as anthropology, archaeology, the histories of science and art, and the conservation of archaeological and art objects with intense exposure to the theory and laboratory methods of the materials science of ancient and art historical materials. The Summer Institute format consists of a one-month intensive lecture and laboratory subject organized around a specific class of materials. The first course, Materials in Ancient Societies: Metals, was offered during June 1982. The second course, Biological Material from Archaeological Sites: Fauna, was funded by a grant from the Alfred P. Sloan Foundation and was offered in June 1983. The June 1984 course, Materials in Ancient Societies: Ceramics, was taught jointly by Professor De Atley, Dr. William G. Melson, Curator of the Division of Petrology at the Smithsonian Institution, Washington, and Christopher Craig, supervisor of the CMRAE Graduate Laboratory. Funding for the course was supplied in large part by donations from the ceramics industry.

A CMRAE committee chose 15 Summer Institute participants from a large pool of applicants. Nine were graduate students, and six were professionals - research professors in anthropology and archaeology, research specialists in archaeological ceramics, museum conservators, and a geological engineer. Nine universities and three museums in the United States and Canada were represented by the Summer Institute participants as well as the Instituto Nacional de Antropología e Historia, Mexico. The course was an outstanding success

and reflects the international interest in and need for the kinds of training the Center uniquely provides.

The Center continued its series of annual proseminars, six informal presentations during each academic year, enabling CMRAE faculty and graduate students to report on research in progress. This year scholars from Brandeis University, MIT, Tufts University, the Fogg Art Museum at Harvard University, and the Museum of Fine Arts, Boston discussed ongoing Center-related research.

HEATHER LECHTMAN

Educational Video Resources

MIT Educational Video Resources (EVR) is the video consulting group for the Institute. Hundreds of faculty, students, and staff come to us for advice on the uses of video in teaching, research, coursework, documentation, artistic creation, and performance. An accompanying listing for the Archives describes nearly 100 projects that we supported during the year. This year we increased the amount of educational video production and documentation of research, while turning over some service functions to other MIT organizations.

In education our facilities are used in the teaching programs for graduate students in the Master of Arts in Visual Studies, including those in the Film/Video Section, Architecture Machine Group, and Visible Language Workshop, as well as those doing theses and projects in other departments.

A sampling of other educational projects:

- *Students in a French class produced six video documentaries on aspects of French culture, with the student crews communicating in French during production.

- *A series of seminars on Project Athena and a four-part instructional series on the UNIX Operating System was videotaped during IAP.

- *Examination review sessions on cable were provided for several large classes.

- *Introductory Physics produces weekly help sessions concerning the problem sets, which are cablecast all night for three nights. One-third of students responding to a questionnaire watch this program "almost every week," 95% watch it sometime during the semester, and 99% urge continuation of the program.

- *A videotaped presentation of the Electrical Engineering and Computer Science (EE/CS) basic computation course (6.001) was used at MIT three times for EE/CS and other faculty, visiting faculty, and visitors from industry, a total of approximately 100 people. Three companies, Texas Instruments, Digital Equipment Corporation, and Hewlett-Packard, used them for small groups of engineers with a tutor as part of the EE/CS Lifelong Cooperative Education Program. During the summer of 1984 we are videotaping three other EE/CS courses.

In research we continue productions that describe MIT projects for specialist and general audiences, among them an introduction to Materials Science and Engineering for students and potential donors, a description of computer-aided design for the Department of Mechanical Engineering, and one on stereo vision for the Artificial Intelligence Laboratory. The Boeing Commercial Airplane Company (BCAC), one sponsor of the MIT Industry Polymer Processing Program in the Department of Mechanical Engineering, requires quarterly progress reports. Formerly, Boeing personnel or MIT researchers had to fly between Cambridge and Seattle. Currently the MIT faculty and students make a videotaped report in EVR studios, send the tape to Boeing for review, and follow it up with a conference call. More people participated on both ends, and excerpts were shown to BCAC top management to justify continuation of research funding.

For the community we continue to record and cablecast significant events, such as dedication ceremonies for new facilities and the MIT Commencement, as well as productions such as a documentary on an Alumni telethon to encourage more volunteers and programming for the Community Service Fund, Safety Office, and Campus Patrol. We advise individuals, groups, and departments about what video systems they should purchase. Our maintenance shop offers its services to any Institute group.

Changes in our tasks will be significant during the coming year. We are among the groups moving into the new Arts and Media Technology Facility when it is completed in the fall of 1984. Following the recommendation by a special committee to the Provost, EVR has transferred rental of video playback units and duplication of videotapes to MIT Audiovisual Services and the MIT Cable System to MIT Telecommunications Systems. However, Cable maintenance services continue to be provided by EVR for the present. All activities involving video production and educational consulting remain with EVR, which will explore educational interactive video resulting from the combination of computer and videodisc.

As an educational activity, EVR will continue to report to the Provost.

EDWIN F. TAYLOR

Facilities Use

The Office of the Provost formulates and implements policy for the use of Institute facilities by recognized MIT groups. The special assistant to the Provost, Louis Menand III, is aided in these efforts by a committee whose members this year were Stephen D. Immerman, assistant dean for Student Affairs; Ronald Suduiko, special assistant in the Office of the Chairman of the Corporation; Mary Morrissey, director of the Information Center; Gayle M. Fitzgerald, coordinator of Conference Services, Winston E. Flynn, assistant registrar; and Frank Yenca of the Student Center Committee. The committee generally meets weekly to review requests for the use of facilities and to discuss issues of policy, costs, and other related matters.

The Institute's tax-exempt status in part governs the use of MIT facilities. Facilities use should contribute to the enhancement of purposes for which the Institute has been chartered, with primary focus on its educational and research roles. MIT facilities may not be used directly to support candidates for public office or for lobbying for particular legislative issues, nor may the Institute's facilities be used to support profit-making organizations. The presentation by undergraduates of talks by candidates for public office is considered to be educational in nature, and therefore provision is made for the appearance of candidates for a variety of public offices.

The domain over which the committee presides includes all of the academic space at the Institute, the Julius A. Stratton Student Center, departmental memorial rooms, and all similar spaces. Inevitably the Provost's Office and the facilities committee are drawn into broader issues involving controversial and difficult potential use of MIT facilities. As a consequence, the Office of the Provost is frequently consulted on a wide range of political, social, and even religious issues stemming from facilities use. For example, the appropriateness of activities suggested for IAP in January of each year is reviewed by the special assistant to the Provost who frequently consults the committee as well as other appropriate offices within the Institute.

In the spring term, Charlene M. Placido, Administrative Officer in the Office of the Provost, chaired the Committee in Dr. Menand's absence.

During 1983-84 the Institute was host to: Hydraulics Division Specialty Conference (American Society of Civil Engineers); IEEE Control Systems Society Symposium on Computer-Aided Control Systems Design; International Symposium on the Use and Development of Low and Medium Flux Research Reactors; The Enigma of Suicide Conference; Association of Collegiate Entrepreneurs National Conference (ACE); and the Eighth International IAVSD/IUTAM Conference, among others.

LOUIS MENAND, III
CHARLENE M. PLACIDO

Harvard-MIT Division of Health Sciences and Technology

In 1984 the Harvard-MIT Division of Health Sciences and Technology (HST) prepared a report of its activities covering the period of 1969-1984. The present statement offers highlights of that report.

In 1970, after three years of planning, the faculties of MIT, the Harvard Medical School, and the Harvard School of Public Health adopted a resolution favoring the establishment of a joint Harvard-MIT institution of health sciences and technology to foster the development of health related programs of education, research, and service, provided that the necessary new resources could be obtained. The Corporations of the two universities endorsed the resolution in the spring of 1970.

A curriculum in the biomedical sciences leading to the M.D. degree awarded by Harvard Medical School was inaugurated in 1971. This curriculum jointly taught by faculty members of MIT and Harvard is oriented towards students with a strong background in quantitative science. Twenty-five students per year, about equally divided between the physical, chemical, and engineering sciences and the biological sciences, are admitted as candidates for the M.D. degree. They are all expected to engage in independent scholarly work and are required to submit a thesis prior to graduation. Approximately 30 percent of the students work for a Ph.D. degree as well as the M.D. in various branches of the biological sciences and in chemistry, physics, and engineering; some venture further afield to economics, anthropology, and history. Most of these students appear to be headed for careers in academic medicine to engage in research, teaching, and health care.

A second major educational program was inaugurated in 1978 after three years of planning. This program in Medical Engineering and Medical Physics (MEMP), directed by Professor Ernest G. Cravalho, is designed to produce highly qualified engineers and physicists who are also knowledgeable in human biology and medicine. These individuals should be well qualified to engage in clinical investigation on important medical problems from the vantage point of their strengths in the physical sciences and engineering. Ten students are admitted each year as candidates for a Ph.D. degree at MIT or at Harvard and are simultaneously admitted as Master's degree candidates in Physics or in a department of engineering.

In 1977, after seven years of experience with the educational and research activities of the Harvard-MIT Program, and after raising \$8.5 million of endowment, the governing boards of the two universities agreed to proceed with the development of a stable institutional structure which would: (1) be an integral part of the two universities, (2) provide a framework for interdisciplinary educational and research efforts and for the development of new professions such as medical engineering and medical physics, (3) facilitate the appointment of necessary new faculty members and the development of necessary new facilities, (4) provide attractive career opportunities for those faculty members whose primary commitment is to the achievement of the Program's objectives, and (5) provide visibility for the commitment of the two universities to this joint enterprise and thus enhance the chances of obtaining the requisite financial support. The term Division was chosen as a name for this administrative and academic structure and accordingly the Harvard-MIT Division of Health Sciences and Technology was established by vote of the Corporations of MIT and Harvard University in 1977.

The Harvard-MIT Division is by design multidisciplinary with faculty members who hold joint appointments whenever possible in existing departments.

The governance of the HST Division consists of the Governing Board, composed of the Presidents of the two universities and two members each from the governing boards of MIT and Harvard; the Administrative Council composed of the Provosts and Deans of the faculties and schools in the two universities concerned with the health sciences; the Joint Faculty Committee, the senior faculty policy making group of the Division; and the Administrative Committee consisting of administrative officers of the Division and representatives of the Office of the Provost of MIT and the Dean of the Faculty of Medicine of the Harvard Medical School.

Educational programs of the HST Division have engaged the services of over 330 faculty with 136 of them currently serving as members of the HST teaching faculty. Of this number, five hold primary appointments in the HST Division; the others are individuals whose primary appointments are in existing departments or schools of the two universities. It should be emphasized that one of the objectives in the establishment of the HST Division was the provision of career paths for faculty members.

The Harvard-MIT Division has provided the stimulus for the development of nearly 90 new courses; 24 in the biomedical sciences, 21 in bioengineering, 12 in the social sciences, 16 in medical engineering and medical physics, six in medical radiological physics, five in physics, two in human biology, and one in biophysical chemistry. Thirty-nine percent of the total enrollment in HST courses has consisted of non-HST MIT and Harvard students.

EDUCATIONAL PROGRAMS

The Biomedical Sciences Curriculum

Admission Policy and Mechanisms: Students apply for admission by application to Harvard Medical School, and the applications are reviewed by a special HST Admission Committee composed of faculty members of the two universities and students in the HST Biomedical Sciences curriculum. The experience of the past several years has shown that there are approximately 400 applicants for the 25 positions in this curriculum.

The curriculum is oriented toward students with strong backgrounds in quantitative science. In practice approximately one-half of the students who are successful applicants have concentrated principally in the physical sciences, i.e., mathematics, physics, engineering, or chemistry, and approximately one-half in the biological sciences, especially molecular and cellular biology. Approximately half of the students admitted come from Harvard College and MIT and the rest derive from major universities in this country.

Special features of the Biomedical Sciences curriculum should be noted. The curriculum introduces sciences basic to human biology and medicine. These sciences include molecular and cellular biology, genetics, immunology, the chemical sciences, the physical sciences and engineering and mathematics. In addition, as a major service in society, medicine engages the social sciences such as economics, sociology, political science, management, and public administration. Fundamental to the understanding of human behavior, normal and abnormal, are the sciences of psychology and anthropology. In seeking to relate these sciences to the study of medicine selectivity has been necessary because of the limited availability of faculty members and more significantly the pressures of time available for educational offerings that are appreciably different in content from those in the standard medical curriculum.

To help promote penetration of the physical sciences into human biology and pathophysiology, physicists and engineers have been invited and persuaded to participate actively in the teaching of some courses in the medical sciences. In courses such as Cardiovascular, Respiratory, and Renal Pathophysiology and in the Functional Anatomy of Man, these efforts have proved productive. A new course, Quantitative Topics in Physiology, was developed by Professor Felix Villars, Professor of Physics at MIT, and his associates who are physicists and engineers. In further development of the interface between the physical sciences and the biomedical sciences, the curriculum has promoted the productive utilization of computer science in Cardiovascular Pathophysiology, Respiratory Pathophysiology, Functional Anatomy, the Human Nervous System, and Topics in Quantitative Physiology. In other courses in which quantitation is more difficult because of the unavailability of the data required, a more qualitative approach emphasizing molecular and cellular biology and biochemistry has been followed; this is particularly valuable in such courses as Hematology and Gastroenterology.

Courses were developed on the Economics of Health Care and on Ethics and Decision Making in Medicine but for teaching of the sociology of medicine, health policy, and the biological basis of human behavior, the HST curriculum has been dependent upon the availability of offerings at Harvard Medical School.

The HST Biomedical Services curriculum requires that each student choose a field of concentration in which several months of elective time are spent. Faculty tutors provide guidance in the choice of subjects and in the pursuit of independent study.

A thesis requirement has been in effect since 1974. HST students are expected to engage in independent study and to present evidence of scholarly work based on laboratory research, clinical investigation, critical analysis of a significant medical problem, or other activities approved by faculty tutors. This requirement is based on the principle that research and independent study are important elements in the education of physicians who should continue to grow intellectually during their professional careers.

Many HST students engage in a combined M.D.-Ph.D. program in preparation for careers in academic medicine. Graduate study for the Ph.D. may be pursued at Harvard Medical School, at Harvard University, or in the Graduate School at MIT. Since the inception of HST, 42 M.D. candidates have received the Ph.D. degree or completed the requirements for it: 38% in the physical sciences or engineering, the rest principally in the biological or medical sciences. In 1983-84, of 74 Harvard Medical School candidates for the M.D. degree who were simultaneously enrolled for the Ph.D. degree, 62% were HST students, 27 at Harvard, 19 at MIT. Approximately half of these students are candidates for the Ph.D. degree in the physical sciences, engineering, or mathematics, the other half principally in the biological or medical sciences.

Performance of Students

On the whole, HST students have performed extraordinarily well in both the preclinical sciences and in clinical medicine. They have been awarded excellent internships and residencies in outstanding university teaching hospitals. Although HST students constitute only 15% of the Harvard Medical School student body, they have received 45% of the Honors in a Special Field awarded to graduating students.

Activities of HST M.D. Graduates

A survey of the first three graduating classes revealed a significantly high percentage (70-80%) of the graduates to be engaged in academic medicine and research.

MEDICAL ENGINEERING-MEDICAL PHYSICS PROGRAM

This program was begun in 1978 after three years of planning. Graduates of the program are prepared to participate in patient care during the acute and rehabilitative phases as well as to engage in original research on fundamental problems of clinical importance. There are several key components: preclinical studies in the biomedical sciences, advanced study in engineering or physics, extensive clinical experience, and thesis research of an original character.

The program is intended for students with a Bachelor's degree in engineering or physics. Admission requirements include at least one semester each of biology, organic chemistry, physical chemistry, and biochemistry, demonstration of superior scholarship, superior performance on the Graduate Record Examination, and strong letters of recommendation.

The biomedical sciences component of the curriculum consists of courses in the preclinical sciences offered by the HST Division. Advanced study in engineering or physics is supervised by the Engineering Department or Department of Physics in which the student is registered and includes sufficient course work and thesis work, if necessary, to meet the requirements for the Master's degree.

A unique feature is the year of clinical experiences consisting of the Introduction to Clinical Medicine, followed by clinical experiences or clerkships in medicine, surgery and various other specialty fields. These clinical experiences provide the student with direct contact with patients and afford an in-depth knowledge of some aspect of specific clinical and research activity. In order to participate in the clinical year, students must have passed a series of qualifying examinations, a written examination set by the graduate department closest to the undergraduate major in engineering or physics, a second written examination given by the Division and designed to evaluate the student's knowledge in the biomedical sciences, and a third oral examination set jointly by the Division and the relevant graduate department and designed to evaluate the student's research potential.

At the conclusion of the clinical experience, students are expected to commence thesis research. This work involves independent investigation of a fundamental problem of clinical relevance. Each student is required to submit a thesis proposal describing the scope and objectives of the proposed work. The proposal must bear the endorsement of the doctoral thesis committee and is reviewed and approved by the Joint Faculty Committee of the Division.

Student enrollment has been limited to ten new students per year.

Performance of Students

Despite substantial academic loads, the students have performed in an outstanding manner based upon evaluations submitted by the faculty in the biomedical sciences and upon grades submitted by faculty in the engineering and physical sciences.

Activities of Graduates

The first group of students has only just graduated but they are already gaining distinction and receiving major awards.

M.D. Degree for MEMP Students

A major issue is the desirability of an option for the M.D. degree for MEMP students. The option to pursue the M.D. degree has been provided at both Harvard Medical School and Tufts Medical School. Similar arrangements have been made at both schools: they require that the students apply for advanced standing in the M.D. program during the last year of doctoral research and present clear evidence of superior research accomplishment for admission. In addition, it is possible for students to pursue the M.D. degree and the HST MEMP doctoral degree by applying to the two programs simultaneously. Nine students are exercising this latter option.

HST RESEARCH PROGRAMS

From its inception, a principal objective of HST has been to foster interdisciplinary research between the faculties of MIT and Harvard Medical School. Research programs developed by HST have spanned the range from fundamental scientific research to applied research and development. Since the first HST research program was funded in 1972, 80 new research programs (each consisting of one to eighteen interdisciplinary research projects) have been launched with 41 currently active. These programs have been supported at the level of approximately \$50.9 million over the last thirteen years. There are currently 115 research faculty and senior research staff associated with HST research programs with 57 at MIT, 48 at Harvard, and ten from other institutions. More than 40 additional faculty members -- approximately equally divided between Harvard and MIT -- serve as thesis advisors to HST M.D. and Medical Engineering and Medical Physics students at any given point in time.

Current research programs are funded at the level of \$7 million per annum. These programs are of two principal kinds: Consortium programs involving large numbers of faculty members of the two universities, and individual research programs under the aegis of the HST Division. The annual HST catalogue describes these research programs. Especially important are some of the Consortium programs: Harvard-MIT Research Program in Short-Lived Radiopharmaceuticals; Interleukin 1; Harvard-MIT Rehabilitation Engineering Center; Measurement of Perfusion from Tissue Thermal Properties; Tuberos Sclerosis Workshop: Cause, Diagnosis, and Management; Stress Morphology Relations for Trabecular Bone in Vitro; Fracture and Viscoelastic Characteristics of Human Cervical Spine; Quantitative Formulations of Wolff's Law in Trabecular Bone; A New Approach to the Analysis of Radiopharmaceuticals; Physical Forces in Skeletal Growth and Development; Quantification of Cellular Response; Phase 1 Evaluation of Equipment for Hyperthermic Treatment of Cancer; Tumor Hyperthermia: Science, Technology, and Evaluation; Evaluation and Improvement of the Bedside Arrhythmia Monitor; Nursing Home Telemedicine; An HMO for Nursing Home Patients; A Portable System for Real-time Arrhythmia Analysis; Myocardial Perfusion Scintigraphy Using a New Technique: The Mesh Chamber; Thromboresistant Materials; Electric Physiographic Studies; A Study of Diesel Exhaust Exposure in Railroad Workers.

Individual research projects are: Cancer Hyperthermia: Temperature, Perfusion, Oxygen Profilometer; Continuous MS Monitoring of Liver Alcohol Metabolism; Analysis of Beat-to-Beat Fluctuations in Electrocardiographic Measures of Ventricular Repolarization in the Study of Mechanism of Ventricular Fibrillation; Random Process Analysis of Beat-to-Beat Fluctuation in Electrocardiographic and Hemodynamic Parameters; Bovine Embryo Transfer Technology; Cryopreservation of Organs; Propagation of Phase Fronts in Cellular Suspension; Regulating Gene Expression through mRNA and Protein Associations: Transshaping Globin mRNA Conformation with Cap Binding Protein; Regulation of Gene Expression in Plants; Structure of Messenger RNA; A Unified Environment for Computer Analysis of Nucleic Acid/Protein Sequence Data; Control of Protein Synthesis by Double-Stranded RNA; Control of Protein Synthesis in Normal and Interferon-Treated Cells: Regulation and Mechanism of Action of eIF-2 Kinases; the Regulation of Gene Expression in Normal Cellular Differentiation and in Human Leukemic Cells; Regulation of Hemoglobin Synthesis and Erythropoiesis; Gel Microdroplets for Microbiology; Spatial Mapping of Enzymes; Transcutaneous Blood Gas, pH and Cardiac Output. The research volume has been growing annually at a rate of approximately twenty percent.

Biomedical Engineering Center

Since its inception in 1976 as an NIH/NIGMS supported Biomedical Engineering Center for Clinical Instrumentation, the Biomedical Engineering Center has been an interdisciplinary laboratory dedicated to the application of engineering and physics to solutions of problems in clinical medicine and medical research.

The Center provides HMS and MIT investigators with laboratory facilities, instrumentation, and a supporting faculty and staff with a range of capabilities including computer science, micro-electronics, electrical engineering, mechanical engineering, physics, physiology, and medicine.

Activities range from basic physiological research to clinical evaluation of instrumentation developed by the Center investigators. Contracts with several companies have been established to assist technology transfer and assure wider utilization of accomplishments. The Center provides opportunities for approximately 50-60 students per year to gain research experience in an interdisciplinary setting. Since its inception, the Biomedical Engineering Center has undergone a gradual evolution in terms of its mission, goals, and capabilities resulting from a steady flow of projects being completed and new projects being introduced. These evolutionary changes will continue as new engineering technologies, materials, and instrumentation techniques become available for utilization in medical research and clinical medicine. Center resources (human and physical) are an important element in the HST Medical Engineering and Medical Physics environment.

HST Fund Raising Activities

The office of the Assistant Director for Resources was established in the fall of 1970. Since the inception of HST, approximately \$15.4 million has been raised -- \$10.3 million for endowment, \$4.73 million for operations, and \$0.34 million for facilities.

IRVING M. LONDON, M.D.

Independent Activities Period (IAP)

Guide Activities

With almost 560 activities listed in the IAP Final Guide, members of the MIT community were once again faced with the pleasurable but nonetheless difficult task of choosing among them. Two of the most popular activities, drawing more than 200 participants each, were a series of films and discussions led by literature faculty on the theme "Images of Women in the Movies" and a panel discussion chaired by Professor Paul Samuelson on "The State of the Economy." Almost 300 people registered for the Student Art Association's courses which attract more people during January than during any other part of the year. More than 50 students accepted the challenge to "outdesign the Aussies" and construct a model of a sailing yacht keel in the Great MIT Keel Haul Contest. John Y. Wang, Class of 1986, won the contest. A few days later, a second model Wang built, with another student, took second place in the other major IAP design contest, Das Harvard Bridge. This time contestants were called upon to outdesign the engineers at the Metropolitan District Commission who must rebuild the deteriorating bridge next to MIT. Marjorie Ferguson, Class of 1984, and Allen P. Bommer, Class of 1984, built the winning model of wood, string, and hardware, which weighed only 1.66 pounds but carried a phenomenal load of 3,700 pounds. The second-best model, built by John Wang and his partner Mark Gebert, Class of 1986, weighed 2.11 pounds and carried 2,300 pounds.

While most activities took place on campus, some inspired people to widen their horizons. Eight people boarded MIT's research vehicle, the Edgerton, for an oceanographic tour of Boston Harbor, while another dozen toured the harbor by tugboat to view the transportation facilities of the Port of Boston. Almost 60 people traveled to the Woods Hole Oceanographic Institution and another 35 to Wallace Observatory. Twenty-four students left campus not for a tour but to work daily as interns in local architectural offices. Traveling farthest of all were eight students and two faculty members who spent two weeks doing "hands-on" astronomical research at the Lowell Observatory in Flagstaff, Arizona. Despite their brief stay, they found 17 new asteroids, confirmed that a suspected binary star in the constellation Taurus is, in fact, double, and discovered that the variable star ZZ Geminorum, in the constellation of Gemini, was about 1.5 magnitudes brighter than usual.

Although most people's experiences with IAP activities were extremely positive, a number of students were disappointed that sections of the intensive language courses were cancelled at the last minute because of budgetary constraints. The advertised Expository Writing II: English as a Second Language was not offered, and only one section was offered in beginning French, German, Russian, and Spanish. Many students were turned away. As a result, the need for intensive language courses during January became a primary topic of student comments on their post-IAP questionnaires. Eleven percent (55/500) of the students writing comments advocated the availability of courses for academic credit, in general, and of intensive language subjects in particular.

Evaluation of IAP '84

Based on statistics and comments gathered on IAP '84, the IAP Policy Committee found that, except for the cancellation of the intensive language subjects, satisfaction with and involvement in IAP remains as strong as ever. Looking first at the Guide activities, the committee noted that 26 percent of the faculty (264/1,009) participated in some way in Guide activities. This is the same percentage as last year, but the level of their involvement seems more intense--last year faculty led 18 percent (122/615) of the activities; this year they led 28 percent (160/558), the highest percentage in five years. At the same time, however, student leadership of activities dropped from 24 percent (148/615) last year to 20 percent (109/558) this year. The Policy Committee is currently considering means of reminding students of the valuable experience to be gained by leading IAP activities.

Reports from activity leaders continued to be as enthusiastic as ever. Of the 457 activity leaders responding to their annual questionnaire, 89 percent characterized their activities as "worth the effort."

For the second year in a row the IAP Policy Committee distributed a questionnaire to all students at the beginning of the second semester to learn how students spend their time during January. While this year's response rate was only half that of last year's (11 percent compared with 22 percent for IAP '83), the data closely followed last year's. Asked to rate their IAPs on a scale from 1 (poor) to 5 (excellent), respondents gave an average rating of 4.17. In response to a new question asking whether IAP should be eliminated, shortened, or kept the same length, only 1 percent chose eliminated, 9 percent said shortened, and 89 percent wanted IAP kept the same length.

Once again many students used the back of the questionnaire to write testimonials to IAP. Their principal concern, as noted above, was the possible discontinuation of the intensive language courses.

Student Exchange

For the first time in many years (since 1976, at least) an MIT student and a student from another school worked out arrangements for a one-for-one exchange during January. Keith Bertrand, Class of 1985, went to Bethel College in North Newton, Kansas, while Garth Isaak, a Bethel senior, came to MIT. Both schools waived tuition and permitted the students to exchange dormitory rooms. While at MIT Garth attended a number of activities and used the libraries for research on his senior thesis in physics. Keith enrolled in an intensive chemistry course at Bethel. Helping with arrangements for the exchange was Keith's sister who attends Bethel.

IAP Committees

This year under the energetic leadership of Professor Shaoul Ezekiel, the IAP Policy Committee has been particularly active. In addition to reviewing and revising descriptions of IAP policies and procedures, the Committee initiated an open forum during IAP on "The Role of Computers in Education." The forum, which was co-sponsored by the Provost's Office, the Dean for Student Affairs Office, and Project Athena, drew more than 200 people and gave all faculty and students their first opportunity to ask questions and state their views on this important topic. In addition to Professor Ezekiel, this year's Policy Committee included: Professor Samuel M. Allen; Professor Charles L. Cooney; Mary Z. Enterline; Professor Gordon Kelly; Professor Daniel Kemp; Dr. Louis Menand III; Daniel Oday, Class of 1987; Professor Charles Sabel; Gregory Tucker, Class of 1985; Professor Cardinal Warde; Rebecca Waring, graduate student; and Professor David Gordon Wilson.

The IAP Administrative Committee worked with the Policy Committee in reviewing activities for appropriateness and allocating funds for activities. Its members also provided needed people-power to organize and staff the IAP booth at the academic midway for freshmen and the luncheons for IAP coordinators. Chaired by Margaret S. Richardson, the Committee included Deirdre Dow-Chase, Andrew Eisenmann, Mary Z. Enterline, Steven Gass, Mary Jasinski, George R. Kendall, Louis Menand III, Janet Romaine, Michael Schlein (graduate student), and Maryglenn Vincens.

Dr. Louis Menand III, special assistant to the Provost, led the IAP Planning Committee, which is composed of departmental coordinators. Although it is not possible to list individually by name the more than 80 faculty, students, and staff who served as coordinators, they are to be commended because the continued success and vitality of IAP results in large part from their initiative, creativity, and dedication.

IAP Staff

The IAP Office continued to be staffed by Mary Z. Enterline, manager, Maryglenn Vincens, staff writer/editor, and George R. Kendall, senior office assistant. As of July 1, 1984, responsibility for the IAP/Wellesley-MIT Exchange Office will be transferred from the Provost to the Dean for Student Affairs. The IAP/Wellesley-MIT Exchange will become part of the Undergraduate Academic Support Office.

MARY Z. ENTERLINE

Libraries

The past year in the MIT Libraries has been characterized by an extremely high level of change, perhaps greater than in any year since the early 1970's when Project Intrex and the Model Library Program were taking place. Changes were necessitated by the need to adapt to staff reductions and other budget cuts, by requirements implicit in the implementation of the Geac circulation system, and, of greatest long term significance, by a major planning effort undertaken on an Institute-wide basis. While a great deal of time and effort was invested in planning, in managing several large special projects, and in the allocation of resources and the establishment of priorities, the Libraries continued to acquire, process, and organize collections and to provide service to members of the MIT community and other users. The maintenance of a consistently high level of service in the face of a reduced budget and the challenge of planning for the future was accomplished in large part through the dedication, perseverance, and imagination of the staff, the most critical ingredient in the continuing development of the MIT Libraries.

Although almost all of the personnel changes necessitated by budget reductions in the fiscal year beginning July 1, 1983 were effected before the start of the year, repercussions continued to be felt throughout the ensuing twelve months. Many of the staff who were transferred to new positions required extensive periods of orientation and training and, in addition, there was a significant amount of reassignment of responsibilities and change in procedures. Further effort was also required in dealing with the effects of the closing of the Von Hippel Reading Room, in redefining the role and services of the Student Center Library, and in accommodating a reduced materials budget. Two major results of changes that were instituted have, and may continue to have, the effect of putting pressure on the Libraries that was not fully anticipated. The increase in self-service photocopying fees has produced a significant increase in journal circulation and a marked decrease in photocopying. Fees charged to non-MIT users for access to the Libraries resulted in the cancellation of a number of corporate and individual memberships and, consequently, failed to generate the level of additional income that was anticipated when the decision was made. While the Libraries did not, fortunately, have to face any budget reductions for the 1984/85 fiscal year, the Institute's continuing tight financial situation necessitated a number of additional budgetary shifts for the year beginning July 1, 1984. Among these were (1) a reduction in the collections budget for humanities with an emphasis on music and current literature; (2) a reduction in the student budget for the Music Library, reflecting a projected lower level of acquisitions and processing; (3) the elimination of the evening and weekend reference assistant position in the Humanities Library; (4) a one year reduction in the materials budget to provide a computer operator position for the Geac system (future funding will come from a reduction in the circulation staff once the system has been implemented).

Clearly, the most pervasive activity in the Libraries during the past year has been the implementation of the Geac circulation system and the MARC record management system (MRMS). During the year a coordinating committee was established, a project manager was hired, a staff member from the Cataloguing Department was assigned full time to the project, a computer room was built in Hayden Library, and the computer was installed. A newsletter was published on a regular basis and meetings were held with the staff to share information about the project. Staff involvement in implementation began in the form of a group of task forces and evolved into two very effective teams organized around circulation and bibliographic issues. Monumental work was required to define the Libraries' organization, holdings, policies, and cataloguing practices and to translate them into tables of data that Geac will use in developing system software. As of July 1, 1984, the Libraries were about halfway through the implementation process. By all measures, the staff, in cooperation with Geac personnel, are doing an outstanding job. The thoughtful and precise manner in which decisions have been made, although extremely time consuming, is essential as they will have an impact on the Libraries' operations for many years to come. The staff, through its involvement with the project, has become increasingly knowledgeable about automation and more comfortable with the potential changes that technology will bring to the Libraries. A great deal remains to be done in the coming year: development of an authority control system; installation of terminals and telecommunication facilities; loading and testing of the archive tape; barcoding of collections; staff training; and, finally, full scale use of the system.

As part of an Institute-wide process, the MIT Libraries participated in the development of a five-year plan during 1983/84. To quote from the Director of Libraries' Executive Summary: "The detailed plan ... has provided the administration and staff ... with an opportunity to assess the quality and level of current activities and to develop a scenario for the future that reflects the Libraries' needs in the context of the Institute's current and planned programs. We believe the plan is imaginative and realistic. It builds upon the traditional strengths of the collections and services that have been designed to serve the very special needs of this institution. It is realistic in that the plan seeks to maximize present and potential benefits of library and information technology while recognizing the limitations that will necessarily be involved in increasing the level of support during the next five years ... The plans and programs outlined represent those activities that are deemed to be of high priority and result from an exhaustive analysis of all aspects of the Libraries' operations in the context of current and anticipated developments, both internal and external." The plan calls for an increase in general operating funds of approximately \$1.1 million, representing about 16% of the current budget over five years with an additional \$1.4 million for non-recurring expenses. The latter amount, much of which is expected to be raised through a development program, is mainly connected with the implementation of an integrated, online library system, the area identified as being the highest priority for the period 1985-1989. The plan also identifies collection development and preservation, improvement of

the physical environment, and the extension of information services as major thrusts. An important activity for the Libraries during 1984/85 will be to revise and amend its plan to reflect changes in education and research programs that have been proposed by MIT's schools, academic departments, and research centers as part of their participation in the five-year planning process.

Given the reality that implementation of the Geac system would occupy a substantial amount of staff time during the coming year, the Libraries' administration, specifically, the Library Council, spent considerable time developing a set of priorities for 1984/85. At an all day meeting in June, followed by several shorter sessions, the Council established six issues or program areas that will be given high priority, at the same time identifying problems and projects that will, by necessity, either be undertaken at a relatively low level of effort or suspended temporarily during the next twelve months. The first area of emphasis will, of course, be Geac implementation. The other key programs are fund raising; space planning; continued planning for automation in the Libraries; planning for the integration of library automation with campus-wide systems, especially Project Athena; and the maintenance of effective services during Geac implementation.

Although planning for the integration of the Libraries' automated systems with MIT campus-wide facilities has been identified as a major project for the coming year, a considerable amount of work was accomplished during the past year. Following a series of discussions with the director of Project Athena, a plan has begun to emerge that views the Libraries as a major node in the Athena network. A dedicated computer linked to the network will connect users with access to Athena terminals to an array of library services that may include the following:

- a package of information services such as library hours; at-the-terminal browsing of holdings by broad subject that would identify the library or libraries holding a particular subject with call number ranges, location of collections, uncatalogued collections, indexes and databases; information on services such as photocopying, maps of the libraries, services for the handicapped.
- access to the Libraries' specific holdings through the Geac public access module; ability to request delivery of a book or article; capability to download information from the Geac system for such uses as reserve list preparation or thesis bibliographies; ability to make recommendations for acquisition.
- access to information outside the MIT Libraries that might include the routing of citations produced through the searching of online bibliographic databases; online assistance in the choice of appropriate databases for end-user searching; ability to request delivery of books and articles from sources outside MIT.

A prototype for some of these proposals could be in place within the next academic year. At each stage of project development, the Libraries will be considering the offering of similar services to those outside of MIT for an appropriate fee.

PROJECTS AND GRANTS

The first year of a two year project funded under Title II-C of the Higher Education Act and focusing on science, technology and society, ended on December 31, 1983. In the cataloguing portion of the project, the Libraries converted 19,180 records representing an increase of 18% over the amount specified in the grant. Four major manuscript collections were also processed as part of this grant. The MIT Libraries received funding for a second year that commenced on January 1, 1984 and will involve the input to the OCLC database of approximately 3,000 titles not presently represented, in the fields of energy, history of technology, computers and society, applied genetics, and technology transfer. An additional group of manuscript collections will be processed as well. In both years of the grant, the Libraries will be preserving on microfiche a number of titles in the subject areas listed above.

Along with the other members of the Boston Library Consortium, MIT participated in a major union list project that culminated late in the academic year in the first online union list of serials. For the first time, the current serial holdings of the 12 libraries are listed both online and in a single, computer-output-microfiche edition that will expedite the location of titles and the interlibrary loan/photocopying system that is one of the principal features of this cooperative network. The BLC union list also features a keyword index. MIT will utilize this system, based at the F.W. Faxon Company, for production of "Serials in the MIT Libraries", with the first version to be issued in the fall of 1984. Future plans call for the development of an online, public access module to complement the current access system that is limited to technical services staffs.

The academic year 1983/84 marked the completion of the fifth year of the Aga Khan Program for Islamic Architecture. During the year the Libraries continued to acquire and process books, serials, and visual materials, to provide reference and information services to both local users and to those abroad, and to extend the developmental work in the documentation projects. The latter program involves the creation of a prototype visual database including an online, searchable file of architectural information linked to an analog optical video-disk of still photographic images. Among the results achieved in 1983/84 were completion of the vocabulary of some 4,000 terms; compilation of a dictionary/glossary of transliterated terms; collection and sequencing of 40,000 images from

the Harvard and MIT collections and the Program's archive; preparation of a pilot disk; inclusion of indexing information on 4,000 images of architecture in India and Bangladesh from a project at Ohio State University; complete indexing of 1,500 images with bibliographic citations, historic background data, and architect information; implementation of a microcomputer (IBM PC/XT) for data input and editing; start of work on programming to link the database and video-disk.

Notification of funding for two new programs was received during the year. The MIT Museum and Historical Collections received an operating grant from the Institute of Museum Services that will provide support for reference and information functions, for development, and for educational programs. Two grants were awarded for the organization and processing of the Roman Jakobson linguistics collection. One, from the National Endowment for the Humanities, will provide support for 18 months for staff to organize and process the manuscript portion of the collection. Another grant under the Title II-C program will support the cataloguing of approximately 2,100 monographs and 50 serial titles in the collection that are not represented in the OCLC database. During the year, the Libraries began searching and cataloguing monographs from this very important collection and, with the support of the two projects listed above, expect to have most of the collection processed within the next two years.

PUBLIC SERVICES

Budgetary restrictions brought with them increased photocopy and fine charges, a changing role for the Student Center Library, and reduced staff in a number of departments. The volume of journal circulation rose significantly over the year, most probably in response to the increase in self-service photocopying charges. Determining procedures for the handling of technical reports with reduced staff consumed the better part of the year. The public services departments now have a solid set of procedures in place, due to the diligent efforts of the staff involved. Changes in the Student Center Library have been dramatic. With a greatly reduced staff, the collection is being weeded and redefined in scope, and preparations are being made for a major installation of Athena terminals. In response to the pressures from outside users in all libraries, a more restrictive entrance sign was posted in each location, and a set of reference guidelines for dealing with outside users was drafted and implemented. Consideration was given to establishing a fee-for-service operation to handle some of the needs of non-MIT users. Discussions are continuing with the Industrial Liaison Program (ILP) to coordinate a fee-for-service system with their services to industry and to try to gain additional "revenue-sharing points" for the services that the Libraries currently provide ILP members. Other activities of note include the completion of a sign system in the Humanities and Science Libraries; expanded use of online bibliographic databases for reference and information services; the establishment of a Women's Studies Research Room in Hayden Library in cooperation with the new Women's Studies Program; and the completion of an extensive report on the past, present, and future of bibliographic instruction in the MIT Libraries.

COLLECTION MANAGEMENT AND TECHNICAL SERVICES

Along with the staff of the public service units, personnel in the Cataloguing Department were deeply involved in implementation of the Geac system. Major activities included the development of functional specifications for processing OCLC archive tapes; compilation of index tables to the MARC Records Management System; a STOPLIST for the author, title, and subject indexes. Together with Faxon and Geac, the MIT Libraries have been working on a system for loading and integrating MIT's serials records and holdings from the Faxon database with the monographic records and holdings in the Geac MRMS database. If successful, this program will not only be of great benefit to the MIT Libraries but will also aid other research libraries that use the Geac system. The Libraries continued to participate in efforts of the Boston Library Consortium to develop a cooperative disaster plan and also worked on the publication of a "Preservation Resources Directory." Plans were completed for the renovation of the Binding and Repair Section's physical facilities in order to improve productivity and environmental conditions. In the area of collection management, a thorough review of duplicate serial and journal subscriptions was completed resulting in over \$40,000 in cancellations; these funds were needed to make up a shortfall in the materials budget for 1984/85.

A major study of various alternatives for retrospective conversion was begun in preparation for the development of a fund-raising project. Although Title II-C grants have had some effect on retrospective conversion needs and while the Libraries continue to convert records for titles returned from circulation, a large volume still remains to be completed. Funds for this purpose will be one of the key points in resource development over the next two years.

ARCHIVES AND RECORDS MANAGEMENT

Work continued on three major grant projects: the Title II-C program in science, technology and society; the National Science Foundation grant for the appraisal of scientific and technical records; and the Mellon Foundation project under which the first draft of a document entitled "MIT Appraisal Process for the Records of Contemporary Science and Technology" was produced. Use of the collections continued at a relatively high level with three topics receiving the most interest: the impact of federal funding on scientific and technical research in the academy; the development of recombinant DNA technology and policy implications resulting therefrom; and the history and impact of the computer. The Records Management Program continued its records scheduling program with schedules produced for the MIT Planning Office, the Francis Bitter National Magnet Laboratory, and the Investments Office. Work also began on a project to write a comprehensive schedule for all of the records created and maintained at MIT

as a result of sponsored research. A major setback in this program occurred during the year because of a flood in the building at 224 Albany Street. The securing of a larger, more secure, and permanent home for the Records Management Program is one of the Libraries' principal space needs during the coming year.

MIT MUSEUM AND HISTORICAL COLLECTIONS

1983/84 saw a major reorganization of the administration of the Museum. Following a detailed analysis and review of every staff position and function, the administration was restructured under three Assistant Directors who report to the Director of the MIT Museum and Historical Collections. Activities have been assigned to one of three areas: collections; education and community relations; exhibitions. At the beginning of the year, administrative responsibility for the Hart Nautical Collections was transferred from the Department of Ocean Engineering to the MIT Museum and Historical Collections.

Major changes in the Museum's physical facilities resulted from the completion of the move of the Resource Sharing Center (now named RetroSpective Collection) to Building N57. Two new, larger, and well-equipped galleries were created along with a major improvement in office and storage space and in the space used for the Museum Shop.

One of the most significant developments in this part of the Libraries was the establishment of a Board of Advisors, the first group of its type to be set up in the 15 year history of the Museum. With members from the Institute administration, Libraries, professional museum world, and alumni, this group will serve to guide and advise the Museum's staff in such areas as collection policy, exhibitions, education programs, and development. Howard W. Johnson, former President and later Chairman of the Corporation of the Institute, was appointed first chairman of this body.

Along with a number of smaller exhibits both at the Museum's central facility and in various buildings on campus, there were four major exhibitions mounted: in Compton Gallery -- "Insights and Explorations", the work of Todd Siler of the Center for Advanced Visual Studies; "Etched in Sunlight", the work of Samuel V. Chamberlain, Class of 1918; "Ring the Banjar" - the banjo in America from folklore to factory; in the Hart Nautical Galleries -- "The Engineering Wizard of Bristol", work of Nathaniel G. Herreshoff, Class of 1870.

SPACE AND FACILITIES

One of the most significant events of the past year was the long-awaited decision by the Institute administration to proceed with a major addition to the Rotch Library of Architecture and Planning. Although still several years off, the prospect of obtaining relief from the Libraries' most serious space problem has had a heartening effect on both staff and administration. During the past year, the Libraries completed the move of collections from Building N51-52 to the new storage facility in Building N57. Renamed the RetroSpective Collection (RSC), this building serves as the principal control for containing the growth of the collections. In connection with RSC operations and the general need for improvement in document delivery, the Libraries purchased a delivery van and began to provide speedier and more frequent delivery of books and other materials throughout the campus. Considerable effort was expended on space planning in the Hayden Library to accommodate needs resulting from the installation of the Geac system and its attendant equipment, especially in the technical services areas. The potentiality of gaining additional space when the Hayden Gallery moves to the new Arts and Media Technology Building provides the Libraries with an opportunity to reorganize and expand a number of activities that are presently extremely crowded. Among the space and facilities projects that the Libraries will be addressing in the coming year are: reallocation of space in Hayden Library; renovation of the basement in the Dewey Library; space for the Hart Nautical Collections in Building N51; a permanent location for the Records Center; renovations associated with Geac circulation installations in many libraries; and additional facilities for video viewing.

ADMINISTRATION

Great progress was made during the year in the computerization of the financial accounting systems in the Libraries. Expanded use of microcomputers in this activity as in many other areas of the Libraries' operations has proven extremely beneficial. Other major activities in the central administrative and personnel functions included: decentralization of student staff administration; the acquisition of a new camera/processor in the Microreproduction Laboratory; and the evaluation and redesign of performance evaluation processes for both professional and support staff.

There were a number of meetings of the librarian and other academic staff during the year that were arranged by a new committee that has taken on responsibility for this activity. In addition to presentations by the Director and by a number of other staff, there were two sessions involving individuals from outside the Libraries: Shirley Echelman, Executive Director of the Association of Research Libraries spoke on ARL and on national problems of research libraries; Francis E. Low, Provost of the Institute spoke to the staff about the Institute's plans and their relation to the Libraries. At two general staff meetings there were presentations by Nancy Kranich, Director of Administrative and Public Services at New York University Library, and Weston J. Burner, Director of Information Processing Services at MIT.

The Libraries continued to offer a wide range of activities during the Independent Activities Period in January, 1984. The subject matter included the history of technology, consumer protection, computer literacy, needlework, playwriting, Ibero-American civilization, book repair, personal computers, thesis preparation, preservation of photographs, Rome through films, occult sciences, office automation, finding a job, the history of MIT, history of the social dance, bicycling, and a number of musical events including concerts by members of several faculty groups.

PERSONNEL

Among the personnel changes during the year were the departure of Susan J. Coté, Associate Director of Libraries, who was appointed Director of Libraries at Case Western Reserve University. Irma Y. Johnson, Head of the Science Libraries and a long-time member of the staff, retired on June 30. Arlyne Jackson, Associate Dewey Librarian, was named a Council on Library Resources Academic Library Management Intern for the year 1984/85 and will be working with Herbert Johnson, Director of Libraries at Emory University. Helen Slotkin, Institute Archivist and Head, Special Collections was named a Fellow of the Society of American Archivists.

GIFTS

Major gifts of books were received during the year from Morris A. Adelman, Robert L. Bishop, and Francis E. Low. Mr. and Mrs. Ellis J. Green donated a number of rare items in science and technology. The Harfax Database Company continued to provide the Libraries with significant additions of reference material in the social sciences. Notable gifts to the Museum included a scale model of the original Rogers Building in Boston; an extraordinary collection of medals, indicative of his many contributions to MIT and the United States from James R. Killian; an early telescope from Julius A. Stratton; a set of gallery prints of classic high speed photographs from Harold E. Edgerton; and a fine ship model of the bark Wanderer for the Hart Nautical Collections. For use in conjunction with exhibitions, the Timex Computer Corporation donated a Timex Sinclair 2068 personal computer. Additions to the Archives included official papers of Kenneth R. Wadleigh, former Dean of the Graduate School; the first installment of records from the current President, Paul Gray, and Vice-President Constantine Simonides; a major collection from the Department of Chemical Engineering consisting mainly of course notes, examinations, theses, and records of field sites; and course notes from the Department of Nuclear Engineering. The largest and most significant gift of manuscripts was the papers of Roman Jakobson presented by his widow, Professor Krystyna Pomorska. The collections of Harold E. Edgerton, Allen Hazen, and Victor Weisskopf were strengthened through the acquisition of new material. New collections were received from faculty members Robert M. Fano, Robert C. Seamans, and Richard C. Lord.

JAY K. LUCKER

Lowell Institute School

The Lowell Institute School (LIS) was established at MIT in 1903 to provide evening instruction in technical subjects for residents of the Boston area. Today the School continues this tradition by offering subjects in the areas of modern technology which are not readily available at other evening institutions. Entry-level courses require an adequate high school preparation, and the more advanced instruction is geared to the practicing technician who has an associate degree or equivalent experience.

The programs of study range from single subjects designed to broaden job skill levels to comprehensive study of new technological areas in preparation for employment in a new field. There is a strong emphasis on practical aspects and development of careful experimental technique combined with sufficient theory to provide an adequate foundation of understanding. Certificates are awarded to those who satisfactorily complete a course. In addition, students who complete a program of courses may earn a Certificate in Drafting Technology or a Certificate in Electronics Technology.

During 1983-84, LIS offered 36 different courses. The fields of instruction included analog and digital electronics including microprocessors through advanced applications; mechanical, electrical and architectural drafting; printed circuit board design; blueprint reading; machine tools; metal joining; scientific glassblowing; building maintenance; first level management; effective speaking; and computer programming. In addition, refresher courses were offered in mathematics to support both the drafting and electronics curricula.

New courses were introduced in home remodeling, computer aided drafting, advanced electrical/electronic drafting, advanced op-amp applications, and an introduction to calculus. In addition, computer aided design (CAD) in the areas of both printed circuit boards and electrical schematic diagrams was offered off campus by the generous donation by Racal-Redac of their CAD teaching facility in Westford. Another local business that assisted LIS in a new course offering was American Alarm & Communications in Arlington, who provided the necessary space and equipment to teach intrusion alarm technology.

LIS continued to offer courses in the intensive one-week daytime format for individuals working in industry. An advanced digital electronics course was conducted on campus for CBS Television Network technicians who had previously completed our basic digital electronics course.

LIS admitted a total of 1,150 students to its courses in 1983-84, 1,138 to the evening classes and 12 to the intensive daytime course. Of those enrolled, 77 percent successfully completed the certificate requirements. Among those who completed courses were 70 MIT employees and two regular MIT students. Fourteen students earned the Certificate in Drafting Technology, and 11 students the Certificate in Electronics Technology.

The past academic year has seen LIS expand its program of unique evening courses which no other Boston area school can match. The high percentage of students who successfully complete their courses indicates that both the subjects offered and the level of instruction are well matched to their needs.

BRUCE D. WEDLOCK

Mining and Mineral Resources Research Institute

The Mining and Mineral Resources Research Institute (MMRRI) of MIT has continued to utilize the resources available to support and encourage new initiatives at MIT in research and teaching activities that are related to mineral resources. Funds available this year have supported a total of six graduate students in the Departments of Civil Engineering, Mechanical Engineering, and Earth, Atmospheric, and Planetary Sciences. Funds were allocated for the purchase of several important items of equipment for the Resource Extraction, Materials and Energy, Reservoir, Geotechnical, Environmental, and Construction Engineering (REMERGENCE) Laboratory and for the Process/Chemical Metallurgy group in the Department of Materials Science and Engineering.

The Bureau of Mines opened competition among universities that participate in the MMRRI program for participation in the Generic Minerals Technology Center in Pyrometallurgy. MIT was accepted as a participant, and Professors Thomas B. King, Donald R. Sadoway, and John F. Elliott are to receive support for research programs in Chemical Metallurgy beginning in the summer of 1984. Through the MMRRI program, Professor Terry A. Ring also continues to receive support of research related to the respirable dusts in metal-mining operations. This support comes through the Generic Minerals Technology Center for Respirable Dusts of the Bureau of Mines. This year the Bureau of Mines has established a Generic Center for the study of problems related to respirable dusts in the mining industry. The participating institutions are the Pennsylvania State University, the University of West Virginia, the University of Minnesota, and the Massachusetts Institute of Technology. Our part of the program is to be a study of the nature of the fine particulates that constitute the respirable dusts in metal-mining operations. Professor Ring and Mr. John F. McCarthy, Research Scientist in the Energy Laboratory, are co-principal investigators for the MIT segment of the Generic Center.

Professor Elliott, Director of the MMRRI of MIT, was given again the Distinguished Professor Award by the American Iron and Steel Institute.

JOHN F. ELLIOTT

MIT/WHOI Joint Program in Oceanography and Oceanographic Engineering

Professor Arthur B. Baggeroer, who holds joint professorship in the Departments of Ocean Engineering and Electrical Engineering and Computer Science, succeeded Professor John G. Sclater as MIT Director of the Joint Program in Oceanography and Oceanographic Engineering with the Woods Hole Oceanographic Institution (WHOI) this past year. Professor Baggeroer was appointed on September 1, 1983, making him the first person outside the Department of Earth, Atmospheric, and Planetary Sciences to hold the position.

Professor Baggeroer's first major task as Director was to negotiate a new procedure for tuition allocation between MIT and WHOI with Dr. Charles Hollister, Dean of Graduate Studies at WHOI. Since the inception of the program in 1968, MIT has had a special arrangement with WHOI for splitting the tuition income of participating students. During the Fall of 1983, Professor Baggeroer and Dr. Hollister devised a new method whereby tuition will be allocated based on a simple measure of instructional costs. Actual percentage figures to be used will be calculated on an annual basis by the co-directors.

During 1983-84, the Joint Program graduated 11 students, all with doctoral degrees. Of these, there were four biological oceanographers, two chemical oceanographers, one physical oceanographer, one marine geologist, and three oceanographic engineers. Enrollment figures as of May 31, 1984 show 97 students in the program; our projected enrollment for September 1984 is 111 students registered throughout six MIT departments. Of these 111, 24 will be in oceanographic engineering, 19 in biological oceanography, 24 in marine geology and geophysics, 27 in physical oceanography, and 17 in chemical oceanography.

Although our applicant pool dropped to 114 for the 1984-85 academic year, we admitted 37 students to the program, 22 of whom accepted our offer of admission. One of our incoming students has received an ONR Fellowship and one of our continuing Joint Program students was an NSF Fellowship recipient this year.

In January 1984, an informal Visiting Committee of the WHOI Trustees was appointed to review the MIT/WHOI Joint Program. The committee met at MIT on April 19, 1984 and at WHOI on April 20, 1984 for discussions with deans, faculty, and students. They also met with members of the WHOI Directorate. Although a formal report has not yet been distributed, the dominant conclusion of the committee is that the Joint Program in Oceanography and Oceanographic Engineering is in "excellent overall health."

MARY ATHANIS

Northeast Radio Observatory Corporation

Haystack Observatory

The Northeast Radio Observatory Corporation (NEROC) is a consortium of 12 institutions* formed in 1967 to promote radio and radar astronomy research and facilities in the northeastern United States. NEROC receives financial support for its principal facility, MIT's Haystack Observatory, from the National Science Foundation (NSF), and project support from NSF, the National Aeronautics and Space Administration (NASA), the National Geodetic Survey (NGS), and the other Federal agencies, and it uses the administrative services of MIT in the conduct of its business. Observing proposals submitted by prospective users are considered by a review committee on the basis of scientific merit and suitability of the available instrumentation.

The main instrument at the Observatory, located at Westford, MA, is a 120-foot diameter paraboloidal antenna enclosed in a radome. It is heavily used by the astronomy community as a radio telescope with radiometers operating at 18-, 13-, 6-, 3.8-, 2.8-, 2-, 1.35-, and 0.7-cm wavelength. The Haystack telescope constitutes an important astronomical resource, particularly in the wavelength region 1.5-0.7 cm, which lies between the shortest wavelengths covered by most of the larger telescopes and the longest wavelengths at which the smaller, true millimeter-wave instruments are most profitably used. At 0.7 cm, the telescope has a beamwidth smaller than the 1-arc-minute resolution of the human eye.

In the past year, the telescope was used by approximately 86 investigators from over 30 different institutions, and 47 articles were published in scientific journals based upon this work. Approximately 16 percent of the telescope usage was by MIT faculty and their students.

A major highlight of the past year has been the approval by the NSF and the USAF to share in the cost of refurbishing and upgrading the 150-ft. radome that houses the Haystack antenna. During 1984 and 1985, about 700 eroded panels of the 900 total will be replaced with thinner, more durable material, and the corroded hardware in the structure will also be replaced. In addition to providing an improved shelter for the antenna, above 40 GHz major benefits will accrue in sensitivity due to the thinner panels and observations will improve following rainstorms due to the faster drying time of the radome.

A new maser amplifier receiver with about 200°K system temperature operating in the broad frequency range 36-46 GHz (0.7 cm wavelength) was installed on the antenna during the past year. It was used to detect silicon sulphide at 36 GHz in circumstellar gas clouds and HNCO at 44 GHz in Sagittarius A, and to study the $v=0, J=1 \rightarrow 0$ transition of SiO at 43 GHz in regions of young star formation.

Highlights of single antenna astronomy research in the past year in the 20-25 GHz band included the detection of NH_3 (1,1) absorption against the strong radio source Cass A, the detection of broad NH_3 (3,3) emission from the Galactic center, and the detection of very luminous H_2O maser emission from a distant (~20 Mpc) galaxy. In addition, the regions of star formation were studied using the inversion transitions of the NH_3 molecule. These transitions which are closely spaced in frequency and detectable using Haystack's high resolution digital correlation spectrometer, require widely differing conditions for excitation and allow molecular cloud parameters such as temperature and density, as well as dynamical information, to be obtained. Anomalies in the amplitudes of the hyperfine lines of the NH_3 molecule were also studied in galactic gas clouds. From these studies the state of excitation of the gas cloud could be assessed.

Very Long Baseline Interferometry (VLBI) research continued during the past year as a major activity at Haystack. In this technique, signals recorded from the same object simultaneously by several telescopes are brought together at a multi-station correlator to yield interferometer fringes. For studies of radio source structure or astrometry, VLBI attains resolution not available through any other means, optical or radio. Haystack is a keystone of the U. S. VLBI Network of antennas which perform VLBI observations six times each year, and provides coordination of the Network in the form of its Scheduler/Manager, currently a Haystack staff member. The U. S. Network and its counterpart in Europe use the Mk III recording system developed at Haystack for observing faint radio sources, and both employ the Haystack Mk III Processor for correlating the interferometer tapes. The benefits offered by Mk III recording - a fivefold increase in sensitivity over Mk II recording - have been extended to a larger and larger community of users as the Mk III system has matured and become an operational system much in demand. In the first five months of 1984, 27 astronomical programs utilized the Haystack correlator.

*Boston University, Brandeis University, Brown University, Dartmouth College, Harvard University, MIT, Polytechnic Institute of New York, Harvard-Smithsonian Astrophysical Observatory, State University of New York at Stony Brook, University of Massachusetts, University of New Hampshire, and Yale University.

Key accomplishments of these recent astronomical programs include the simultaneous observation of left- and right-circularly polarized radio emission from quasars. Cross-correlation of these signals from 3C345 allowed the synthesis of the electric and magnetic fields relative to that quasar's jet axis. Radio binary stars such as HR 1099 and HR 5110, long a subject of speculation regarding their radio flares, have now been imaged both during their quiescent state and during flares when they are found to expand. Their measured high brightness temperature indicates their emission process is through gyrosynchrotron radiation rather than thermal emission. Finally, the wider bandwidth of Mk III recording has allowed the measurement of absolute motion between a stationary nucleus and a moving component in a "superluminal" quasar, 3C 345. This last result has reliably validated the work from the past decade of a large group of investigators who measured internal, relative superluminal motions using other recording techniques but could only postulate which components were moving.

Successful VLBI experiments were conducted between Haystack and the Nobeyama, Japan telescope at 22 GHz resulting in a 1.5 nano-radian resolution hitherto unachieved. More recently, 1 nano-radian resolution was obtained using the Haystack correlator to process data collected with millimeter-wavelength (89 GHz) telescopes across a continental baseline.

In February 1984, the Haystack Observatory entered into a formal agreement with the National Radio Astronomy Observatory (NRAO) to design a major element of the Very Long Baseline Array (VLBA). The VLBA, to be constructed under NSF sponsorship, consists of a 10-element VLBI array of 25 meter telescopes covering the continental USA, Hawaii and Puerto Rico. Haystack staff will be responsible for the development of the data acquisition and playback system of the VLBA; this includes design and construction of a prototype of the digitization, alignment and high-density recording sub-systems. The VLBA represents a major new start in the NSF astronomy program and will provide VLBI scientists, including those at the Haystack Observatory, with a powerful high resolution astronomical instrument.

With support from NASA, Mk III techniques are being applied to measure baselines between a large number of sites which are of geophysical interest to NASA's Crustal Dynamics Program. Observatories such as Haystack and that at Onsala, Sweden are used to measure stability or motions between major plate systems and have shown a preliminary motion between the U. S. and Europe of 1.5 cm/year. Regional deformation in the western U. S. and Alaska-Pacific plate systems is being monitored by mobile VLBI systems which visit a large number of sites and are tied to a few fixed bases. The Haystack VLBI correlator is used to process all of these data, and has correlated two large ten-day observation sets so far in 1984. An intensive campaign involving sites from the Kwajalein Atoll, Marshall Islands, to Wetzell, FRG, is taking place in the summer of 1984 and represents the largest application of VLBI to geodetic purposes yet. A new faster correlator is being developed at Haystack to enhance the Mk III system processing capacity to handle the large load of data. A major highlight of our VLBI development program during the past year has been the successful completion and demonstration of a prototype high density recording system, capable of recording at least 20 Mbits per square inch (a factor of 10 higher than current systems), which will reduce the number of tapes utilized in VLBI experiments. Efforts are currently underway to correlate the high density recordings and to gain field experience with the new system. This development is also being considered for application to the VLBA design.

The 60-foot diameter Westford antenna, located one mile south of the 120-foot telescope, was operated as a dedicated VLBI station for the National Geodetic Survey (NGS). The POLARIS (Polar Analysis by Interferometric Surveying) Project measures changes in the absolute rotation of the earth by measuring UT1, and the changing point of intersection of the earth's axis and the crust, or polar motion. Along with stations at Ft. Davis, TX and Richmond, FL, and often with other telescopes in Europe, observations are made for 24 hours every five days to determine the earth's rotation parameters. The data are compared to those obtained by optical and satellite-tracking methods in the international MERIT campaign of intercomparison of techniques. VLBI measurement r.m.s. accuracy is about 0.3 msec in UT1 and 15 cm in the polar motion X-component, and currently represents the most accurate and reliable technique for measuring these quantities. In addition, during Spring 1984, daily, short observing sessions of 1 hour each are being made in order to determine Earth rotation parameter UT1 only. It is hoped that this will make the coupling between total atmospheric angular momentum and Earth rotation rate more understandable. The goal is to measure the times at which sudden changes in the Earth's rotation take place. In addition, these measurements are of practical importance in timekeeping, surveying, and navigation, as well as being of fundamental interest to earth science.

JOSEPH E. SALAH

Office of Minority Education

OVERVIEW

The 1983-1984 academic year marked the second year in which the Office of Minority Education (OME) had a full time Director, Dr. William D. McLaurin. Advice and direction to OME were provided on a regular basis by the OME Faculty Advisory Committee headed by Professor Frank S. Jones and including Professors James Bruce, Ernest Cravalho, Kenneth Manning, Arthur Mattuck, Margery Resnick and Associate Provost Frank E. Perkins. The year can best be characterized as one in which the Office expanded some programs, initiated some new efforts, and sought to better integrate itself within the general MIT community.

The expansion occurred in our pre-MIT programs Project Interphase (PI) and the Minority Introduction to Engineering (MITE). The new initiatives are a Sophomore Watch begun with David Wormley in Mechanical Engineering and offering Physics 8.01 during Independent Activities Period (IAP) for those students who dropped, failed or otherwise did not perform well in 8.01 during the fall semester. We have attempted to more actively involve faculty and administrative staff in the other programs run by OME. The Office was also much more active in several MIT community events including the First Annual Puerto Rican Festival, the Catalyst Black Student Union (BSU) Magazine, MIT R/O activities, the banquet honoring MIT astronaut Ronald McNair, the Second National Conference on Black Administrators at Predominantly White Colleges and Universities, and the Ambassador Program.

OME HIGHLIGHTS

Project Interphase

Following an extensive evaluation and final report, this year's seven week edition of Project Interphase included an expansion of the Physics component to include weekly Physics Labs headed by Professor David Frisch, a bit less structured academic time, more emphasis on study groups, better planning with the MIT Writing program, better recruitment to fill the 50 slots available (47 this year), and the employment of a much better qualified junior staff.

Minority Introduction to Engineering and Science (MITES)

The MITE program added a science emphasis and thus became MITES. The expanded curriculum now includes mathematics, biochemistry, mechanics, English, electronics, computer science, and three-week labs in design and chemistry. The length of the program was extended from three to six weeks with the number of students (who just completed their junior year in high school) increased from 43 to 56. Deans Gerald Wilson (Engineering) and John Deutch (Science) spearheaded a fundraising effort designed to elicit financial support from private corporations. Last year of the 43 MITE students attending this summer program, 28 applied to MIT; 22 got accepted, and 14 of those 22 will attend MIT this fall. MITES also established a corporate fellowship program in which MITES students become corporation fellows.

Sophomore Watch

This program is an extension to our early warning system in which sophomore students who for a wide variety of reasons had difficulty their freshman year received special help and counseling during the sophomore year. Begun this year with the Mechanical Engineering Department, the Office expects to expand the program to two or three additional departments next year.

Physics 8.01 During IAP

26 students were able to take advantage of the opportunity to take 8.01 during IAP 1984 in a concentrated study format pioneered by Professor John King. The Office provided the administrative support for this effort and worked with Alan Lazarus and the Undergraduate Physics Office to offer this educational option to students selecting this course. We hope that such an option might be available in other freshman core subjects.

MIT Activities

In an effort to better integrate minority students into the general MIT community, the Office worked with and supported a number of activities that might accomplish this mission. The First Annual Puerto Rican Festival educated the MIT community to the culture of its Puerto Rican students. The BSU's

Catalyst informs the MIT community about the many activities and accomplishments of its black students. Ronald McNair honored and educated the entire MIT community about his exploits in outer space. The Black Administrators Conference provided many insights about Predominantly White Universities to Black Administrators from around the country. Finally, the Ambassador Program sponsored by the National Society of Black Engineers is expanding its outreach program into the public schools of Boston and Cambridge to inspire disadvantaged students to pursue careers in engineering and science.

SUMMARY

One of the main purposes of the Office is to "close the gap" between the academic performances of minority and non-minority students. Through efforts to better support students, faculty, and staff, we intend to increase minority grade point averages and graduation rates while significantly lowering minority attrition. Our efforts are beginning to show some results. Freshman Watch fall 1983 was effective in significantly lowering the number of students failing from mid-semester to the end of the fall semester. The spring semester preliminary results show significant decrease in CAP warnings and required withdrawals among freshman students compared to spring 1983 results. On the other hand, the total number of students receiving higher marks in Physics 8.01 increased. We still have a long way to go, but with help from the entire MIT community, we can improve minority education at MIT.

DR. WILLIAM D. MCLAURIN

Operations Research Center

The Operations Research Center (ORC) was established in 1953 to provide educational and research opportunities for students and faculty interested in the interdisciplinary field of operations research. The academic staff of the ORC is drawn from many departments, including the Sloan School of Management, Electrical Engineering and Computer Science, Urban Studies and Planning, Aeronautics and Astronautics, Civil Engineering, Mechanical Engineering, Ocean Engineering, Mathematics, and Physics. The ORC is managed by two codirectors, Professors Richard C. Larson and Jeremy F. Shapiro, and a core of administrative staff. Approximately 35 graduate students were enrolled in the master's and doctoral degree programs, and 20 faculty and a number of visiting scientists were affiliated with the Center.

Faculty and students at the ORC were engaged in a broad range of activities during the past year. Research was directed at numerous topics in applied industrial operations research, network optimization, public sector applications, energy planning, mathematical programming, and computer graphics modeling. In this report, we discuss briefly each of these areas and provide information about the Center's educational programs.

RESEARCH ACTIVITIES

Mathematical Programming

ORC faculty continue their nationally recognized research in mathematical optimization subject to constraints. This active research area, which has come to be known as mathematical programming, has involved both theoretical and applied contributions.

With support of the Electric Power Research Institute, a stochastic programming model was developed for application to long-term planning problems faced by electric utilities. These models combine features of deterministic mathematical programming for optimally acquiring and allocating resources, with those of decision analysis for determining hedging strategies and contingency plans in the face of uncertainty. To reduce the immense storage and computational requirements of the exact formulation of such models, novel decomposition schemes were devised and implemented for breaking the long-term planning models into manageable components which can then be systematically reassembled. Success in this area has led to dissemination of research results among several electric utility companies that have expressed interest in implementing the approach.

Additional extensive work in the area of applying mathematical programming to the development of decision support systems and applications has occurred in such areas as energy planning in developing countries, vendor selection systems for large computer manufacturers, and scheduling systems for paper mills.

Another major research thrust in mathematical programming dealt with optimization of dynamic periodic systems. The concern was with (1) identifying the level of complexity needed to solve a problem; (2) developing and analyzing heuristic approaches for solving intrinsically difficult problems; and (3) developing efficient solution procedures for those problems that are solvable in an amount of computer time that grows no faster than a polynomial function of the size of the problem. The research in dynamic/periodic systems is motivated by applications in a number of contextual areas including transportation (e.g., airplane scheduling), work force scheduling (e.g., scheduling workers to periodically repeating shifts), and in inventory control (e.g., determining periodic ordering policies to satisfy product demands). The focus of this research has been to unify a set of previously disparate research areas by focusing on fundamental questions related to the intrinsic difficulty in solving periodic optimization problems. This research was supported by the National Science Foundation.

Under support from the Office of Naval Research, additional mathematical programming research focused on complex scheduling problems associated with naval "emergency scheduling problems," such as those that arise when a large number of ships must be moved from one area to another in a prespecified time window. Progress was made in developing effective heuristic procedures for solving these emergency scheduling problems, including interactive procedures and hierarchical decomposition techniques.

Substantial research progress was made in the theoretical understanding and development of mathematical programming. One such line of research focused on fixed point methods and combinatorial theory aimed at understanding, unifying, and extending the classical combinatorial results related to fixed point theory. Other thrusts in this area included optimization of algebraic systems, in which substantial progress on the "matroid parity" problems was achieved; the solvability of certain set containment problems related to polyhedra and linear programming; and the relationship between the linear programming simplex algorithm and network flow problems.

Network Optimization

Under National Science Foundation funding, ORC faculty and students continued studying a variety of basic research problems in network analysis and optimization. Included were network design problems, traffic equilibrium problems, large-scale location problems, and general linear activity equilibrium modeling. Since many problems in applications contain tens of thousands of network nodes and arcs, much of the focus of this research has been on the further development and enhancement of network optimization techniques that would allow the derivation of either exact or accurate approximate solutions to long-standing classical problems in network optimization. Substantial progress has been made in this area during the preceding year.

Public Sector Applications

Operations research applications in the public sector were developed by ORC faculty and students in the areas of criminal justice and urban services. Under a grant from the National Institute of Justice, research was completed on the development of mathematical models for analyzing the use of prison space. A statistical mathematical procedure was developed, entitled, "the optimal allocation of prison space." New criminal justice work was completed, studying the possible implementation of a criminal offender sentencing policy called "selective incapacitation," in which judges give stricter sentences to individuals considered to be most dangerous to the population at large. This research was undertaken with a data set from a cohort of Philadelphia males born in 1948 and followed through their eighteenth birthdays. In related work, projections were made on the need for prison space through the year 2020.

Under a new grant from the National Institute of Justice, work commenced on developing algorithms for computer aided dispatch systems for police departments. These systems help "911" call-takers and police radio dispatchers to quickly receive and process calls for police service from the public. The aim of the new research is to utilize the unique computational capabilities of the on-line digital computer to provide decision support to dispatchers and call-takers heretofore unavailable in a manual environment. The initial research focused on optimal queueing policies by priority of police call for service, and on accurate estimations of anticipated delay in police response given the current status of police cars in the field.

Under National Science Foundation funding, work continued on the development of procedures for locating one or more facilities in a stochastic or probabilistic environment. While the work is primarily theoretical, it is understood contextually for ambulance dispatch systems. The question is where to locate one or more ambulances on a transportation network in order to minimize the average ambulance response time, where response time is the sum of the queueing delay (due to all ambulances being simultaneously busy) and the travel time to the scene of the medical emergency. Substantial progress was made in understanding models having complex priority structures and in implementing the model in a high-resolution computer graphics workstation environment.

Applied research was undertaken to aid managers of certain paratransit systems. Such systems utilized a number of drivers and a fleet of vans to pick up elderly and handicapped individuals at predesignated times and locations and to deliver them to specified destinations, again within a prespecified time window. Building upon MIT's work on "dial-a-ride" systems, a set of computer algorithms was developed for implementing a model in a microprocessor environment, to assist planners and dispatchers of paratransit systems in designing schedules and routes for paratransit vehicles. The work was carried out in cooperation with the Transportation Systems Center of the U.S. Department of Transportation and the Kit Clark Senior House (KCSH) in Dorchester.

Computer Graphics

Operations research is a field that develops models and algorithms for solving complex decision problems. In the vast majority of operations research applications, the "end product" is a computer program designed to undertake complex computations in order to assist decision makers. In many ways the impact of operations research methods and models has been technologically bound -- bound by speed and storage limitations of modern digital computers. Until recently, the typical operations research implementation was carried out for large firms or organizations on large mainframe-type computer systems. However, with the remarkable and dramatic reduction in the cost of computation and with the proliferation of personal and more advanced workstation type computers, it is the belief of ORC faculty and staff that OR procedures can now be implemented on a local level, often in very small organizations. In addition, new workstation computer nodes will provide a model-creation environment for operations researchers previously unavailable, an environment which can graphically display in high resolution the consequences of alternative procedures for attempting to solve a problem. For these reasons, the ORC has identified as a priority initiative the implementation of state-of-the-art high-resolution graphics computer workstations within the ORC for use by students, faculty, and staff. During the academic year 1983-84, the ORC successfully secured funding from the Office of Naval Research to implement such a system. The system is anticipated to be fully operational by October 1, 1984.

EDUCATIONAL PROGRAMS AND ACTIVITIES

The Operations Research Center offers two interdepartmental graduate degree programs, one leading to a PhD degree in Operations Research and the second leading to a master's degree. During 1983-84, 35 students were enrolled in these programs -- 24 PhD candidates and 11 SM candidates. Six master's degrees and three PhD degrees in Operations Research were conferred during 1983-84, and six more PhDs and one master's degree will be completed during the summer of 1984.

Students in the Operations Research Center represent a variety of backgrounds and countries. Approximately 50 percent of ORC students are from foreign countries; approximately 20 percent of the students are women. ORC students have attained considerable scholastic achievement, as evidenced by the number of fellowship and scholarship holders among them: several were awarded scholarships by their respective governments; one student was awarded a National Institute of Justice Research Fellowship. In addition, the Operations Research Center is proud to have two of its PhD students awarded the Goodwin Medal, which is MIT's highest award to a graduate student, recognizing conspicuously effective teaching. Several other students received departmental teaching awards.

The Operations Research Center regularly offers professional courses during the Summer Session. In the summer of 1983, three such programs were offered -- "Resource Management: A New Approach to Corporate Planning"; "Decision Analysis: Basic Concepts and Applications"; and "Decision Analysis with Multiple Objectives: Concepts and Applications."

The ORC Seminar Series is considered to be an important contribution to the educational process. The series is organized by two graduate student coordinators, and prominent OR professionals from business and industry as well as from academia are invited. Last year we were fortunate to have among the speakers Professor Michel Balinski from the Ecole Polytechnique in Paris, Professor Madfred Padberg from New York University, and Professor Yu-Chi Ho from Harvard University. Among those speakers representing industry, Dr. Clifford Orloff, President of Airport Connections, and Dr. Jer my Bloom, Corporate Planning Analyst for GPU Service, made presentations.

RICHARD C. LARSON
JEREMY F. SHAPIRO

Project Athena

INTRODUCTION

Project Athena is a five year program to explore the innovative use of computer-based learning tools in university educational programs. The project's primary objective is to improve the education MIT provides to its undergraduate and graduate students. Athena will combine \$50 million in hardware, software, maintenance, and staff from Digital Equipment Corporation and IBM with \$20 million to be raised by MIT to achieve this objective: Digital equipment will be used principally in the School of Engineering, and IBM equipment will be used by the rest of the Institute.

Athena also has some important secondary objectives including:

- to establish a base of experience in using computers in different ways that is sufficient for MIT to make well-informed decisions about educational computing in the future;
- to create a computational environment that can accommodate equipment made by different computer manufacturers without imposing large costs on users or developers of educational software;
- to encourage the sharing of ideas, program code, data, and experience across the entire MIT community;
- to develop computer-based learning tools which can be used by other universities.

Attaining these goals has produced a design for Athena that has a number of distinctive characteristics. First, in order to affect the curriculum fundamentally, computational resources must be made similar to other utility-like services provided on campus, i.e., they must be ubiquitous.

The size of the potential user community made use of a single, large mainframe infeasible. Instead, a system of distributed microcomputers was selected, each capable of supporting most of a single user's computational needs.

It was decided that simply providing a campus-wide system was likely to be insufficient to yield a fundamental change in instructional approaches. We also chose to provide faculty with the opportunity to obtain funding for educational projects that used Athena. These funds are intended to support faculty salaries, student assistants, and other expenses related to the projects. This internal grant program is administered by faculty/student committees whose membership reflects the diversity of the MIT community. We anticipate spending \$10-\$12 million over five years for curriculum development.

The desire to create an environment that encouraged sharing of information and expensive services such as graphics output and large data bases led to the design of an integrated, campus-wide network of computers, each of which could freely communicate with the others at extremely high speeds. This network will be implemented in stages over the course of the project.

The desire for a system that was as manufacturer-independent as possible and that allowed users to share programs easily led to the concept of coherence. Coherence has two distinct aspects. First, users of the system should have one or more powerful, easy-to-learn modes of interaction with the system which are as invariant as possible over different types of hardware. These interfaces should be available at all levels, including the operating system and applications programs created by faculty for student use. Second, one program should be able to obtain services from and provide services to other programs, regardless of the computer languages in which they were written and the machines on which they are run. For example, if one faculty member writes a large numerical package in Fortran, a user of the Athena system should be able to draw upon that package (as a "service") even if he or she is working in Lisp on an entirely different computer.

Finally, it should be stressed that Project Athena is an experiment. We envision exploring a very wide range of uses of computers in education, some which will prove effective and others which may well fail. It is a clear part of Athena's mission to encourage innovative concepts with the goal of learning how computation can be effectively used in the educational process.

The remainder of this annual report is divided into five sections:

- a review of the status of faculty/student projects under Athena

- a description of the Athena staff
- a description of Athena working groups
- a summary of the software facilities we have now and will provide in the near future
- a report on the equipment we now have operational and will be installing in the next six months

For further information on Project Athena, including its genesis, overall funding, and current curriculum development programs, see An Introduction to Project Athena, a booklet published in Fall, 1983, and Faculty/Student Projects, a booklet published in Spring 1984. Copies are available from Project Athena in Building E40 at MIT.

FACULTY/STUDENT PROJECTS

The Athena Executive Committee allocated a total of \$1.3 million for this year to be used to fund faculty projects. The annual funding level will increase significantly in future years with the actual annual levels dependent on the outcome of on-going fund raising activities. While the final budgets are subject to revision, we plan to commit approximately \$2.5 million per year for each of the next four years.

In February 1984 the Athena Resource Allocation Committees completed the first of this year's three rounds of solicitations, proposals, and grants for Athena curriculum development projects. This first round generated a large number of proposals for relatively limited resources. Seventy-six proposals were submitted to the Resource Allocation Committees. These proposals requested a total of about \$2.5 million.

In this first round, approximately \$442,800 was actually granted to faculty for Athena projects. These funds were allocated to 16 projects in the School of Engineering, four projects in the School of Humanities and Social Science, eight projects in the School of Architecture and Planning, six projects in the School of Science, and one project from the Office of the Dean for Student Affairs. In addition to these 35 funded projects, a number of additional projects are planning to use Athena facilities but without Athena funding. A detailed booklet describing these projects is now available upon request from Project Athena.

March 30 was the deadline for submission of the next round of proposals. Forty-two proposals requesting a total of \$1,677,000 were received in this round. Eighteen of these were approved for funding at a total level of \$526,000.

Supporting these faculty/student projects is the primary responsibility of two applications consultants on the Athena staff. These two individuals are available as technical consultants to Athena projects as well as to faculty who are considering undertaking an Athena project. In addition to providing technical assistance to faculty projects these applications consultants also exchange information among projects. We have also assigned other Athena staff to specific projects requiring their specialized expertise.

In addition, as another method of facilitating communication among faculty who are working on projects, we expect to conduct a series of symposia in which the progress of various projects and the evaluation of their results can be presented and discussed.

PROJECT ATHENA'S STAFF

The staff of Project Athena has grown rapidly in the past year. At this point, there are 26 people affiliated with the project. This group includes employees of MIT, Digital Equipment Corporation, IBM, Bolt Beranek and Newman, and Codex. This entire staff resides in Building E40 at the corner of Amherst and Wadsworth Streets. When all the staff of the project are finally hired, there will be approximately 35 people on the staff.

The staff is organized into five distinct working units. These groups are as follows:

User Services - This group includes staff working on user and technical documentation, consultants to the faculty projects, educational specialists developing various courses about the Athena system, student consultants who answer users' questions in the Athena computer clusters, and administrative support staff. most of the contact faculty and students will have with Athena is with this group.

Operations - This group has responsibility for all installation and operations of Athena equipment. This includes coordination with MIT physical plant and field service personnel of Digital and IBM, system backup, bug reporting, systems release engineering, coordination of equipment maintenance and supplies, and scheduling equipment delivery and installation.

Software Development - This group has responsibility for design, coding, testing, and documentation of software essential to making Athena an integrated computer network. Work within this group is divided into specific projects that will vary widely over time. Current projects include: development of a data base management system for user registration, graphics and windowing facilities, the ability to use files on remote machines without special user protocols, and the development of a "name server" that will allow for identification of owners of remote files and electronic mail delivery across the entire system.

Advanced Research and Development - This group has responsibility for the design of what has been called the "coherence technology." This includes both the design and prototyping of new user interface systems and the development of methods for calling procedures written in other languages that might be on remote machines.

Networking - This last group is staffed primarily from a grant of personnel from the Codex Corporation, a subsidiary of Motorola. Because this group has responsibility for networking all computational facilities on campus, it reports directly to Prof. James D. Bruce, Director of Information Systems at MIT. They are housed in E40 and now work primarily with the rest of the Athena staff.

ATHENA WORKING GROUPS

In addition to the staff and committees, Project Athena is using working groups composed of faculty, students, and staff. Working groups are formed on an ad hoc basis by the Director of Project Athena, to help resolve specific, user-oriented problems, and to serve as points of contact between staff and the community in specific areas. An Athena staff member is responsible for the activities of each working group.

We have formed or are in the process of forming working groups in several areas. In the initial round of faculty proposals, there were several topics--graphics, data base management, real-time data acquisition--that were important components of a number of proposals submitted by the faculty for funding under Project Athena. These vital, generic areas require advice from the MIT community. They are representative of issues that will benefit from the formation of working groups.

The list of working groups we plan to form is still evolving. The current list is given below:

| | |
|----------------------------|-------------------------------|
| Graphics/Window Management | The Electronic Classroom |
| Real Time Data Acquisition | Interactive Videodisk Systems |
| Data Base Software | |
| Management Software | Athena Archives |
| Programming Languages | Athena Security & Privacy |
| MACSYMA | Athena & Social Environment |
| Statistics & Econometrics | Student Participation |
| Numerical Analysis | |
| User Documentation | |
| Athena Courses | |
| Seminars/Conferences | |

ATHENA SOFTWARE

Project Athena's operating system is UNIX, originally developed at Bell Laboratories. In particular, Athena runs the 4.2 BSD UNIX from the University of California at Berkeley.

Although sometimes frustratingly cryptic to first-time users, UNIX has gained wide popularity not only for the power of its system concepts and tools, but for the open, creative, sharing community environment it seems to foster among users on a single machine and across networked systems.

The Athena staff will be developing additional system software to provide capabilities that we feel are essential for Project Athena, such as the ability for students in a large class to work from a number of different Athena machines while sharing information easily. Other software tools and applications, such as spreadsheets or graphics packages, will be acquired from outside or developed by Athena funded projects as necessary. In most of these areas we have formed working groups to help us determine an appropriate approach. Examples of these software tools and application areas are discussed below.

Emacs is the supported Athena text editor for editing both text and programs. We have licensed Emacs from Computer Corporation of America (CCA). The decision to support this editor was due primarily to the large Emacs user community at MIT. Emacs is currently available on all the Athena VAX 11/750s.

In the area of numerical analysis software, Athena has licensed the Numerical Algorithms Group (NAG) library package of numerical routines. We will be forming a working group to look at the other requirements in this area.

A graphics working group has been formed to study what Athena should do in the area of graphics software. As a provisional solution to the graphics software problem Athena is supporting the Penplot package developed at MIT's Joint Computer Facility. Penplot is a vector graphics package that can operate at either a low level (draw a line) or high level (make a 2-dimensional graph) of abstraction. The port of Penplot from the VMS to UNIX environment is completed. Penplot works on all the available Digital graphics terminals. Penplot can be called from Fortran and from C. We are now finalizing arrangements to deploy a more complete, interactive graphics development package called BLOX.

There is currently no supported data base management system available under Athena. The staff evaluated the version of the Ingres relational data base system that comes with 4.2 UNIX and concluded it was not robust enough to be released for serious user applications. We hope to have a long-term approach as well as software available for data base management by September.

For document production, Athena currently supports the Scribe formatter licensed from Unilogic. Scribe provides text formatting facilities such as automatic pagination with page numbers, headers and footers, text justification, hyphenation, and indexing. Improved support for mathematical equation layout is due soon. We are now in the process of evaluating more sophisticated packages that fully exploit high resolution, bit-mapped graphics workstations to display the formatted text as it will be printed out.

MACSYMA, the symbolic manipulation software that was originally developed at MIT, is currently available under Athena.

Athena supports the mh (Mail Handler) electronic mail facility that makes it possible to send mail to other users across the Athena network. It is also possible to send and receive mail from other machines on the MIT Chaosnet. Athena users can also send electronic mail outside MIT.

Athena currently supports four languages: C, Lisp, Fortran, and Pascal. One Lisp compiler, Franz Lisp, is currently available. We are in the process of evaluating alternate Lisp compilers for long term use.

ATHENA FACILITIES

As of mid-June 1984 Project Athena has sufficient facilities so that any faculty member who wants an Athena computer account can get one.

Project Athena will not be able to provide accounts to all students by September 1, 1984, as originally targeted. We will begin to phase in student use of Athena in significant numbers starting in September 1984. The first group will be students taking courses that use Athena resources granted through either of the Resource Allocation Committees.

There are currently four operating Athena clusters containing Digital equipment for use by other than the Athena staff in buildings 1, 11, 38, and E40. A fifth cluster is scheduled to open in Summer 1984 in building 66. Each cluster has a work area, a machine room, and possibly a separate room housing the printers. The following chart summarizes the current plan for Athena facilities containing Digital equipment for Phase I of the project.

| <u>Location</u> | <u>Number of VAX 11/750s</u> | <u>Number of Workstations</u> | <u>Status</u> |
|-----------------|------------------------------|-------------------------------|-----------------|
| Building 11 | 5 | 20 | complete |
| Building 1 | 9 | 30 | complete |
| E40 | 6 | ~ 35 for staff | complete |
| Building 38 | 5 | 16 | complete |
| Building 66 | 7 | 36 | in construction |
| Building 4 | 5 | 20 | not yet started |
| Building 37 | 9 | ~40 | not yet started |
| Student Center | 6 | ~30 | in design |

We expect to have an initial set of dial-up ports and telephone lines for general use on Athena systems available in July. Faculty who wish to access Athena from terminals in their offices or at home will have to provide both the terminal and the modem. Athena will provide the dial-up ports and telephone lines to the Athena clusters.

Seventy IBM PC/XTs running PC-DOS have been allocated for acculturation purposes to departments in the schools of Architecture and Planning, Humanities and Social Science, and Science; ESG; the Statistics Center; and the Office of the Dean for Student Affairs. The purpose of these initial machines, which were distributed in April, is to permit users to become acquainted with personal computers and do preliminary software development and testing.

An IBM workstation that is fully functional, Athena-compatible, and runs the 4.2 BSD UNIX operating system is not yet available. In the meantime, we have provided access to the Digital VAX clusters for all curriculum development projects approved by the Resource Allocation Committees until IBM workstations can be made available.

In order to make access to UNIX more convenient for students and faculty outside the School of Engineering, we will make some 80 IBM PC/XTs available as terminals to Digital VAXs at the beginning of the 1984-1985 Academic Year. These 80 PC/XTs will be located in approximately seven areas spanning the campus.

The Sloan School of Management is also receiving a grant of hardware and software from IBM. This grant consists primarily of IBM PCs and PC/XTs, and a 4341 mainframe, but also includes five Athena compatible workstations. The first shipments of this equipment have arrived, and work on revising the School's decision support systems core curriculum is now underway. The remaining 50 PCs will be used for development of curriculum by Sloan School faculty. These will be networked in early 1985.

The above plans represent only a small fraction of the equipment Athena will ultimately install. Over the next five years, approximately 900 IBM workstations and 1600 Digital workstations will be placed in classrooms, living groups, laboratories, and other areas around the Institute. Future reports will describe specific plans for the deployment of this equipment.

STEVEN R. LERMAN

Project STILE

Project STILE (Student-Teacher Interactive Learning Environment), drawing from the experience of its staff with the MIT/Wellesley Upward Bound Program and based on Robert Rosenthal's pioneering research on the self-fulfilling prophecy, is an in-service human development program for teachers, parents, and students. The Project was founded in 1977 by MIT staff and Cambridge public school teachers, parents, and students under the auspices of the Massachusetts Department of Education Title IV-C funding for innovative programs. The major premise of the Project is that school performance can be dramatically improved by helping teachers develop skills to create more interactive classroom environments for their students and by looking to parents and the community as educational resources.

The classroom approach is based on an observation and feedback system which helps teachers to effectively communicate high expectations for all their students. Parents, trained in STILE techniques, assist in the process by observing and providing teachers with feedback. Students are trained as participant observers in the classroom and use this unique position as an opportunity to provide feedback to teachers. The optimum objective is an ongoing three-way interaction among teachers, parents, and students.

Project STILE was validated as an exemplary educational program by the Massachusetts Department of Education in 1979 and has been disseminated to a number of Massachusetts communities including Belmont, Chelmsford, Dorchester, Hamilton/Wenham, Nantucket, and Somerville. In addition, the Project has worked with tutors in the Education Division of the Massachusetts Department of Correction, the Boston School Improvement Program, and Arlington Cable T.V. which videotaped a three-session parent workshop.

JOHN P. TERRY

ROTC Programs

The Reserve Officer Training Corps (ROTC) programs at MIT continue to be solid and very popular educational programs for our students. They provide considerable and substantive opportunities for individual growth, leadership, development, and financial support. The Army and Navy units held constant their enrollment figures for 1983-84, while the Air Force experienced a slight increase (1.9%) over the previous year.

Students from neighboring universities have participated in MIT's ROTC programs in record numbers, 152 students out of 524 (29%). The Army ROTC unit has had the largest enrollment of non-MIT students (42%) while the Navy (29%) and Air Force (25%) have had fewer cross-registered students. Out of the three schools that we have cross-enrollment arrangements with, Harvard University has the largest number of students enrolled in our ROTC programs with 119 students (23%), followed by Tufts University with 54 students (10%), and Wellesley with 16 students (3%). Having students from Harvard, Tufts, and Wellesley has helped the MIT ROTC units maintain strong and viable numbers, as well as add to the intellectual diversity of the corps.

Enrollment in the three ROTC programs at MIT in the fall of 1983 was as follows:

| <u>SERVICE</u> | <u>YEAR</u> | I | II | III | IV | <u>TOTALS</u> |
|----------------|-------------|-----------|-----------|-----------|-----------|----------------|
| Army | | 27 | 21 | 15 | 18 | 81* |
| Navy | | 69 | 60 | 23 | 23 | 175** |
| Air Force | | <u>97</u> | <u>73</u> | <u>53</u> | <u>45</u> | <u>268</u> *** |
| | TOTALS | 193 | 154 | 91 | 86 | 524 |

* Includes 34 students cross-enrolled from Harvard University (18), Tufts University (9), and Wellesley College (7).

** Includes 50 students cross-enrolled from Harvard University (33), Tufts University (15), and Wellesley College (2).

*** Includes 68 students cross-enrolled from Harvard University (31), Tufts University (30), and Wellesley College (7).

Seventy-three seniors received commissions during the year with the following distribution: Air Force (39), Army (18), and Navy (16).

The MIT Planning Office, upon request from Professor Frank Perkins, prepared an institutional research report on the history and current status of the cross-registration of students from neighboring institutions into the MIT ROTC programs. The report reviewed the number of cross-enrolled cadets, the number of military scholarships received, and the amount of financial aid those scholarships save participating schools. Estimates were provided in the report concerning the cost to the Institute for maintaining the cross-enrollment programs and suggestions were made for ways to improve those programs so that they might better serve the MIT community.

We are most appreciative of the assistance provided by the MIT planning office in the persons of Robert Kaynor, Stacey Ellender, and Robert Simha in researching and writing the ROTC cross-registration report. This document has been very helpful in providing baseline data for discussing equitable ways of having the neighboring institutions share in the costs of providing ROTC services to their students through cross-registration arrangements with MIT. Such discussions are now underway with Harvard, Tufts, and Wellesley.

Several outstanding service activities punctuated a very successful year for the MIT ROTC units, such as the Annual Tri-Service Awards Banquet, the MIT Military Ball, Field Day Events, and the Annual Tri-Service Pass-in-Review Parade.

The ROTC Faculty Advisory Committee, under the chairmanship of Professor David K. Roynance, continued to monitor the ROTC program and to evaluate prospective military ROTC instructors.

Captain David V. Burke, Jr., Detachment Commander of the Navy ROTC and Colonel Joel S. Hetland, Detachment Commander of the Air Force ROTC, both completed their third and final year of service with the MIT ROTC units. Captain Burke and Colonel Hetland have provided exceptional leadership and direction for the Navy and Air Force service units, respectively, and they will be sorely missed by students and staff alike. We wish them well in their new assignments. The third detachment commander, Lieutenant Colonel James P. Hassett (Army) and three other members of his eight member staff have completed their first year of service at MIT and will be returning for the next academic year.

JOHN B. TURNER

Sea Grant College Program

Sea Grant is a national program created by Congress two decades ago to promote greater use and prudent management of ocean and coastal resources. Like its predecessor, Land Grant, the program encourages government, university and industry cooperation. A federal appropriation provides a basic level of funding, with the monies distributed through grants by the National Office of Sea Grant to 31 university-based programs. Each grant requires that matching funds be raised from non-federal sources, including industry, private foundations, state and local governments, and universities. By insisting that the federal funds be supplemented by support from others, authors of the Sea Grant Act hoped to attract the participation and commitment of those who would make use of the knowledge and technology generated by the program.

At MIT last year 31 faculty from 6 departments participated in Sea Grant research. The National Sea Grant Program contributed \$1,650,000 which was matched by \$1,300,000 from industry, local and state governments and MIT. MIT Sea Grant also received \$194,000 in research support from a number of other federal agencies.

RESEARCH

MIT Sea Grant's research during the past year focused on four major areas, each reflecting a key facet of coastal and offshore resource development and management. The areas included offshore facilities; unmanned, underwater work vehicles; coastal processes; and living resource development.

Offshore facilities research has evolved with the changing needs of the oil and gas industries. As they have moved further offshore and into more hostile environments, new data and design procedures have been required. The impact of severe wave and sea conditions on the behavior of offshore structures is an area of critical interest. Last year faculty and students in the Ocean and Civil Engineering departments undertook two studies that will improve modeling under extreme wave conditions and predict the local response of marine structures under extreme loads. A research group in the Constructed Facilities Division of the Department of Civil Engineering completed a procedure for analyzing offshore geotechnical risk. The procedure, which is being made available in a comprehensive users manual, could help industry save millions of dollars. In a related project, a consortium of five petroleum companies provided support for research that is combining data gathered by the MIT geotechnical team with that collected by industry to validate and improve the predictive capabilities of an MIT theoretical soils model. Because the behavior of mooring systems and marine risers seriously affect the safety, efficiency, and reliability of most offshore platforms, especially those designed for deep water operations, the offshore industry has recommended research in this area. Based on earlier MIT Sea Grant studies, faculty and students in the Department of Ocean Engineering continue to work to provide more complete understanding of the dynamic behavior of cables and risers. Industry, which is working closely with the researchers, is contributing about half of the funding for the work.

Robots will play an important future role in building, monitoring and repairing offshore structures and pipelines. To help further research in this area, last year Sea Grant obtained a long-term industry loan of an unmanned, underwater vehicle to be used by faculty and students in the Ocean Engineering and Mechanical Engineering departments to field test laboratory concepts. MIT's unmanned, underwater vehicle program was initiated in 1976. Since then, it has won national attention and respect for work in supervisory control, a concept that allows a human on the ocean surface to instruct and supervise a "robot" working on the ocean floor. In addition to offshore applications, this research has important potential applications for gathering scientific data that will be helpful in making decisions on fisheries management and offshore waste disposal.

One of the first underwater tests for the new experimental vehicle, named Sea Grant I, will involve a stud welding gun. The gun has been developed at MIT to perform strong reliable welds in wet conditions. Over the last year, engineers in the Department of Ocean Engineering have changed the gun to conform to recommendations made by underwater equipment manufacturers, marine contractors, and commercial divers. The advice was given by an Alfred P. Sloan School marketing class which Sea Grant enlisted to scrutinize potential applications, suggest manufacturing options, and recommend changes for improving the gun's versatility and operation.

Coastal process research, including hydrodynamics, has received increasing Program emphasis in the past few years. A new computational scheme has been refined to help coastal zone planners find generic

solutions for improving circulation in small, enclosed areas. Faculty from the Department of Civil Engineering carried out a joint effort with the MIT Energy Laboratory Electric Utilities Program to create a model that will give New England communities an inexpensive, accurate way of assessing the impact of proposed harbor development. Another model for wind, waves and currents, when completed, is expected to save millions of dollars in marine operations and in the design of breakwaters, erosion protection measures, as well as in submarine pipeline and offshore structures.

In living resource utilization, MIT has traditionally concentrated on fishing gear and food processing technologies. Those efforts are being broadened to take advantage of advances in genetic engineering and biotechnology. Research in the Department of Food Science and Nutrition in the past year has shown that fish wastes contain large amounts of heparin, an anticoagulant that is widely used in surgical procedures. Heparin derived from fish, rather than cows and pigs, could offer unique biological properties that increase potency and decrease toxic side effects. In addition, for the fisherman a new profitable market would be open for thousands of tons of wastes which are currently discarded. The development of a matrix fabricated from chitosan, a polymer derived from crab wastes, is also being carried out in the Department of Food Science and Nutrition. The matrix, which can immobilize cells, has promising potential for bioproduction and fermentation processes.

In all four research areas, Sea Grant has continued its practice of working closely with the people in the marine community who will make use of the results. To facilitate this cooperation, last year the Program established a Marine Center to enlist government and industry advice on future research directions and to ensure that research results are effectively transferred to those who can put them to work.

ADVISORY SERVICES

The Marine Industry Advisory Service established the first collegium at MIT. It remains one of the largest and most active groups fostering industry-Institute cooperation. Last year, members attended workshops to discuss a strategic and tactical model for oil spill response, the MIT underwater vehicle program, marine corrosion and biofouling, and hydrodynamic modeling in nearshore and coastal environments. In addition to the workshops, other services provided by the Collegium include introducing members to faculty who share specific technical interests, providing research reports, and obtaining financial and in-kind support for MIT researchers.

During the past year another advisory service component, the Massachusetts Marine Liaison Service (MMLS), made arrangements for a small New England company to take over a machine which students in the Department of Mechanical Engineering had designed to skin the abundant dogfish shark. A faculty member will continue to work with the company to get the prototype machine into full operation on an assembly line basis. For the company and consumers the result will be a new food product from a fish that is abundant and underutilized.

The Marine Liaison Service has also arranged a contract and working agreement with the Naval Ship Research Development Center in Bethesda, Maryland to use the wide towing basin and the circulating water channel at the David Taylor Model Basin for advanced fishing gear research. Faculty and students from MIT and other universities, as well as gear manufacturers, will now have access to a large, sophisticated facility in the US. Previously, researchers had to travel to Europe for comparable laboratory tests.

Through MMLS, Sea Grant continued interactions with the Commonwealth of Massachusetts. The two once again jointly supported an education program for professional fishermen at the Massachusetts Maritime Academy. In its eighth year, the program offers classes on topics ranging from electronics to survival techniques to management methods.

Thirty-four reports were added to the Sea Grant report series through the the Communications Service. The new publications are housed with over 200 other MIT Sea Grant Reports in the Marine Resource Information Center. This small reference facility helps the MIT community and the public gain easy access to the Program's past and current research and to marine-related information from the entire Sea Grant network of 31 institutions. The Program's newsletter, the MIT Sea Grant Quarterly Report, and the directory of Marine-Related Research at MIT, prepared by the Center's information specialist, offer a complete look at the full range of ocean and coastal research at the Institute.

EDUCATION

In 1982, the great potential of biotechnology in the marine sciences was discussed at the annual Sea Grant Lecture and Seminar, an educational forum established over ten years ago at MIT. This past

spring a follow-up Sea Grant Lecture and Seminar, hosted by the Program's education staff, focused on applications of biotechnology for marine polysaccharides, a family of polymers that includes heparin and chitin. One hundred representatives from industry and university laboratories gathered at MIT to explore scientific advances, marketing issues, and government regulations associated with using marine polysaccharides to manufacture pharmaceuticals, foods, animal feeds and to control some marine pollution.

Sea Grant's educational efforts take many forms, including conferences such as the one described above, courses and seminars for marine professionals, support for UROP students, textbooks and classes for undergraduates. The Program's education director has also worked with MIT faculty and a group of public school educators to develop a series of teaching modules for elementary school children. The modules use water to introduce youngsters to basic concepts in biology, physics, chemistry and math. Completion of the modules in the next year will offer children in grades K-12 the opportunity to explore the world of mathematics and science through insights into the principles of distillation, thermal properties, chromatography, the kinetics and mechanisms of solvent extraction.

PROGRAM MANAGEMENT

The Program Director is Professor Chryssostomos Chryssostomidis, Professor in the Department of Ocean Engineering; Associate Research Directors are Anthony J. Sinskey, Professor in the Department of Nutrition and Food Science, and Keith D. Stolzenbach, Associate Professor in the Department of Civil Engineering. E.R. Pariser is the Associate Director for Education and Training. Norman Doelling is Executive Officer and the Manager of the Marine Industry Advisory Service Collegium. Arthur B. Clifton manages the Massachusetts Marine Liaison Service, Elizabeth T. Harding is the Manager of the Communications Information Service, and Lawrence W. McKinnon is the Administrative Officer.

Sea Grant administers the Doherty Professorship endowed by the Henry L. and Grace Doherty Foundation for untenured faculty at the Institute. In the spring of 1984, Harold Hemond, Assistant Professor in the Department of Civil Engineering, and Dick K. Yue, Assistant Professor in the Department of Ocean Engineering, were named as the recipients of the chair. Hauke Kite-Powell, an undergraduate in the Department of Ocean Engineering, received the Dean A. Horn Award, a grant established to honor the former Director of the MIT Sea Grant Program.

CHRYSSOSTOMOS CHRYSSOSTOMIDIS

Summer Session

Special Programs

The Summer Session Office administers an extensive series of one- and two-week special programs for professional men and women who wish to keep pace with developments in their fields. This activity has prospered each summer since its initiation in 1950.

The total registration of 1,426 in the 1982 program was a decrease in the registrations of 1,893 in 1980 and 1,887 in 1981.

Noteworthy trends in recent years are the increasing numbers of women registrants and of applications from Mexico.

Regular Subjects

Graduate students comprise 80 percent of the student body in summer. The 1982 registration of 2,707 students was an increase from the 2,364 in 1981.

FREDERICK J. MC GARRY

Technology Adaptation Program

The Technology Adaptation Program's (TAP) primary objective is to provide a focus at MIT for research and education related to the role of science and technology in the socioeconomic growth of developing countries. The multidisciplinary program is a mechanism to bring faculty and students at MIT together with faculty and staff in foreign universities, research institutions, and government organizations. Its focus is to

- promote an awareness of the relationship between science, technology, and development on the part of faculty and students at MIT;
- provide a focal point for the activities of faculty, students, and visiting scholars interested in the field of technology and development;
- assist the faculty, students, and staff of the collaborating institutions in other countries to develop research and academic interests consistent with their national needs;
- serve as a contact for interested organizations outside MIT (government, academic, private sector) to access the Institute's resources and its knowledge of developing countries--particularly of their socioeconomic and technological problems;
- explore opportunities to undertake cooperative investigations with government, academic, or private organizations and institutions.

The program carries out its objective through research, academic programs, and contacts with international and national organizations that are concerned with, or have an interest in, broad areas of technology and development.

The TAP's experience has been that through cooperation among institutions in developed and developing economies, science and technology can be put to more productive use. As a result of such cooperation, both developing and developed countries can reach a better understanding of their own scientific and technological needs.

ORGANIZATION

The TAP is organized according to the following principles:

- 1) The Program relates to those research activities for which there exists faculty support and faculty willingness to participate. The Program does not undertake research projects which require large-scale non-faculty staffing. The research activities are supervised and conducted by faculty members, and are administered through their respective home departments.
- 2) The Program committees are composed of MIT faculty members and the Program Director (who is also a faculty member), thus maintaining academic quality control not only in the conduct of research and educational obligations, but also in the selection of topics for research and the institutions with which the program develops educational ties.
- 3) The Program's activities are carefully scrutinized by appropriate Institute committees such as the Committee on International Institutional Commitments. The Institute is consulted in the early stages of negotiation on all potential sources of funding, including public and private sources both in the US and abroad.

The TAP is organized with the following basic components:

- 1) The Program Director, Professor Fred Moavenzadeh of the Department of Civil Engineering, is responsible for the coordination of all resources utilized for the program.
- 2) The TAP Policy Committee is chaired by Professor Nazli Choucri of the Department of Political Science (who is also Associate Director of the Program). Members are Professors Moavenzadeh, Daniel M. Holland of the Sloan School of Management, and Jack P. Ruina of the Department of Electrical Engineering.
- 3) The TAP Advisory Committee, composed of the deans of the schools, Professors Choucri and Moavenzadeh, and chaired by the Provost, is responsible for overseeing TAP activities and advising of Institute policies and administrative procedures.

Jeanne De Pass is the Program's Administrative Officer and Kevin J. O'Toole serves as the Technical Officer. Robert P. Greene served as the MIT/TAP Representative in Cairo until March 1984.

RESEARCH

Collaboration among MIT faculty members and their counterparts in academic institutions of developing countries is the backbone of the research program. Its success hinges on strong input and active participation by members of government and industry. Through the conduct of research projects, the previously untapped resources of the academic community are mobilized; and government agencies and the private sector develop and improve the skills and capabilities they need to carry out their responsibilities.

This cooperative research approach

- directs research toward issues of national importance;
- gives opportunities for the national organizations and local industries to get to know and appreciate the intellectual and professional capability that exists in their universities and academic institutions;
- brings together those capable of solving problems with those needing problems solved;
- fosters the discovery of solutions to important problems of national interest;
- creates an opportunity for MIT faculty and students to be involved in research relevant to the technology requirements of the developing world and for them to develop expertise and experience in the field of technology and development.

The TAP uses four mechanisms for research.

- Long-term Research Projects

New links are made between the academic community and government agencies when a broad problem is researched that is of mutual interest to an MIT faculty member, a faculty member from a collaborating university, and a government agency or a private sector enterprise. Teams drawn from each of the three institutions investigate various aspects of the problem.

Long-term research projects which were conducted during the past year focused principally in three broad areas: (1) Energy, (2) Manufacturing, and (3) Public Works. The projects were done in collaboration with faculty from Cairo University.

1) Energy

Energy-Economy Interactions and Energy Policy. The objectives of this project are to examine energy/economy interactions, specifically the role of petroleum in the Egyptian economy, in terms of quantities and pricing; to analyze the effects on the petroleum sector of alternative levels of investments in exploration and development; to examine resource flows domestically and internationally associated with the petroleum sector; and to identify pricing policy issues facing the government. This project is under the direction of Professor Choucri (Department of Political Science). Dr. Supriya Lahiri is contributing to this project.

Energetics in the Egyptian Metal Industries. The objective of this project is to study and recommend methods of bringing about near-term and long-term improvements in the aluminum and iron-and-steel industries. The project is under the direction of Professor David Gordon Wilson (Department of Mechanical Engineering).

2) Manufacturing

Engineering Applications for the Plastics Industry. The objective of this project is to develop a capability at Cairo University, and in several private and public companies, that will support the ministries' plans to broaden the application for plastics materials. The project is under the direction of Professor Frederick McGarry (Department of Materials Science and Engineering).

Production Planning Methodology for the Egyptian Automotive Industries. The objective here is to design a new system to plan and control assembly, fabrication, and procurement in the Industrial Vehicle Division at El Nasr Company. The project is under the direction of Professor Gabriel R. Bitran (Sloan School of Management).

3) Public Works

Intercity Multimodal Transportation. The objective of this project is to develop a methodology that will make possible the systematic analysis of future transportation proposals in Egypt. The methodology,

which addresses both intercity freight and intercity passenger movements on highways, railways, and inland waterways, will complement previous transportation planning efforts in Egypt. This program is under the direction of Professor Moavenzadeh. Research Associates Michael Markow, Brian Brademeyer, and Dr. Morteza Salehi in the Department of Civil Engineering are contributing to this project.

The Hydrology of Agriculture in Egypt. This project focuses primarily on agricultural water use in Egypt. The goal is to provide better estimates of agricultural water demand and to search for more effective ways to provide this water. Concentration is given to irrigation scheduling and land reclamation. This project is under the direction of Professors Rafael Bras and Peter Eagleson (Department of Civil Engineering).

Water Resources Planning Models. The objective of this project is to identify and evaluate alternative water resource development plans and their economic, physical, and social impact. This project is under the direction of Professor David Marks (Department of Civil Engineering).

Performance of Paraffinic Asphalt-Cements in Egyptian Road Construction. The objective of this project is to evaluate the properties of the Egyptian waxy asphalt cements and improve the performance of Egyptian pavements constructed by means of these asphalts. The project is under the direction of Professor Mohsen Baligh (Department of Civil Engineering). Professor Amr Azzouz of the same department is also contributing to this project.

Guidelines for Urban Area Planning. The objective of this project is to study methods whereby the use of infrastructure can improve urban land development patterns. The project is under the direction of Professor Ralph Gakenheimer (Department of Urban Studies and Planning) and Professor Nabeel Hamdi (Department of Architecture).

● Short-term Research Projects

Short-term research projects are developed by faculty members of collaborating universities, either independently or in cooperation with MIT faculty. They are funded for three months to one year and focus on specific tasks such as

- 1) developing feasibility studies for particular industrial organizations;
- 2) preparing major research proposals to be submitted to national or international organizations for funding;
- 3) establishing specific support systems--for example, computer, library, personnel management, accounting, procurement, and contracting.

Two short-term research projects were undertaken this past year:

- 1) Pre-feasibility Study of Gypsum Quarrying and Product Manufacturing in Egypt;
- 2) Informatics and Development.

● Young Faculty Career Development Support

The Program requests newly-appointed faculty members in collaborating institutions to submit proposals for research on topics that are both of interest to them and relevant to national needs. The proposals are reviewed by appropriate university committees and those approved are funded for one year, renewable for an additional year.

Young faculty are given research support and support for their graduate students. Their work establishes them in a particular area of research that has a high likelihood of being subsequently funded by government agencies.

At Cairo University, 13 post doctoral fellowships were completed and five were continued during the year. Six new doctoral fellowships were awarded.

● Industrial Internships

The program supports industrial internships so that faculty members can work in particular industries or government agencies to become familiar with and contribute to the solution of problems that interest the industry or government agency. Industries find it helpful to have highly qualified individuals contributing to the solution of their operational problems, and faculty members are familiarized with research needs of a particular industry. In many instances, internships lead to long-term research involvement.

Ten internships were awarded to Cairo University faculty members during the past year.

DEVELOPMENT RESEARCH AND TECHNOLOGICAL PLANNING CENTER AT CAIRO UNIVERSITY

The concept of establishing a permanent institution to foster and encourage research by Cairo University faculty and students on topics relevant to the developmental objectives of Egypt was an outgrowth of the successful experience of the collaborative effort between Cairo University and MIT in the Technological Planning Program. In order to sustain these efforts, Cairo University established in 1979 the Development Research and Technological Planning Center (DRTPC) as an autonomous research unit, and provided it with more than 2,500 square meters of space in a new building on the campus. The center is currently providing an institutional mechanism at Cairo University for conducting contract research in the area of science, technology, and development.

EDUCATIONAL ACTIVITIES

TAP has expanded educational opportunities at MIT. Opportunities for learning have been made available to both faculty and students interested in general or specific topics related to transfer and adaptation of technology, and valuable experience on specific, real problems has been gained. The projects have provided an opportunity for future decision makers to serve as apprentices under experts in particular areas of technical and economic development. Some of the more specific educational opportunities offered during the past year include those outlined below.

Master's Degree Program at MIT

TAP provides educational and research opportunities for master's candidates who are interested in the transfer and adaptation of the technologies of their own areas of specialization to the needs of developing countries. Students who elect this opportunity devise an educational program which includes those subjects required for their chosen area of concentration, and at least one subject which deals with management techniques of special importance to developing countries, one graduate subject in economics which is related to developing countries, one subject in the social sciences area which deals with structures required to support the applications of technologies, and one subject in an engineering area related to the transfer or adaptation of new technologies in developing countries. Eleven students this past year received financial support in the form of research assistantships associated with current TAP research projects. Since the inception of TAP, 59 Master of Science degrees, 18 Doctor of Philosophy degrees, and five Engineer degrees have been awarded. Approximately 150 Research Assistantships have been offered.

Visits by Foreign Scholars

To date, more than 200 foreign scholars have visited MIT. Some have attended short courses on specific topics, while others have followed more informal programs designed to increase their awareness of current developments in their fields. During their visits to the Institute, most of them also have performed work on specific research projects in collaboration with MIT counterparts. In addition, several have had the opportunity to meet with other MIT staff members interested in similar problems of technology adaptation and development.

Conferences, Workshops, and Seminars

Conferences, seminars, and workshops are an integral part of TAP. These activities are designed to promote an awareness of a selected science and technology issue or to upgrade specific capabilities. The events bring together individuals from different organizations to exchange information and disseminate the findings of the TAP.

During the past year two major conferences were held in Cairo. In January 1984, the Seventh Anniversary Technical Conference was held at the DRTPC. This conference met to report on the research accomplishments of the joint Cairo University/MIT projects. In March 1984, a technical conference on Transportation Policy, Planning and Management in Egypt was conducted in Cairo.

A seminar series on Energy and Development was held during both the fall and spring semesters at MIT. The series was designed to increase interaction between the MIT community and policy analysts or representatives both in the United States and overseas.

Seminars on Energy and Petroleum in Egypt and Engineering Applications for the Plastics Industry were held in Cairo by the joint Cairo University/MIT research teams.

In December 1983, Mr. M. Peter McPherson, Administrator of the Agency for International Development, visited MIT under the auspices of TAP. Mr. McPherson delivered an address entitled "The Cutting Edge of Third World Development: Science and Technology" to members of the MIT community.

TAP is currently in the process of establishing a major new program with the Technical University of Berlin. Committees from TUB and TAP have explored the feasibility of collaboration with an academic institution in a third country focused on the role and contribution of science and technology to that

country's socioeconomic growth. Portugal and Turkey were selected as appropriate countries for consideration, and visits were made by a joint TAP/TUB team in March 1983. The purpose of the visit was (1) to identify academic institutions in each of the two countries willing and qualified to participate; (2) to explore tentative areas of research that could be of mutual interest to the participating institutions; (3) to ascertain the availability of faculty and their willingness to participate in these joint activities; and (4) to explore the availability of international or bilateral sources of funding.

The institutions that appeared to offer the most potential for collaboration were the Universidade Tecnica de Lisboa and the Universidad Nova de Lisboa in Portugal, and the Middle East Technical University in Ankara, Turkey.

Since the initial exploratory visits, a more detailed framework for the tripartite collaboration has been developed. A follow-up visit to Lisbon has taken place to consolidate plans for the next phase.

In June 1984, a workshop was held at the Middle East Technical University as part of the collaborative efforts underway with the Technical University of Berlin.

ADMINISTRATION

In March 1984, the Agency for International Development renewed their contract with TAP and provided an additional \$10 million for continuation of the work in Egypt until December 1986. During the new phase of the program, increased emphasis will be placed on institutionalization of the Development Research and Technological Planning Center at Cairo University. This Center, which was formed as an outgrowth of the TAP in 1979, is an autonomous organization for sponsored research and educational activities and administers the joint program at Cairo University.

Mr. James J. Culliton, Director of Personnel, visited the DRTPC in October 1983 to review the administrative aspects of the Center with its director.

Mr. Philip Keohan, Comptroller, and Mr. John P. Donahue, Associate Comptroller, provided assistance to DRTPC personnel at Cairo University in April 1984.

PUBLICATIONS

TAP publishes its own series of technical reports in addition to those papers which are included in the broader area of the principal investigators' journals. Since the start of the Egyptian project, more than 400 papers and reports have been published.

TAP initiated a newsletter titled "Technology and Development." The newsletter's primary objective is to provide a channel of communication for development-related programs and projects at MIT to share their activities and their findings with those interested and concerned with the socioeconomic development of the third world.

FUTURE PLANS

TAP has reviewed its long-range plan with the Provost and has started to take steps to implement specific actions.

- The Policy Committee has recommended that a Visiting Committee be established to replace the present Advisory Committee. This new committee should have membership from international organizations such as The World Bank, OECD, United Nations, AID, and those Canadian international organizations which have had considerable experience in development.
- The academic program is being reviewed with the intention of strengthening the master's degree program. The Policy Committee is pursuing funding possibilities from foundations to support fellowships, curricular development, conferences, workshops, and seminars.
- TAP has started to increase its interaction with the private sector, both in the United States and overseas. US firms are increasing their involvement in the developing world and TAP is able to provide the necessary expertise and insight to insure that the objectives of both sides are met. Foreign private sector organizations such as the Volkswagen Foundation have shown an interest in providing support for TAP's work.

FRED MOAVENZADEH

Undergraduate Research Opportunities Program

With the close of the 1983-1984 academic year the Undergraduate Research Opportunities Program (UROP) reaches an anniversary of fifteen years at MIT. A stable participation level of approximately three-quarters of the undergraduate body, about 60 percent of the faculty, and student research support which easily tops the \$2 million mark (most of it from faculty research contracts) confer on UROP what could be described as "youthful maturity." These yearly reports have been chronicles of tremendous growth and very little change since that first fall of 1969. UROP is still the same program it was intended to be when it was launched. UROP's selection a year ago by the National Commission on Excellence in Education as a national model program was described in the Chronicle of Higher Education this year and accordingly attracted much attention.

We have been consulted about program operations frequently -- and sometimes repeatedly -- by Brown University, Stanford University, Rensselaer Polytechnic Institute, Imperial College, the University of Melbourne, and many others. At this point in our history, and with so many institutions interested in UROP's development, it was the right time to discuss UROP's origins and operating style on paper. Thus, at the behest of the Society for Research into Higher Education at the University of Surrey, Professor Margaret L. A. MacVicar, UROP director and founder, and Associate Director Norma McGavern prepared a paper entitled "Not Only Engineering: The Undergraduate Research Opportunities Programme" for 1984 SRHE conference: "Education for the Professions." The paper will be published with conference proceedings and has been made available in unpublished form to inquirers here at MIT and elsewhere.

A disadvantageously stable factor of UROP operations has been our virtually unchanged MIT General Funds budget for student research support. Since 1973, MIT's financial commitment has been approximately \$375,000. Seen within the framework of the nation's dramatic economic changes, evident in the more recent years of our 15 year history, this General Funds limit places us in a difficult situation as we look ahead to the coming academic year. We have steadily run office operations with a small staff and lean style. However, inflation has run far ahead of our ability to serve students and faculty with direct UROP funds. We will need additional funds if we are to bring UROP's direct General Funds-supported student wage rate (currently \$4.50 an hour) into line with the Institute's minimum student wage rate set a year ago at \$5.25 an hour. Our opposition to the linkage of regularly increasing tuition costs to yearly minimum wage rate increases (an issue discussed again in the Student Wage Review Committee) had a degree of impact upon this year's Administration decision to keep the hourly rate at its current level. Ever-increasing Institute minimum wage thresholds are ultimately self-defeating. For our part, we have strongly urged faculty to pay at least the \$5.25 rate when paying students wholly from their own funds, even though we cannot afford this pay rate from our level-funded General Funds allocation. Faculty cooperation on this issue has been quite generous. Without the steady and enlarging pool of faculty-contributed research support to undergraduates, we could not have maintained access to UROP for the past decades' undergraduates.

Confidence in the abilities of undergraduates has been amply demonstrated by the financial support offered by faculty supporting students from sponsored research grants. We have waived overhead during this academic year on student wages of an amount 15 percent higher than the previous academic year (1982-1983), and 90 percent higher than two years ago (1981-1982). The summer of 1984 will probably bring us up to the \$2 million mark on overhead-waived student wages alone, if not slightly beyond. Early figures indicate a higher amount of wages on which we have waived overhead than ever before, about eight percent above summer 1983. This rate of increase has been in play since 1974. During term time, the number of students receiving credit was about the same as the number receiving pay. Total participation figures are virtually the same as they were last year in all modes: pay, credit, and volunteering. The program seems at its asymptotic maximum of participants in the recent years.

Besides our need for additional money for student wages, UROP has a desperate need for a modest increase in space. Meetings for students, discussions with visitors, and other gatherings are often by necessity held in other Institute rooms rather than in our own offices. Although we have a temporary room near our offices for storage purposes, a request has formally been made again to get additional permanent space. We have also given thought to the value to the Institute of UROP's taking on the role of a "mini-Athena foundation," serving as a resource for UROPers who need computers to work with faculty on educationally related software. Project Athena hopes to locate computing facilities in Building 20, and it is hoped by its proponents that UROP will provide the berth. A work station of some 20 computers entails requesting additional space, however. Further, UROP may be the recipient of a number of donated computers from another source also to be used by UROPers. This has increased the urgency of our request for additional space.

Support from sources outside MIT has allowed UROP to stretch our MIT funding and reward outstanding achievement. Each year about 30 students apply for Eloranta Summer Fellowships, made possible by a gift from Dr. Edwin H. Land, Visiting Institute Professor and founder and former president of Polaroid Corporation, to foster creative intellectual activity of outstanding merit during the summer months. This year's winners, Mihai D. Manoliu and Stephen D. Baker, both members of the Class of 1984, each received \$4000 stipends. Mr. Manoliu will use his fellowship for research in musical instrument design, instrumentation, and the study of music psychology. Mr. Baker will travel to Florence, Italy to study the architectural design methods of Filippo Brunelleschi. Funds from the MIT Chapter of the Society of Sigma Xi, offered in support of research in applied science, were given to three students: One student went to Sweden in the summer of 1983 to develop detailed geological maps of a mountain range, another studied the freezing and thawing processes in biological cells, and the third student was given funds for materials and services to study the genetic analysis of toxic plants. This latter student, Mark Segal, Class of 1984, also received the Asinari Award based on his UROP record. James McCormack Awards were given to a mechanical engineering student developing a system for monitoring road usage, and a student working to develop a scientific theory about how the mind makes sense of music. Funds from the Class of 1970 provided support to Douglas Danley, Class of 1984, to work on the development of a photovoltaic water pump for use in underdeveloped countries, a project which resulted from work he did while in the Peace Corps on leave from MIT. Another recipient investigated health care costs and insurance company reimbursement policies. Another class gift established last year, the Class of 1972 award, enabled UROP to support four students: one working on the control of acid rain, another improving energy efficiency in building design, a third working on a study comparing indoor and outdoor air pollution, and the fourth award to a Massachusetts State Legislature intern assisting in the writing of legislation to prevent arson for profit. Seven awards were made from the Uniroyal grant which supports beginning researchers. Financial pressures persuaded the Uniroyal Foundation not to renew its support to UROP although it expects to resume support sometime in the future. Three students received Clapp and Poliak funds for excellence in engineering design: One student for work to improve the production of polyurethane, and two students working together to design an improved hovercraft skirt. New England Life Insurance Company UROP Awards were given to five students involved in health-related research. Two of the students conducted some of their research at Boston area hospitals. Ten traineeships were offered by the Civil Engineering Department in the spring term to undergraduates, mostly freshmen, doing their first civil engineering research. These awards are granted to stimulate interest and research in this department. Thirteen students -- a record number -- received Sea Grant awards for research in ocean management and ocean resources. Two of the recipients made research presentations to representatives of the national Sea Grant Program when they visited MIT this spring.

A prize was established in 1982 by the family of Joel Matthew Orloff in memory of their son, a physics major and member of the Class of 1978. The prize is a cash award and certificate given each year to the undergraduate demonstrating the most outstanding ability and creativity in physics-related research conducted in any MIT academic department. The Orloff Award Committee chose Raymond Goldstein, Class of 1983, to receive the second Orloff Award. Professor Nihat Berker of the Department of Physics nominated Mr. Goldstein for the award on the basis of research they carried out over a two-year period on the theory of phase transitions. In addition to the Orloff UROP Prize, Mr. Goldstein won the national Apker Award Competition given by the American Physical Society. He also won an Eloranta Summer Fellowship in 1980.

Recognition of student achievement was especially evident in the numerous alumni invitations extended to undergraduates this year. Especially noteworthy was the invitation to three students to address the 1983 National Alumni Conference held this year in Cambridge. "They stole the show," said one member of the audience. Lloyd Hey, Class of 1984, spoke of his work "Understanding the Healing Process through a Cartilage Model;" M. Anjali Sastry, Class of 1986, discussed "Analysis of the Recovery Time Following a Nuclear Attack on the United States;" and Edwin Seidewitz, Class of 1984, related the work he and other students had done on "The Goddard Project: Designing a Satellite-Launching Rocket." This was the second time students were asked to address this body.

Alumni clubs on both coasts invited UROP students to share their research experiences with them. For several clubs it has become an annual event held at a time when newly-admitted MIT students may be invited. Students spoke to groups in New Haven, Connecticut; Totowa, New Jersey; Los Angeles, San Diego, and to the MIT Club of Boston.

As an expression of gratitude to particular friends of MIT, the Development Office began a series of VIP visits, each to be a day filled with a personal tour, and private talks and visits to people and programs of special interest. An ideal way for these visitors to get to the heart of the educational process was to meet and talk with undergraduates working with faculty on research. UROP students met with Mr. Harry Kalker, a member of the Class of 1923, on one such visit, and Mr. Allen Latham, Class of 1930, on another.

Two UROP students, Lloyd Hey and Lesa Aylward, Class of 1984, members of the MIT Chapter of Tau Beta Pi, the national engineering honor society, produced a mixed media show which included the photographs and comments of UROP students. Done quite independently by these two students, it was aimed at interesting young people in careers in science and engineering. Representatives from the Office of Admissions, Alumni Association, and Campus Information Services expressed interest in the finished product. This slide show

also became part of the curriculum in the Weston public schools during two days in the spring. UROPers were invited by the Weston school department to teach in place of regular science faculty for two days while teachers attended a national conference in Boston. The slide show promoted discussion about what scientists and engineers do when it was shown to Weston elementary school students.

Other special programs occurred during Independent Activities Period (IAP) and were designed to aid UROPers and would-be UROPers. "Starting Out and Starting Over" was a well-attended workshop held by Assistant Director Michelle Lamarre on how to find a UROP project. Experienced UROPers participated to help show the way. Together with the Career Planning and Placement Office and the Student Employment Office a summer job/summer UROP student information meeting was held. A briefing meeting acquainted potential Eloranta Summer Fellowship applicants with guidelines for proposal preparation. A four day workshop, "How to Give Speeches and Make Research Presentations," was given to help undergraduate researchers who wanted to learn to speak more effectively in public. Both undergraduates and graduate students attended. Ms. McGavern ran the workshop for its second year. In fall 1984 this will become an undergraduate seminar. Support for this effort came to UROP from the Raymond Stevens Fund.

Computing has already entered the UROP office life by way of the recent purchase of an IBM personal computer. At the end of the spring term, guided by Maureen Horgan, our newly "educated" computer expert, the PC produced our first UROP statistics. Real efficiency in day-to-day operations remains to be proven in the next year.

Professor MacVicar was on partial leave during the first term of this academic year as vice president of the Carnegie Institution of Washington, D. C. Ms. McGavern oversaw day-to-day operations during that period. Our clerical overburden and budgetary constraints led us to make a significant structural staffing change this year. Our administrative assistant position will no longer be a full-time one at the end of this fiscal year. At the same time, our current part-time secretarial position has grown to a full-time job. Susan Mitchell-Hardt, our administrative assistant since 1980, will leave as this change comes about. Marcia Cassidy, our part-time office assistant in the 1982-1983 academic year and full-time office assistant in the summer of 1983, left at the beginning of the new academic year to join the San Francisco string quartet. Our present part-time secretary Ms. Horgan, a professional trombone player, a member of the UROP staff since Ms. Cassidy's departure, has been promoted to half-time staff administrative assistant beginning July 1, 1984. A full-time secretary, Lisa Merritt, has been hired and will begin on that date. Mr. Gregory Smith continues as our special projects coordinator in addition to his activities on behalf of the Council for the Arts.

MARGARET L.A. MACVICAR
NORMA G. MCGAVERN

Upward Bound Program

The MIT/Wellesley Upward Bound Program is a coeducational, multiracial educational program for Cambridge high-school youth. Now in its seventeenth year, the program services 70 academically promising young men and women from disadvantaged backgrounds. The goal of the program is to motivate these youths to attend college, and to provide them with the necessary skills needed to succeed in college. To a large extent, the program is influenced by the research done in the 1930s and '40s by social psychologist Kurt Lewin and his associates. The program has met with good success, operating on the assumption that ego growth and academic performance are closely related. A developing ego needs to experience success in a warm and personal structured environment to develop strongly, in both a personal and social sense. This development can be brought about through intervention outside of the family and school.

Upward Bound represents such an intervention. It has been established that the effects of failure can be reversed by presenting a young person with real success, and that further success leads to an increase in the student's level of aspiration. The program staff are often the first to see real academic promise in the youngsters. The staff, together with teachers and fellow students, play a crucial role, because what students think they can do is dependent on what others think they can do. The students' perceptions of their abilities, and therefore what they will try to accomplish, are thus to a large extent determined by the staff.

Summer Program

The summer program, conducted in residence on the Wellesley College campus for six weeks, is designed to provide the student with an intense academic and social experience. Classes are team-taught by experienced high school teachers, students from Wellesley College and MIT, undergraduate and graduate students from local colleges and universities, and Upward Bound alumni now attending college. Upward Bound students carry three classes, each of which meets for an average of 60 minutes per day, during the six-week summer program. Each student is required to take a mathematics and an English course and one science elective. Science courses include biology, physics, human physiology, computers, and chemistry. The mathematics program includes an enrichment section for students who have done poorly in algebra I or II, geometry, or trigonometry, and pre-calculus and calculus courses for students who will be attending college in the fall.

The Academic Year

The academic year program, while somewhat less intense, is equally important. Building on the motivation and enthusiasm developed over the summer, the academic year program is designed to help the student cope with the myriad of academic, social, and family problems that confront him or her in Cambridge. To achieve this, the following programs, staffed primarily by MIT and Wellesley undergraduates, have been developed and implemented:

Study Skills. The MIT Upward Bound offices are open for study four days a week: Monday and Tuesday from 3 to 6 P.M. and Wednesday and Thursday from 3 to 8 P.M. Tutors are on duty to provide homework supervision for both individuals and small groups. Tutors are typically MIT or Wellesley College undergraduates who meet regularly with core staff to discuss students' progress and/or difficulties.

Tutoring. Whenever requested or needed, tutors are assigned to individual students. These pairings meet on a regular basis at a specified day and time until it is mutually agreed that the individual tutorials are no longer necessary (usually indicated by improvement in grades). Organization and time management are stressed, as well as effective negotiation techniques.

College Report, Class of 1984

Graduating seniors have been placed in colleges as follows: Emmanuel College, Clark University, Northeastern University, Salem State College, Southeastern Massachusetts University, University of Massachusetts at Boston, University of Massachusetts at Amherst, Massachusetts Institute of Technology, Franklin Institute, Pace University.

We continually look forward to increase participation by MIT and Wellesley College undergraduates through our continued involvement in the Wellesley College Teacher Certification Program and outreach efforts.

RONALD S. CRICHLLOW

Wellesley-MIT Exchange Program

The 1983-84 academic year marked the sixteenth in which students from MIT and Wellesley cross-registered for courses at the other school through the Wellesley-MIT Exchange Program. Since the beginning of the Exchange, cross-registration has remained the main emphasis of the Exchange, although other cooperative efforts have been developed.

Cross-Registration

Whether they are from MIT or Wellesley, students who have cross-registered praise the experience. In written course evaluations at the end of the term, they frequently use phrases like "fantastic course," "excellent teacher who knows the material," "good class participation," "different emphasis," and "a wonderful change."

This year the number of students cross-registering was relatively high. The only exception was a slightly lower than normal participation by MIT students during first semester when 102 MIT students enrolled in 135 Wellesley subjects. Participation climbed second semester to 181 MIT students taking 201 Wellesley subjects. Cross-registration by Wellesley students was strong during both semesters, with 167 Wellesley students taking 220 MIT subjects in the fall and 221 Wellesley students taking 282 MIT subjects in the spring.

Residence Exchange

In addition to cross-registration, the Exchange provides a limited number of students with the opportunity to live in the other school's dormitories through a residence exchange. The students pay tuition to their home institution, and room and board fees to the school of residence. This year nine students from MIT lived at Wellesley for the entire year. Eleven Wellesley students lived at MIT for the first semester and seven for the second semester.

This spring the Wellesley-MIT Joint Committee reviewed the residence exchange, which had been in effect for two years. Based on comments from participants, the committee concluded that in almost all cases the residence exchange has proven valuable to the individual students. Heads of house at Wellesley reported that the presence of MIT students--who are housed in only two dormitories--has had a favorable impact on the dormitories involved. At MIT, where Wellesley students are scattered throughout the housing system, house masters said that the visibility of Wellesley students in a dormitory depends on the personalities of the individual students. Because experiences in the residence exchange have been positive and the administrative costs are not large, the Joint Committee decided to continue the program at the same level with no more than 15 students from each school per semester.

Faculty Exchange and Joint Subjects

Although students do most of the commuting between the two campuses, a few faculty members are teaching at the other school. This year two assistant professors in French spent second semester in a faculty exchange. Professor Sabine Raffy of Wellesley taught two MIT sections of 21.204 French IV, while Professor Janice Vanpee of MIT taught Wellesley's French 122 Intermediate French and French 330 Intellectual Revolutions. Although there have been other exchanges between faculty in French, this is the first in recent years.

James Kodera, associate professor of religion at Wellesley, once again taught Religion 108 Introduction to Asian Religions at MIT. More than 45 MIT students completed this second-semester subject.

The Center for Materials Research in Archaeology and Ethnology offered a new subject listed in both school's catalogues: 21.543 (Wellesley Anthropology 308) Mathematics and Computers in Archaeological Data Analysis.

Joint Wellesley-MIT Teacher Certification Program

This year two students--one from MIT and one from Wellesley--were certified as teachers under the Joint Wellesley-MIT Teacher Certification Program approved by the Massachusetts Department of Education. The MIT student was Laura Motz, Class of 1984, who majored in mathematics. Wellesley is the authorized certifying institution for the program.

Joint Committee

The 1983-84 Wellesley-MIT Joint Committee was chaired by Robert J. Silbey, professor of chemistry at MIT, and Maud H. Chaplin, dean of the college at Wellesley. MIT members included: Russell Basch, Class of 1986; Mark Caylor, Class of 1986; Mary Z. Enterline; Professor Woodie C. Flowers; Kathleen Harragan, Class of 1984; Dean Holliday C. Heine; Professor Judith Kildow; Dr. Louis Menand III; Associate Provost Frank Perkins; Brian E. Simmons, Class of 1985; and Professor Joseph M. Sussman. From Wellesley, members were: Dean Molly S. Campbell; Professor Theodore Ducas; Barbara Farquhar; Professor Phyllis Fleming; Lynn Hunt, Class of 1984; Dean Florence C. Ladd; Dorothy Moeller; Professor Sabine Raffy; Frances Sessa, Class of 1985; and Professor Susan Silbey.

New Affiliation of Exchange Staff

At MIT, the Exchange Office continues to be staffed by Ms. Enterline, manager, Maryglenn Vincens, staff writer/editor, and George R. Kendall, senior office assistant. On July 1, 1984, the office, which has been reporting to the Provost's Office, will become part of the Undergraduate Academic Support Office under the Dean for Student Affairs.

MARY Z. ENTERLINE

Whitaker College of Health Sciences, Technology, and Management

Since I assumed the Directorship of the College on July 1, several new programs have been established and existing ones have continued to grow. A number of new appointments have been made.

Programs and Research

Whitaker College is an academic entity designed to promote interdisciplinary collaboration among faculty members from various MIT schools and provide a focus for research and education in the medico/biological field. The concept of Whitaker College derives from the notion that problems in biology and medicine are complex, and require knowledge from a number of disciplines for their solution. To implement Whitaker College's objectives, a limited number of programs have been identified.

PROGRAM IN BIOLOGICAL IMAGING

This program is headed by Professor Alan Nelson. Prof. Nelson and his colleagues are combining computer-based technology with the electron microscope. They have already developed several new imaging techniques, including visualizing magnified live individual cells in three dimensions. The goal of the laboratory is to become a national resource for computer-aided microscopy and image technology (through an NIH center grant). This field is a high priority for Whitaker College; and I hope that this important area of biological and medical imaging will continue to develop. This program is heavily interdisciplinary and draws from faculty members in the Departments of Nuclear Engineering, Electrical Engineering and Computer Science, and in neuroscience. Educationally, the program in biological imaging is tied to a Ph.D. in radiological sciences, which is funded by an NIH Training Grant and operated in conjunction with the Department of Nuclear Engineering. Under this grant, five new students were admitted this year to begin in the fall of 1984.

PROGRAM IN MEDICINAL CHEMISTRY AND CONTROLLED DRUG DELIVERY SYSTEM

Another interdisciplinary program, headed by Professor Robert Langer, is centered on the development of new systems for drug delivery and drug removal. The work focuses on devising methods for controlled release systems which produce near constant drug levels, thus avoiding peaks and valleys in the concentration of pharmaceutically active substances in the blood. In addition, Dr. Langer and his colleagues are interested in selective drug removal systems. An example of this type of work is the removal of heparin from the blood of patients. Heparin is administered to patients with kidney failure in order to avoid clot formation when blood contacts the artificial kidney, but it must be removed upon completion of the treatment in order to diminish the risk of hemorrhage. Dr. Langer is in the process of developing such a drug removal system by way of a filter containing an immobilized enzyme (heparinase). This filter has worked successfully in dogs. Another application is a filter to eliminate bilirubin in neonatal jaundice. Dr. Langer has a primary appointment in the Department of Nutrition and Food Science, and a secondary appointment in the Whitaker College.

PROGRAMS IN HUMAN BIOLOGY

A. Receptor Mediated Endocytosis. While Dr. Langer is concerned with maintaining near constant drug levels in the extracellular space, Professor Monty Krieger's research is directed at understanding the process by which animal cells internalize physiologically active molecules. His work is focused on the transport of cholesterol across the cell membrane. The first step in this process is the binding of extracellular molecules to specific receptors on the external surface of the cells. Next the portion of the plasma membrane bearing the receptor-ligand complex invaginates and forms an endocytic vesicle which contains the ligand. Dr. Krieger's goal is to understand the biochemical steps involved in endocytosis. The importance of understanding receptor mediated endocytosis goes beyond the transport of cholesterol. Prof. Krieger, in cooperation with Prof. Langer, is searching for ways to displace the cholesterol from the transport protein and bind other pharmaceutical compounds to it. By this technique, they may achieve intracellular transport of a variety of pharmacologically active compounds. Prof. Krieger, whose appointment is joint in Biology, is involved in graduate and undergraduate teaching in the Department of Biology.

B. Thrombosis and Atherosclerosis. Another medico/biological program is directed by Professor Robert Rosenberg. Prof. Rosenberg has appointments in the Department of Biology, Beth Israel, and in Whitaker College. Specifically, he has been studying the biosynthesis of heparin-like molecules with anticoagulant activity. He is also investigating the way in which platelets are formed in the bone marrow.

PROGRAMS IN NEUROSCIENCE

This area is expanding very rapidly both in the United States and abroad; major universities such as Rockefeller, Washington University in St. Louis, Stanford, University of California, San Francisco, Johns Hopkins and Harvard are all very actively pursuing the establishment of research programs and education in the neurosciences. MIT has quite an interesting and unique tradition in the brain sciences, and there are now a number of active groups on campus. Among these: (1) the group of Professor Nelson Kiang in auditory physiology with colleagues in the Department of Electrical Engineering and Computer Science and the Research Laboratory of Electronics. (Dr. Kiang's laboratory is located at the Massachusetts Eye and Ear Infirmary, Eaton-Peabody Laboratory of Auditory Physiology.) The research activity of this group encompasses auditory physiology, auditory psychophysics, speech understanding and production; their approach is very quantitative and they are recognized leaders in the field. Prof. Kiang has an appointment in Whitaker College (joint with the Department of Psychology and the Harvard Medical School). Further appointments in this area are foreseen in order to complement and strengthen the research activities of this group. (2) Another group of neuroscientists is in the Department of Psychology. Their interest is directed at studying the relationship between brain and behavior. Some of the brain scientists of the Department of Psychology (neuroanatomy and neurophysiology) have moved their laboratories to the sixth floor of the Whitaker College. They have received joint appointments in Whitaker and are expected to play a major role in the development of educational and research programs in the College. (3) A third focus of the brain sciences is in Whitaker College, where two complementary lines are in the process of development: systems neuroscience and neurobiology.

A. Systems Neuroscience. Systems neuroscience at MIT is concerned primarily with sensory and motor systems. The aim of this work is to understand the transduction and encoding of sensory stimuli and the organization of sensory-motor performance. This work is strongly interdisciplinary. The research draws primarily on computer science and engineering and neurophysiology. To promote research in this area, we have established in Whitaker College a Center for Biological Information Processing.

The Center for Biological Information Processing, directed by Professor Tomaso Poggio, works closely with the Artificial Intelligence Laboratory to promote synthesis of computational and experimental approaches to brain research. It will combine research in neurobiology, neurophysiology and computation, and will involve close collaboration with faculty from MIT and other institutions. Research at the Center will focus on the computations underlying problems in vision and motor control, with the ultimate aim of understanding their neural correlates. Research at the Center will also seek to establish a bridge between computational theories and biophysical mechanisms, to show, both theoretically and experimentally, how networks of neurons and synapses can implement visual and motor computations. Two junior appointments are expected in the area of systems neuroscience.

B. Neurobiology. Molecular neurobiology is a relatively new area of research which is quite under-represented at MIT. To remedy this situation and establish a strong research effort in this area, we have established four tenure-track positions in Whitaker College. Two appointments have been made in 1984 - Professor Ronald McKay and Professor William G. Quinn - both will begin research at MIT in Whitaker in July. Prof. McKay is an outstanding neurobiologist with a background in molecular neurobiology. He is a leader in the study of neuronal development. Prof. Quinn is a biologist interested in memory and learning. His background is in biochemistry and genetics. These two appointments, plus the other two that we anticipate, will allow the establishment of a strong group of molecular neurobiologists. The rationale for developing such a group is that recent advances in molecular biology promise major breakthroughs in certain areas of membrane physiology, synaptic transmission, neural development, and storage and retrieval of information. In addition, given the strengths that exist at MIT in molecular biology (in the Department of Biology and in the Cancer Center, for example), a small group of neurobiologists in Whitaker should be in a position to become leaders in the field by relying upon the expertise, the techniques, and the graduate students of these centers. In a sense, the establishment of the neurobiology group is paradigmatic of what Whitaker wants to achieve: to develop new areas through interdisciplinary work by relying upon a pre-existing strength.

An education program encompassing systems neuroscience and neurobiology is being planned.

PROGRAM IN HEALTH POLICY AND MANAGEMENT

The results of research not only generate new knowledge, but they also influence the world and society in which we live. To study the impact of medico/biological knowledge upon society, MIT has developed in Whitaker a Program in Health Policy and Management (directed by Professor Stan Finkelstein). This program draws upon the Sloan School of Management, and the Departments of Economics and Political Science. Its educational goal is to train people capable of dealing with the complexities of health care. The graduates of this program will have competence in management and economics, as well as an awareness of the political consequences of making decisions in the area of health. The faculty's research themes range from the impact of medical technology on society to the environmental determinants of health and the problems related to health care delivery. The Ph.D. program is specifically geared to attract M.D.s and this year the second class of four students was admitted and will be matriculating in the fall of 1984.

Other Activities

A Distinguished Lecture Series in the Brain Sciences was offered by the College during the academic year. Sponsored in part by a grant from the John D. and Catherine T. MacArthur Foundation, four lectures, including presentations from two Nobel Laureates, explored different foci in the field of neuroscience. I am pleased that the presentations were so well attended and received by the Institute community.

Five pre-doctoral students working with faculty in the Whitaker College were awarded fellowships. Three were recipients of the Surdna Foundation fellowship. Two were recipients of an award generously provided by the Edward J. Poitras Fellowship fund. Both fellowships provide both tuition and stipend over a twelve month period.

Faculty and Staff

A number of new appointments were made in the Whitaker College this year.

I assumed the Directorship of the College on July 1, 1983.

Professor Nelson Y.-S. Kiang was named Eaton Peabody Professor of Communication Sciences in the Whitaker College, joint with the Department of Psychology at MIT and the Harvard University School of Medicine.

Professor Ronald D. McKay has been appointed Associate Professor of Neurobiology and Professor William G. Quinn has been appointed Associate Professor of Neurobiology. Both appointments are joint with the Department of Biology and are effective July 1, 1984.

Vera Ballard was appointed Administrative Officer and M. Terry Heyward was named Administrative Assistant to the Director in the fall of 1983.

Joint appointments to the College this year include: Dr. Ann M. Graybiel, Professor of Neuroanatomy; Dr. Peter H. Schiller, Professor of Neuroscience; and Dr. Gerald E. Schneider, Professor of Neuroscience - all joint with the Department of Psychology; Dr. Richard J. Wurtman, Professor of Neuropharmacology and Dr. R. Alan North, Associate Professor of Neuropharmacology, joint with the Department of Nutrition and Food Science; and Dr. Tomaso A. Poggio, Associate Professor of Vision Science and Biophysics, joint with the Department of Psychology and the Artificial Intelligence Laboratory.

EMILIO BIZZI, M.D.

Chairman of the Faculty

The activities during the past year of the Committee on Educational Policy (CEP) and of other Faculty Committees are highlighted in the following report.

Imbalance in Undergraduate Enrollment Among Departments

The enrollment imbalance problem and related issues occupied a significant portion of the CEP's attention this year. The substantial growth over the past decade of undergraduate enrollments in the School of Engineering, and the Department of Electrical Engineering and Computer Science in particular, has created especially severe and damaging strains on the EECS faculty, and seriously jeopardizes the intellectual balance at MIT and the diversity of interests among the group of students who choose to study here. The problem and possible ways to address it were the topic of intense discussion within the CEP and the Committee on Undergraduate Admissions and Financial Aid (CUAFA), the Academic Council, several community forums, meetings of the EECS faculty and the MIT faculty as a whole, and many other groups during the year.

By late fall, it appeared that no combination of "desirable" actions offered sufficient short-term relief to the problem. It seemed necessary to choose between accepting severe ongoing damage to an outstanding department and taking an action which restricts, for a limited period of time, students' highly valued freedom of choice to select their major field of study. In general terms, the two options available are: a) to apply restrictions after students enroll at MIT or b) to take a restrictive action before they enroll, during the admissions process.

The details of possible restrictive actions of both types were presented at a Special Faculty Meeting in December; the Faculty was asked to support an action which would restrict undergraduate EECS enrollments in the Class of 1988 (entering MIT in the fall of 1984). The Faculty decided to take no action with respect to that Class, in part because of disagreement with the substance of the options presented, but largely because of concerns about fairness (that changes in the rules for the Class of 1988 were being made midstream) and because of feelings that the effectiveness of the various nonrestrictive efforts to address the problem should be tested further.

The December Faculty Meeting increased the community's awareness of the enrollment problem and enlarged the arena in which effective action on a variety of fronts could be taken. During the winter, various Institute efforts were initiated or strengthened in a concerted effort to address the enrollment imbalance. These included increasing the resources available to the EECS Department (including help from other departments), eliminating admission of college transfers into the EECS Department, making efforts to widen the pool of qualified applicants to MIT, expanding activities by other departments to attract additional undergraduates to their programs, providing better career information, and taking steps to encourage better advising and greater exploration of alternatives by students in the career selection process. (Several of these are described in greater detail below.) In addition, Institute-wide computer subjects outside EECS are being developed to help emphasize that computers play a significant role in research and teaching in almost all Courses of study at MIT. Over the longer term, it is hoped that many departments will explore additional degree program opportunities to meet student interests, such as engineering science options in the School of Science, computer/electronics options in appropriate departments, and cooperative programs in fields outside engineering.

During the spring term, the EECS department heads articulated more precisely the nature of the problem, as well as the impact on the Department of continued overload; several models were worked out for estimating the undergraduate enrollment that can be handled reasonably by the Department. A phased reduction of EECS sophomores from the level of 380 last fall to 270 by the fall of 1986 was considered reasonable; this would lead to an acceptable steady-state level of 900-950 EECS undergraduate majors by the fall of 1988. Inability to meet the established benchmark enrollment levels would indicate that the various noncoercive measures were not sufficient and that a restrictive action would be unavoidable (despite strong aversion to such an action).

The outline of a contingency plan (worked out initially by a CEP subgroup, C. Canizares, chair, A. Fleisher, L. Trilling, D. Wiley) was presented by the CEP to the Faculty in May. The Faculty agreed that if restrictions are to be used for a limited period of time, they should be applied during the admissions process and communicated to students before they accept admission to MIT, rather than after students enroll here. The CEP will develop a detailed contingency plan during the summer, to be presented to the Faculty in September. An important goal is to make the least possible perturbation in the current admissions process and on perceptions of MIT.

Whether or not restrictions will be required, it is essential that MIT take the necessary steps to identify and respond to the long-term trends that appear to be at the root of the present problem, so that the values of intellectual openness and administrative flexibility can be preserved in the future. Adjusting to what appear to be some basic changes in the role of science and technology in today's society requires the formulation of a longer-term institutional response, including a fundamental review of our educational programs in this context. Such issues should be high on the Institute's agenda in the coming year.

Career Choice Survey

A survey was distributed to upperclass students on spring term Registration Day, in order to better understand those factors that are most influential in helping students arrive at their choice of major. (The survey was developed by a task force consisting of T. Allen, chair, L. Bailyn, L. Gould, M. Richardson, B. Simmons, and D. Wiley.) Professor Thomas Allen undertook an analysis of the survey responses and highlighted the following: a) Many students choose their major field of study before coming to MIT (39 percent overall, 48 percent of EECS majors). b) Students are strongly influenced by career issues and perceptions of the job market when choosing a major (but there appears to be some misinformation regarding differences between fields). c) A number of characteristics of the MIT environment are instrumental in influencing or reconfirming the decision about major, such as the department's reputation, experience in specific subjects, and other students. d) Part-time or summer jobs, as well as hobbies, that expose students to the field of electrical engineering or computer science have a significant effect on directing students who major in those fields. e) "Fascination with the subject matter/enjoyment of work in the field" was cited most frequently by students in the various departments as having had a strong influence on their choice of major. It is reassuring that students are choosing on such a basis -- if this response is not an after-the-fact rationalization of the decision. A full report on the survey findings will be available in the fall.

Broadening MIT's Application Requirements

In an effort to broaden the pool of applicants to get the best students possible into MIT, as well as to help MIT utilize its resources for undergraduate education more efficiently, a proposal was made at the February Faculty Meeting to replace the admissions requirement of a year each of high school chemistry and physics with the requirement of two years of laboratory science. It was felt that the core science requirements at MIT would continue to provide a sufficiently strong message about the special character of an MIT education and the importance of high school preparation in the basic sciences, but some faculty members expressed concern that the proposal would alter the perception of MIT as a rigorous, science-based institution and that the change would adversely affect the quality of high school science education.

Subsequent discussions led to Faculty approval of a modest change in the Faculty Regulations which will allow, in an explicit way, exceptions to the secondary school preparation normally expected of MIT applicants. A set of guidelines also was adopted by the Faculty in order to specify more precisely what is intended by the change. The new policies will allow the catalogue and other publications to be more welcoming to high-caliber students who have not met the normally expected high school preparation in every detail -- and thus the Admissions Office staff will be able to accomplish objectives similar to those under the original proposal. Admitted students will be qualified to do the rigorous, science-based work MIT requires of its students, but the change offers some flexibility in diversifying the academic interests among our students. A comprehensive review and evaluation of the change will be undertaken by the CEP during the 1988-89 academic year.

Structure of the Undergraduate Program

Last year's annual report discussed in some detail the need to examine fundamental questions about the General Institute Science Requirements (including the content of the freshman year) and about the appropriate balance in the undergraduate program between professional goals and those that are broader, more liberal in character. Preliminary discussions in the fall to plan a review of the freshman science core revealed little general agreement on the extent to which there is a problem, as well as resistance to undertaking a major review in the absence of a groundswell of significant concerns. Thus, it was agreed to look first at the overall structure of the undergraduate program, the roles of the various components, and their coherence. The minimum goal is to clarify Faculty Regulation 2.82, which defines the various parts of the undergraduate program.

A set of questions was framed in April in order to obtain departmental views on various issues concerning the structure of the undergraduate program. The letter to departments raised a number of concerns. a) It questioned whether MIT's core requirements and departmental programs are responding appropriately to meet the future needs suggested by current trends and developments. b) It suggested that the goal of bringing students to the ever-expanding forefront of their professional fields produces pressure on the curriculum which conflicts with the desirability of providing students with time for elective choice, for reflection,

and for taking part actively in our rich and diverse community. c) It raised concerns about the sophomore year. More specifically, when the Science Distribution Requirement was established in the mid-sixties, its goal was to broaden students' opportunities for exploring various careers before making a professional commitment; the sophomore year was to be "a year of tentative commitment and controlled flexibility" for students. Many departmental programs have subsequently absorbed the Science Distribution Requirement by requiring specific subjects -- leading to a general feeling that intense professional specialization must begin with the sophomore year (if not earlier), changing the character of that year from what was intended.

Departments were asked to comment on: a) the appropriate content of the science core, b) implications of abolishing the Science Distribution Requirement or changing it to achieve different educational goals, c) sensible ways to specify the boundaries of departmental programs (e.g., in terms of both credit units and subjects), including constraints imposed by accreditation requirements, d) making it the normal practice that students do not formally declare their departmental major until the middle of the sophomore year, and e) the appropriate focus of the Laboratory Requirement in meeting general and/or professional education goals. Departmental responses will be summarized over the summer in a report, which will help guide both the direction and the intensity of continuing CEP actions on these matters next fall.

End-of-Term Pace

The findings of a survey conducted in December 1982 to help understand the pace at the end of the term were reported to the Faculty last April. It was found that excessive end-of-term pace/pressure, and its detrimental effect on performance, appear to be a significant problem for both undergraduate and graduate students. The last week of classes is especially stressful because students often are expected to complete numerous papers, lab reports, and projects, while at the same time prepare for final quizzes that week and/or final exams the next week. A CEP subcommittee (L. Gould, chair, C. Canizares, S. Smith, D. Wiley, N. Wilson) framed some specific recommendations that were based in part on student and faculty responses to the April summary report. The proposals keep the end-of-term calendar and regulations simple and reasonably consistent with the wide range of teaching and learning styles at MIT, yet address, with minimal changes, the more significant concerns about end-of-term pace/pressure currently experienced by students.

Basically, two changes were made: a) All classes will end on the Thursday of the last week of classes, in order to provide a longer unencumbered reading period for students in preparing for final exams; and b) exams and assignments during the last week of classes will be restricted, which will distribute the end-of-term work somewhat better and provide a less abrupt entry into the reading period. Associated with the formal change in Faculty Regulations is the strong expectation that, during the first three weeks of the term, students will be provided complete descriptions of the requirements in each of their subjects, including due dates for required work and the schedule of exams during the term; this is essential so that students can effectively manage their work throughout the term. The changes, approved at the February Faculty Meeting, take effect in the fall term of 1984.

Project Athena

The CEP had several discussions with the Project Athena leadership during the year. Substantive issues focused around the CEP's role in the areas of evaluation and oversight. It was generally agreed that a serious evaluation effort should be built into Project Athena, but that the CEP was not the appropriate group to undertake it. The Provost convened a committee of faculty members who will take general responsibility in the area of evaluation, particularly of Project Athena's impact on the overall educational environment and sociology at MIT. Because of its educational responsibilities and its representative role as a Faculty Committee, the CEP feels that it has an important oversight function to fulfill with respect to understanding the impact of Project Athena on the educational programs at MIT, including significant aspects of the freshman year. This role will be assumed initially by having two CEP members (Professors Leonard Gould and Aaron Fleisher) serve as liaison representatives to the IBM and DEC resource allocation committees. The oversight function may develop further as Project Athena takes a more concrete shape.

Catalogue Review

The ad hoc catalogue committee (described in last year's report) completed its review of the catalogue this year by developing guidelines and objectives for presenting more effectively MIT's departmental degree programs and opportunities in Chapter VI. Several studies suggested that many departments had not updated their descriptions in recent years, and that the way the catalogue is used -- in conjunction with other available information -- did not justify the level of detail and comprehensiveness found in some departmental descriptions.

Other CEP Actions

The CEP discussed concerns that had been raised about some of the ROTC scholarship procedures, which appeared inconsistent with general Institute policies. Efforts are under way by the ROTC Committee to clarify some of the issues and to strengthen the links among the Office of the Dean for Student Affairs (ODSA), the Student Financial Aid Office, the ROTC Program, and students in addressing the concerns that have been raised.

The CEP reviewed and approved (as a three-year educational experiment) the Integrated Studies Program, a special freshman program centered in the Program in Science, Technology, and Society. The basic goals are to provide for a group of about 50 freshmen an educational setting which emphasizes the connections of the scientific disciplines with their historical and cultural contexts and their applications to human needs, and to do this in surroundings which create the spirit of a closely knit learning community among the participating students and faculty.

Among other actions this year, the CEP: a) discussed with staff members from the ODSA concerns about academic honesty and the need for greater clarity on the issues and procedures, particularly regarding student collaboration on work that is graded; b) concurred with the Committee on Academic Performance's view that the regulations regarding the completion of "Incompletes" be followed, with special emphasis given to the importance of negotiating an agreement between the student and instructor; c) approved and forwarded to the Faculty changes proposed by the Department of Chemistry in the subjects that can satisfy the General Institute Requirement in Chemistry; and d) developed policies and procedures for severely limiting the ability of transfer students to switch their registration into departments that have an overenrollment problem.

Other Faculty Committee Reports

Several chairs of the Faculty Committees have submitted summaries of the major agenda items addressed during the past year, excerpted as follows:

The Committee on Academic Performance (CAP) reviewed most of its procedures and made decisions on the following issues: a) only the end-of-term summaries and grade reports of students enrolled in ROTC should be provided to the ROTC staff; b) the CAP will enforce the faculty regulation on the completion of an Incomplete with respect to graduating seniors as well as all other undergraduates; c) individual departments and the Dean for Student Affairs, rather than the CAP, should take the responsibility for advising students required to withdraw for academic reasons regarding their plans and programs while away from MIT; and d) the CAP endorsed the new procedures for the withdrawal of undergraduates for financial reasons.

In addition to its routine business, the Committee on Curricula approved the curricula for the new freshman-year Integrated Studies Program and changes in subjects satisfying the General Institute Chemistry/Biology Requirement, as well as participated in the catalogue review. Future consideration will be given to the following: the growing practice of requiring graduate subjects in undergraduate programs, concerns about the Chemistry/Biology Requirement, and uncertainty about the use of Wellesley subjects for HUM-D credit.

The work of the Committee on Discipline consisted of adjudicating a number of specific grievances brought to its attention by members of the MIT community.

The Committee on Undergraduate Admissions and Financial Aid dealt with three major issues this year: a) In the area of financial aid, the chairman of CUAFA was a member of the Academic Council Task Force on Financial Aid, which has spent the past two years reviewing our current need-based financial aid system, as well as assessing the future costs and impacts of our current system and possible modifications. This group will be reporting to the Faculty next year. b) CUAFA was very active in discussions aimed at easing the enrollment pressure in EECS. Enrollment restrictions at the time of admission, although unpalatable, seemed to be the preferred alternative. The Committee also participated with Admissions Office staff in revisions of "MIT Today" and the admissions application form; the revisions were directed toward broadening the career aspirations of entering students, informing them that access to certain departments may be restricted, and improving the information we have about applicants' interests and activities. c) As part of the discussion of increased diversity of student interests, CUAFA considered policies to increase the recruitment and enrollment of transfer students, and prepared a report which advocates a modest increase in transfer students. It was a pleasure for CUAFA to work this year, in trying times, with the Director of Admissions, Peter Richardson. His announced retirement heightens our awareness and appreciation of his contributions to MIT.

With the September 1983 implementation of the Institute Writing Requirement, the Committee on the Writing Requirement has moved into a supervisory role, overseeing the smooth functioning of the four options of Phase I, as well as exploring possible options for Phase II. The Committee spent much of the year defining this second phase and meeting with many Institute departments to help them create alternatives for their

majors to satisfy Phase II, particularly in those cases where options are not readily available. Questions of standards remain the Committee's most serious policy issue; a statement of standards will be disseminated next fall and an Institute-wide board of evaluators is being set up to resolve disputes.

The major agenda items discussed by the Committee on Industrial Liaison were the following: a) problems in hiring Industrial Liaison Program (ILP) officers, including consideration of establishing internships in the ILP for MIT students in order to provide a source of properly qualified candidates; b) the possibility of accepting into membership interested, but geographically remote, companies which could not be given the level of service traditionally provided by ILP through existing ILP offices; c) the possibility of tapping new types of companies which would be of interest to departments such as Architecture and Urban Studies and Planning; and d) the opportunity and challenge offered to ILP by the increase of "Collegia."

The Committee on the Library System devoted most of its discussions to two related topics: a) the impact of budget cuts on library programs, including in particular the effects of staff reductions, increased fees for services, cancelled subscriptions, and changes in the operation of the Student Center Library and various reading rooms, and b) the five-year plan of the library staff -- which left the Committee concerned about the probable continued divergence between anticipated resources and perceived needs in an era of exploding growth and change in library materials and technologies.

The Committee on Outside Professional Activities devoted most of its attention to investigating confidential matters pertaining to faculty conflict of interest and to advising faculty and administrative staff in this regard. Some minor revisions were made in relevant sections of "Policies and Procedures" and the new statement was circulated to the faculty.

Professor Philip Morrison was named the Killian Faculty Achievement Award Lecturer, and Professors Joshua Cohen and Jae Soo Lim were recipients of the Edgerton Faculty Achievement Award.

Sincere appreciation is extended to the following faculty members for their special contributions and service as appointed chairs of the Standing and Special Faculty Committees during the past year: William Kaufmann (Academic Performance), Alvin Drake (Curricula), Elias Gyftopoulos (Discipline), Steven Lerman (Faculty-Administration), Eric von Hippel (Industrial Liaison), William Siebert (Library System), Richard Cartwright (Nominations), Thomas Sheridan (Outside Professional Activities), Campbell Searle (Student Affairs), Sheila Widnall (Undergraduate Admissions and Financial Aid), Kenneth Hoffman (Writing Requirement), Herman Eisen (Killian Award Selection Committee), and Anthony French (Edgerton Award Selection Committee).

The following retired from the CEP at the end of (or during) the 1983-84 academic year: Professors Allan Henry, Jean Jackson, Kenneth Keniston, Thomas Kochan, Kenneth Manning, Phillip Sharp, Leon Trilling, and John Waugh, and student members Donald-Bruce Abrams, Steven Barber, Stephen Smith, and Joyce Whang. Their contributions are greatly appreciated. We also especially thank Professor Sheila Widnall for her extraordinary contribution of energy and insight in helping the CEP address various aspects of the enrollment imbalance problem.

ARTHUR C. SMITH
DAVID S. WILEY

School of Architecture and Planning

Over the past year the planning needs of the Institute and the School have converged on the preparation of five-year plans. For the School, this is part of a process begun earlier to review curriculum relative to the future of the professions, to alleviate the burdensome debt-to-earnings ratios of students, and to upgrade inadequate and deteriorating physical facilities.

While enrollment trends have remained about steady in architecture and planning, changes in the make-up of our applicant pools continued to cause concern. The drop in minority planning applicants, reported last year, was not reversed. The Master of Architecture program experienced a noticeable drop in the number of qualified applicants. And we continue to hear from accepted students who choose other schools that cost is an important factor.

Such evidence underlined the urgency of increasing the financial resources the School makes available to students and raising their earning power. At the same time the School must maximize the use of existing resources within constraints that have included the Institute's required seven per cent budget cut for the three-year period ending in 1985.

EDUCATIONAL INITIATIVES

The School's efforts to respond to financial pressures on our graduates as well as to the changing demands of our professions yielded substantial achievement. This process of change was seen in new and redirected academic programs.

Real Estate Development

In December 1983 the MIT faculty approved a new master's degree in real estate development planning and management, the Master of Science in Real Estate Development. The academic program for this degree begins in the fall of 1984 and draws on a collaboration of faculty in the School with faculty from the Department of Civil Engineering and the Sloan School of Management. The program is designed to be completed in 12 months by students with some prior experience in the field, or to be taken as a specialization by students pursuing architecture and planning degrees. The first class of students was admitted to the Master of Science in Real Estate Development Program in April. Thirty-six students were offered admission from a group of 225 applicants. The students are highly talented and diverse. The group averages 29 years in age and includes lawyers, architects, planners, accountants, and engineers.

As a companion to the new degree program, the Center for Real Estate Development was formally created at an inaugural conference, attended by 1200 people, on September 27, 1983. The conference drew participants from throughout the country, and addressed the changing character of the development process in the next decade. The Center also sponsored three other major events: A seminar featuring former Boston mayor Kevin White and Mr. Daniel Rose, a major New York developer, discussing public-private partnerships in the redevelopment of central cities; a seminar with Mr. Ernest Hahn of Ernest W. Hahn, Inc., and Mr. Gerald Trimble, Executive Director of the San Diego Centre City Development Corporation, discussing the joint efforts of the developer and the city to revitalize San Diego's decaying downtown; and a full day colloquium on zoning co-sponsored with the Lincoln Institute for Land Policy.

During its first year the Center has also launched a major research program. Projects underway include a study of new downtown retail facilities such as Boston's Quincy Market and Baltimore's Harborplace, a study of the relationship between design quality and building performance, the development of a series of models to predict changes in the demand for commercial space, an evaluation of an innovative private sector program to develop low and moderate income housing, and a study of research and development expenditures in the Japanese building and construction industry.

During summer 1984 the Center sponsored three advanced management courses, open to the general public. Topics included Microcomputer Applications to Real Estate, Managing Risks in Real Estate Development, and Understanding Urban Office Markets.

The Center's activities have been supported through the participation of 65 member companies. The Center's membership program, which is modeled on the Industrial Liason Program, encourages contact and exchange between member companies and the Center's faculty. A fundraising drive to establish an endowment for the Center is also under way.

The Center has been ably led through this challenging formative period by Charles H. (Hank) Spaulding '51, who has very generously donated his time and a considerable gift in funds to the task of establishing

the Media Laboratory will house existing and long-term research sponsored by Nippon Telegraph and Telephone and Japan's Public Broadcasting Corporation, NHK, as well as research in advanced television supported by a consortium of American broadcasters and TV equipment manufacturers.

Computer Resource Laboratory and Project Athena

With the advent of the Institute's Project Athena, the School was able to put in place the components of a joint architecture and planning computer laboratory for teaching and curriculum development, which opened in temporary quarters (the Emerson Room) in the spring. The laboratory will provide training already in demand and likely to become more important to practice in the next decade.

Undergraduate Program

Enrollment of undergraduate majors has tended slightly downward in architecture and strongly downward in urban studies. The fall-off in planning majors is explained generally by the fact that ten or so years ago urban issues were more conspicuous, though no more important, than they are today. We continue, however, to have a large number of undergraduates registered in our subjects for their humanities distribution requirements.

The Department of Architecture intends to develop and expand undergraduate offerings, especially in the area of Media Arts and Sciences. The Department of Urban Studies and Planning has joined with the Institute's other social science divisions, also experiencing major fall-offs in undergraduate majors, to look at new options, including consolidation.

Research Support

The research support provided through the Laboratory of Architecture and Planning (LAP) is a key element in our strategy to increase student aid. We have, therefore, decided to enlarge the dollar amount of the LAP's research base and to concentrate its topical focus. The LAP will continue its successful continuing education program and administrative support to special programs, while making new development efforts in the area of building technology research.

FUNDRAISING

To meet both education and facility needs, we have been consolidating development plans for raising the considerable outside funds that are necessary to increase the School's endowment and annual giving base. The preparation has included both the study of detailed space improvements and the strengthening of communications within the School and between the School and its professional community.

The School's long-term space planning report, presented to the Administration, contains overall guidelines for moving some School activities out of the central area of MIT so that more effective use can be made of the space that is available there, including expansion of Rotch Library and accommodations for a School lecture, exhibit and social center. Sketch concepts have been prepared for Rotch Library expansion, a School Center, and renovation of N51-52. These plans are being detailed over the summer and will be incorporated in a fundraising campaign scheduled to start in the fall. The School hopes to complete its program of space improvements by 1989.

The School's alumni newsletter, PLAN, now in its second year of publication with a new format and schedule, has brought about dramatic improvement in outside communications. Architext, a Department of Architecture newsletter started in 1983, and DUSP News continue as lively and fortnightly purveyors of departmental news. We are also redesigning and developing other publications and a program of School-wide events, which will define and extend our sense of community. A student-faculty committee are coordinating a selected program of public lectures and exhibits, with student work commencing this summer on a new exhibition area. Already in place for our use is a new cafe, designed and constructed by students and located on the fourth floor of Building 7. Another committee has begun work on an exhibit and symposium that in 1986 will complement a visiting retrospective exhibition of Alvar Aalto's product design.

PUBLIC LIFE

During the summer and fall of 1983 a research team of the Laboratory of Architecture and Planning planned and staffed the design programming phase of a national competition for the redesign of Boston's historic Copley Square. The result of their work was an informed competition program that translated community concerns into design requirements, including guidelines described by the competition jury as "detailed" and "rigorous" and representative of "the needs of the ultimate clients, the people of Boston."

Boston's recent transformation and future development were subsequently the subject of three public forums and a conference held in the spring with the joint sponsorship of MIT, The Boston Globe and other universities and professional societies. The events, designed and managed by School research staff, involved planners and architects, officials, and citizens in a debate on Boston's physical form,

the program. Professor Larry Bacow, as Associate Director for Education and Research, is responsible for coordinating educational activities for the new degree program.

In the fall, the Center will move into new quarters on the third floor of the Armory (W31). The new facilities, which have been designed by Professor Emeritus Eduardo Catalano, will house a classroom that will seat 80 students, a seminar room, a computer laboratory, a student reading room, and exhibition space, as well as faculty and administrative offices.

Developing Areas

The Department of Urban Studies and Planning will offer a new degree option, emphasizing city and regional planning in developing areas throughout the world, beginning in fall 1984. Intended as an alternative track to the existing Master in City Planning (MCP) curriculum, the MCP/Developing Areas program will center on development and planning problems of particular relevance to countries in Africa, Asia, the Middle East, Latin America, and the Caribbean basin. Although the department has for some time had a specialization in developing areas, the new degree program responds to problems that call for new skills, ideas and techniques and that create a need for additional practitioners and scholars throughout the developing world.

The School is without peer in its ability to call on a rich knowledge and experience in the issues of planning in developing areas. The Special Program in Urban and Regional Studies (SPURS), for instance, in its seventeen years has hosted a year of study at MIT for some 200 mid-career professionals who have gone on to fill policy-making positions in national, regional and local planning agencies around the world. In June SPURS offered its first summer course of special interest to developing-countries planners. Some 47 attendees represented 21 countries.

Also aimed at professionals in developing areas is a seminar series directed by the Aga Khan Program for Islamic Architecture. This past year these seminars were held in Cambridge, MA, Singapore, and Tunis. And throughout the year the Special Interest Group in Urban Settlements (SIGUS) ran a program of conferences and lectures, which brought together interested students from the MIT and Harvard communities.

Public Management

Faculty and students working in the public policy arena increasingly find their attention concentrated on issues of public management. The delivery of urban services, the distribution of resources and its concomitant management of conflict and negotiation, a renewed demand for large-scale physical planning, and increased consideration of infrastructure redesign are among the many components that generate the need for new understanding and skills in public management. In response, the Department of Urban Studies and Planning is developing a curriculum around a proposed degree option, MCP/Public Management. This would involve bringing together contributions from DUSP, the Department of Political Science, the Sloan School of Management and the Operations Research Center. A prospectus for possible foundation support is being prepared over the summer.

Media Arts and Sciences

The year began with the creation of a new interdisciplinary research laboratory, called the Media Laboratory, and the naming of its director, Professor Nicholas Negroponte. The laboratory is a coalition of faculty from the Schools of Engineering, Humanities, and Architecture and Planning and will become a major occupant of the new Arts and Media Technology Building, nearing completion on the East Campus. Support for the activities of the Media Laboratory ranges across the Institute and draws upon the energy and imagination of those interested in education, communication and the arts. The academic program in media arts and sciences, currently represented by the Department of Architecture's Master of Science in Visual Studies degree program, is being expanded to include a new Ph.D. in Media Arts and Sciences. A nation-wide search led to three new faculty appointments in this area. This area of study is expected to attract not only graduate students, but also undergraduates in increasing numbers. Increased research volume and student population in media arts and sciences will account for the major faculty growth in the School in the next five years.

The ten groups and their respective leaders currently making up the Media Laboratory are advanced television (Professor William Schreiber), electronic publishing (Professor Andrew Lippman), human-computer interface (Dr. Richard Bolt), computers and graphics (Professor Muriel Cooper), learning research (Professor Seymour Papert), imaging technologies (Professor Steven Benton), film and video (Professor Richard Leacock), telecommunications (Professor Jerome Wiesner, Acting), computer music (Professor Barry Vercoe), and computers, theater and entertainment (Mr. Marvin Denicoff).

The \$30 million Arts and Media Technology facility includes an additional \$10 million in new hardware for media research, to which Wang, DEC, RAC, and NEC have generously contributed, respectively, office automation, scientific computing, video, and signal processing equipment. The year concluded with the signing of a three-year \$1.8 million research agreement with IBM for work in home computing. In addition,

especially with respect to the condition and appearance of its public realm. Attention focused on three sites chosen for their importance to Boston's future development: the financial district and the waterfront, Copley Square, and Boston's inner-city neighborhoods. Extensive newspaper and television coverage attended all the events, and the Globe will publish a supplement in the fall based on the findings of the conference.

VISITING COMMITTEE

In April a well-attended Visiting Committee meeting reviewed the School's educational programs and its plans for student aid, space, and fundraising. High marks were given to the School's directions and future plans. At the same time, concern was expressed about progress in minority admissions and faculty appointments and about the potential for the media technology and real estate programs to flourish while the traditional core programs become poorer in both dollars and the quality of applicants.

JOHN de MONCHAUX

STUDENT ENROLLMENT AND COMPOSITION 1983-84

| <u>Department of Architecture</u> | <u>Total</u> | <u>Women</u> | <u>%Women</u> | <u>Minority</u> | <u>%Minority</u> | <u>Foreign</u> | <u>%Foreign</u> |
|---------------------------------------|--------------|--------------|---------------|-----------------|------------------|----------------|-----------------|
| Undergraduate | 69 | 29 | 42% | 4 | 6% | 0 | 0% |
| M.Arch. | 100 | 38 | 38% | 9 | 9% | 8 | 8% |
| S.M.Arch.S. | 71 | 22 | 31% | 0 | 0% | 47 | 66% |
| S.M.Vis.S. | 45 | 17 | 38% | 2 | 4% | 4 | 9% |
| Ph.D. (resident) | 14 | 3 | 21% | 0 | 0% | 7 | 50% |
| Special Students | 9 | 7 | 78% | 0 | 0% | 4 | 44% |
| Jt. M.Arch./M.C.P.* | 0 | 0 | 0% | 0 | 0% | 0 | 0% |
| Jt. S.M.Arch.S./M.C.P.* | 5 | 4 | 80% | 0 | 0% | 4 | 80% |
| <u>Architecture Totals</u> | 313 | 120 | 38% | 15 | 5% | 74 | 24% |

Department of Urban
Studies and Planning

| | | | | | | | |
|--------------------|-----|----|-----|----|------|----|------|
| Undergraduate | 8 | 4 | 50% | 1 | 12% | 0 | 0% |
| M.C.P. | 78 | 44 | 56% | 22 | 28% | 7 | 9% |
| Ph.D. (resident) | 44 | 20 | 45% | 5 | 11% | 22 | 50% |
| Jt. M.C.P./M.Arch. | 4 | 3 | 75% | 2 | 50% | 0 | 0% |
| Special Students** | | | | | | | |
| SPURS*** | 15 | 5 | 33% | 0 | 0% | 15 | 100% |
| CFP | 4 | 2 | 50% | 4 | 100% | 0 | 0% |
| <u>DUSP Totals</u> | 153 | 78 | 51% | 34 | 22% | 44 | 29% |

School

| | | | | | | | |
|-------------------------|-----|-----|-----|----|-----|-----|-----|
| Undergraduates | 77 | 33 | 43% | 5 | 7% | 0 | 0% |
| Graduate | 361 | 151 | 42% | 40 | 11% | 99 | 27% |
| Special Students | 28 | 14 | 50% | 4 | 14% | 19 | 68% |
| <u>TOTAL ENROLLMENT</u> | 466 | 198 | 42% | 49 | 11% | 118 | 25% |

* Joint degree students are also counted in the degree programs in which they registered.

** Non-degree

*** Special non-degree programs in the Department of Urban Studies and Planning: the Special Program for Urban and Regional Studies of Developing Countries (SPURS), begun in 1967; and the Community Fellows Program (CFP), established in 1971.

FACULTY, OTHER ACADEMIC STAFF, AND RESEARCH STAFF -- 1981-82, 1982-83, 1983-84

| | 1981-82 | | | | 1982-83 | | | | 1983-84 | | | |
|--|--------------|---------------|--------------|-----------------|--------------|---------------|--------------|-----------------|--------------|---------------|--------------|-----------------|
| | <u>Total</u> | <u>E.F.T.</u> | <u>Women</u> | <u>Minority</u> | <u>Total</u> | <u>E.F.T.</u> | <u>Women</u> | <u>Minority</u> | <u>Total</u> | <u>E.F.T.</u> | <u>Women</u> | <u>Minority</u> |
| <u>Architecture</u> | | | | | | | | | | | | |
| Faculty | 34 | 28.5 | 4 | 1 | 34 | 28 | 3 | 1 | 39 | 33 | 3 | 1 |
| Other Academic Staff | 59 | 25 | 14 | 1 | 41 | 21 | 6 | - | 27 | 13.5 | 4 | - |
| Research Staff | 7 | 6.5 | - | - | 8 | 8 | - | - | 6 | 6 | - | - |
| Without Pay | 14 | 10 | 3 | - | 7 | - | 2 | - | 11 | 7 | 5 | - |
| <u>DUSP</u> | | | | | | | | | | | | |
| Faculty | 28 | 23.5 | 4 | 4 | 27 | 24.5 | 5 | 4 | 26 | 24 | 5 | 4 |
| Other Academic Staff | 16 | 6.25 | 1 | 3 | 12 | 5.8 | 3 | 2 | 15 | 5.9 | 3 | 1 |
| Research Staff | 3 | 2.2 | - | - | - | - | - | - | - | - | - | - |
| Without Pay | 6 | - | - | 1 | 15 | - | - | 1 | 17 | - | 3 | 2 |
| <u>Laboratory of Architecture and Planning</u> | | | | | | | | | | | | |
| Faculty | - | - | - | - | - | - | - | - | - | - | - | - |
| Other Academic Staff | 2 | 2 | - | - | 2 | 2 | - | - | 2 | 2 | - | - |
| Research Staff | 8 | 4 | 5 | - | 9 | 8 | 6 | - | 12 | 4 | 8 | - |
| Without Pay | 11 | 8 | 5 | - | 7 | 5 | 2 | - | 11 | 8 | 3 | - |
| <u>SCHOOL TOTALS</u> | | | | | | | | | | | | |
| Faculty | 62 | 52 | 8 | 5 | 61 | 52.5 | 8 | 5 | 65 | 57 | 8 | 5 |
| Other Academic Staff | 77 | 33.25 | 15 | 4 | 55 | 28.8 | 9 | 2 | 44 | 21.4 | 7 | 1 |
| Research Staff | 18 | 12.7 | 5 | - | 17 | 16 | 6 | - | 18 | 10 | 8 | - |
| Without Pay | 31 | 18 | 8 | 1 | 29 | 5 | 4 | 1 | 39 | 15 | 11 | 2 |

Department of Architecture

The organizing effort of this academic year has been the formulation, at Institute request, of a five year plan for the Department. The Department's five year objectives are embedded in those of the School of Architecture and Planning as a whole, and the plan was created in concert with other elements represented on the School Council.

The purpose underlying the plan is to continue energetically to develop theory in a field significantly lacking it, to undertake with increased energy to share our views in the wider world of architectural education and practice, and to continue to provide training to enable our graduates to enter the world of practice.

Objectives more sharply focussed in the planning process are increased collaboration within and among programs, further development of a research tradition in the Department, increased engagement of academic programs with issues of current and future professional practice, and effective action on issues of gender and race within the Department.

Within the Department, valuable input in the previous year from the National Architectural Accrediting Board evaluating team, the School Visiting Committee, and internal curriculum review committees has resulted in revisions in four degree programs, with the fifth, the undergraduate Bachelor of Science in Art and Design (BSAD) program slated for review in 1984-85.

Attention to the professional Master of Architecture (MARCH) curriculum as the center of the Department has been foremost, and the issue of diversity in design studio teaching has been a key element in the planning process. A committee of senior design faculty was convened this year to assess areas in which increased range of design theory is necessary and desirable, and to make a proposal for achieving appropriate diversification. Their report, expected in summer 1984, will serve as the base for further program development in fall 1984.

Several initiatives support the Department's intention to strengthen teaching and research activity in architectural technology and connections with building technology activity across the Institute: a search now underway for a senior faculty member to head the Building Technology program; focus of the Laboratory for Architecture and Planning effort on building technology research; and creation of a new career development chair in building technology, made possible by a gift from George Macomber.

Establishment of the Media Laboratory, whose academic component resides in the Department, will have marked effect in the next five years, in particular on the Master of Science in Visual Studies (MSVS) degree program. Increased faculty size, the addition of new areas of teaching and research in Media Arts and Sciences (MAS), and the affiliation of allied efforts across MIT to the Lab's work suggest growth and diversification within the MSVS program and will serve as the base for a new PhD stream in MAS begun this year.

A number of new programs have been put in place this year, in collaboration with the Department of Urban Studies and Planning (DUSP) and others. The Center for Real Estate Development (CRED), established by DUSP, with Architecture, Civil Engineering, and the Sloan School, will offer students significant opportunity, through its teaching and research, to address issues in this central realm of decision making in current practice. The School Computer Resource Laboratory (CRL) became operative this year, supporting Architecture and DUSP in their teaching and research and in training community members in computer use. As a beginning, a new subject, Computers in Architecture, developed and taught by Professor Patrick Purcell and Mr. Frank Miller, attracted more Course IV students from all programs than it could enroll. Support to be forthcoming from Project Athena should bring the CRL more nearly up to the ability to meet School needs.

Increased activity will occur in design and planning for developing areas, an area of study to which the Department has a long-standing commitment. The addition of a senior Professor in Architecture and Design for Islamic Cultures, through the Aga Khan program, and the proposal of a new concentration in the Master of Science in Architectural Studies

(SMArchS) program in Design for Islamic Cultures, expand the opportunities for work in the field. Finally, collaborative work between SMArchS Housing and Settlement faculty and students and the new DUSP Master's program concentration in developing areas will begin in the new academic year.

The Department participated with School Council in the development of a fundraising plan to address two critical and perennial areas of need: financial support for students, who continue to be constrained by high tuition costs and low starting salaries, and for upgrading the School's inadequate and dilapidated space. The first priority space improvement is expansion of Rotch Library, which needs double its present area. A feasibility study for expansion of Rotch Library has been prepared by Professor Imre Halasz, as have studies for a School Center (by Professor Jan Wampler) and renovation of school spaces in Building N51-52 (by Mr. Shun Kanda).

Finally, it should be noted that the considerable energy and talent of Department students were turned to a number of tasks this year with wonderful results. An editorial board of Course IV students produced an internal newsletter, Architext, which appeared monthly through 1983-84. Women students have formed Women in Architecture, whose work addresses gender issues in Department teaching and administration. With Department and Institute support, the group has launched efforts to establish a network of women in architecture nation-wide and create a resource base from which to research the impact of gender on design, to assist in identifying potential women and minority faculty particularly in design, and to identify participants in lectures, seminars, and a possible new subject in women's studies. And student designer/builders, who found support from the Department, MIT's Physical Plant and the President's Office, created the beginning of a school center in the form of a coffee house on the fourth floor of building seven. It is hoped that the attractive and popular common public space for the School can be expanded over this summer to include exhibition facilities.

PROGRAMS

In 1983-84, the Department had a total of 299 regular students and 18 non-resident and special students in its five degree programs. Enrollments in PhD (23), SMArchS (71), MSVS (45) and MARCH (103) remained relatively stable, and BSAD (69) continued the downward trend of the last ten years. Of the total student population, 26 percent are women, three percent are minority, and 23 percent are international. There were 501 applications for admission to the Department in fall 1984, with PhD applications increased due to the new Media Arts and Sciences concentration announced this year, and a 16 percent drop in applications to the MARCH program.

Master of Architecture (MARCH)

The ratio of applications for admission to the professional (MARCH) program to available places remains high, 235/31; however, a drop is noted in applications from 280 the previous year. MARCH admissions was chaired by Professor Leon Groisser with the active involvement of eight members of the design faculty and six MARCH students. The Department continues to enroll a high percentage of women students (38 percent in 1983-84), one of the highest among accredited schools of architecture in the country. The trend for Department pre-professional (BSAD) graduates to elect to study for professional degrees at other universities continued this year.

Curriculum reformulation begun last year was continued by three program committees. Proceeding from a report from the Future of the Professor Committee (Bruce Anderson, chair), a committee led by Dean Emeritus Lawrence B. Anderson made a study of professional practice in the building industry, including office and construction management. Its report is expected to result in a new subject offering in fall 1985. The MARCH curriculum committee suggested development of a platform subject in visual training especially for architects, in response to the migration of department visual studies teaching to the Media Arts and Sciences. A seminar of design teachers and other department faculty, chaired by Professor Maurice Smith, was therefore convened in spring 1984. Participants shared views on form organization and visual literacy, with the object of formulating an appropriate curriculum for a new subject expected to be offered in spring 1985. Finally, a faculty study group, (Professors Robert Slattery and Wampler, co-chair), was constituted to formulate strategies for appropriate diversification in design studio teaching, utilizing existing faculty resources and projecting needs for additional staff. The objective is to widen the range of design theory offered and to maximize connections of design teaching to other components of MARCH and other Department programs.

The student lecture series offered a slate of speakers including Boston architect, Graham Gund, Adele Santos, chairman of Architecture, University of Pennsylvania, Dolores Hayden, UCLA, and a number of Department faculty, who made presentations of recent work.

Six MARCH students were commissioned during the summer of 1983 to redesign and rennovate the Margaret Cheney Room, a lounge, study and kitchen facility for Institute women students. The designer-builders were Pat Harris, Kim Sammis, Lee Olsen, Susan Steubing, Jane Katz and Margaret Lew.

Awards to graduating MARCH students were as follows: Francis Ward Chandler Prize to Richard Furman and Jeff Schoellkopf; William E. Chamberlain Prize to Keith Giamportone and Barbara Thornton; the Alpha Rho Chi Medal to Ann Compton; the AIA Certificate of Merit to James Edgcomb; the AIA Medal to Dennis Carlberg. In addition, Stephen Baker was awarded a Peter J. Eloranta Fellowship by the Institute for travel and study in Europe in summer 1984.

Master of Science in Architectural Studies (SMArchS)

The post-professional program, SMArchS, enrolled 71 students in fall 1983, for study in Housing and Settlement Design, Building Technology, Environmental Design, and History, Theory and Criticism (HTC). As in the past, the program attracted a significant number of international students (72 percent of the program's total). Applications for admission for 44 available places remain high (127). Professor Julian Beinart chaired the program.

The Building Technology Group, led by Professor Eric Dluhosch, organized a two-day meeting of faculty in architecture, planning and engineering and representatives of the building industry, finance and government at MIT's Endicott House in June 1983. The symposium, funded by a gift by John F. Hennessy (MIT '51), engaged the subject of economic problems of innovation in the building industry and their implications for education and research. Proceedings of the symposium will be forthcoming in summer 1984.

Special Interest Group in Urban Settlement (SIGUS) was formed this year, based in Housing and Settlement Design. Coordinated by Professor Nabeel Hamdi and Mr. Reinhard Goethert, SIGUS presented three one-week workshops and a two-day seminar around issues of housing strategies, infrastructure and settlement design. The events, open to SMArchS students and other interested community members, were led by distinguished visitors involved in housing in the developing world.

Awards to SMArchS students: Martin Bressani, in HTC, was the first recipient of the Marvin E. Goody Prize, offered Institute wide for a proposed thesis in building arts. The \$5000 prize, established last year, is funded by a gift to MIT from Joan E. Goody in the name of Marvin E. Goody (MARCH, '51) and former member of the Department faculty. Cheryl Wendelken was awarded the Institute's Ida M. Greene Fellowship for the coming year.

Master of Science in Visual Studies (MSVS)

The MSVS program enrolled 45 students for study with its five member groups: the Architecture Machine Group, Visible Language Workshop (VLW), Center for Advanced Visual Studies (CAVS), Film/Video, and holography/spatial imaging -- a new concentration which admitted three students this year. The addition of new fields of concentration in Media Arts and Sciences through the Media Laboratory will broaden substantially available areas of concentration in the coming year.

A major event attendant on approval of the Media Laboratory was the opening of an integrated search for six Assistant Professors in Media Arts and Sciences. A call for candidates in film/video engineering, computer graphics, and photo electronics, and in three new areas -- personal computation, epistemology and learning, acoustics and audio engineering -- brought response from 168 applicants. A search committee of Laboratory faculty and staff, chaired by Professor Nicholas Negroponte, has recommended three appointments and will continue its search to fill the remaining positions in the next year.

The VLW assumed responsibility this year for teaching the popular creative photography subjects formerly offered in the Creative Photography Laboratory (CPL). Research awards

and equipment gifts were received from Polaroid, Compugraphic, Atari, and Apple Computer. Grants to the VLW from MIT sources included funding from Project Athena to begin an Electronic Journal project for VLW and eventually Institute network use, and from the Council for the Arts for an exhibition program and to preserve the CPL's archive collection. Four exhibits were mounted at the VLW and faculty and student work was shown in a number of outside exhibits, including the ACM/SIGGRAPH National Conference Art Show, July 1983.

Film/Video increased its subject offerings in response to a large demand from both undergraduate and graduate students. The Monday Night Film Series, continuing under a grant from the Louis B. Mayer Foundation, featured screenings of work and discussions with visiting artists. Among many awards to students in Film/Video were: the Laya and Jerome B. Wiesner Art Award in Creative Arts to MSVS candidate, Barry Strongin, and award of the Silver Electra to MSVS student, Steven Konstant, for best videotape at the Birmingham Alabama International Film Festival. MIT's Council for the Arts made grants to two thesis students in the section and to Benjamin Bergery's Workshop in Elastic Movie Time.

Professor Richard Leacock, director of the Film/Video section, and Ms. Glorianna Davenport continued shooting "New Orleans in Transition," a three-year case study of the change in urban environment occasioned by the Louisiana World Exposition. The film, funded in part by the National Trust for Historic Preservation, is scheduled for release in 1985.

PhD

PhD students totalled 23, 14 in residence, 9 non-resident, approximately the same as the past three years. 34 applications were made to HTC, the program's original area of concentration. The new concentration in Media Arts and Sciences, opened this year through the Media Laboratory, drew 39 applications. 11 people were offered admission for study in epistemology and learning, electronic music, and media technology.

Selection of Professor Kurt Forster to head a prestigious study center away from MIT (see Faculty, below) has necessitated the second major search in HTC in three years. A committee, chaired by Professor Stanford Anderson, worked throughout the year and will conclude its search for a faculty person in architectural history early in 1984-85.

The PhD forum continued the practice of inviting local scholars and/or professionals for discussion of current work with doctoral students and interested faculty. Among this year's participants were James Ackerman, Eduard Sekler and John Stilgoe from Harvard. The HTC Lecture Series sponsored five talks for the Department and Institute community by scholars from American and European universities.

RESEARCH

The Department's research volume totalled \$1.4 million in 1983-84; \$1.12 million in research funding was held in the Architecture Machine Group, now a part of the Media Laboratory. The direction of several ongoing contracts was altered, and some new ones initiated as a result of the Lab's formation. Movie Manuals and Color Dynamics, two Office of Naval Research Contracts addressing computer-based communications media for instruction and analysis, are entering their last year and are examples of Architecture Machine Group work that is directly related to the work of the Media Laboratory. Three new programs were begun, funded by Coleco Industries, Nippon Telephone and Telegraph, and Columbia Pictures Industries that address home computing, telephony, and broadcast television piracy. The Graphical Marionette, funded by NHK (Japanese Broadcasting Corporation), is continuing. The balance of Department research was administered through the Laboratory of Architecture and Planning and is described in its report below.

A Department Research Forum in November offered a two-day public presentation of faculty research interests. Areas of inquiry described included both funded and unfunded projects. Written statements, which had generated discussions, were compiled by Professor Edward Robbins and edited into a compendium titled "Research and Inquiry, Architecture, MIT: Personal Concerns and Preliminary Accounts." Professor Robbins also coordinated the research forum.

FACULTY

The Department was shocked and saddened by the unexpected death of Professor Robert B. Newman (MArch, '49) early in the fall term. Professor Newman had been associated with the Department since 1951, teaching a highly regarded subject in architectural acoustics. Richard H. Bolt immediately took up teaching Professor Newman's subject, accepting appointment as Adjunct Professor.

Professor Negroponte returned from leave at the World Center for Microcomputer Science and Human Resources in Paris to assume directorship of the Media Laboratory. Joining the Department faculty in association with the Media Laboratory were Professor Seymour Papert, formerly in the Division of Study and Research in Education at MIT, and Jerome B. Wiesner, Institute Professor and President Emeritus of MIT.

Professor Forster resigned in January 1984 to become Director of the J. Paul Getty Center for the History of Art and the Humanities, Los Angeles. Professor Anne Wagner joined the HTC group in fall 1983 to teach Department and Institute Humanities Distribution subjects in the history of art.

Dennis Frenchman (MArchAS, MCP '76) accepted joint appointment in Architecture and DUSP this year to serve as director of the Environmental Design section of SMArchS. Mr. Frenchman is principal in Lane-Frenchman Associates, a Boston firm responsible for urban design projects throughout the northeastern US.

Visiting appointments to architecture design faculty in fall 1983 were Ravi Sikri (BArch '64), Peter Prangnell, Professor at University of Toronto, and Carmen Corneil, University of Toronto, in spring term.

Professor Horacio Caminos, who joined the Department in 1961, retired in spring 1984. Professor Caminos began in the Department as an architectural design studio teacher, and for the past 16 years has been director of the Settlement Design concentration now contained in the Department's post-professional SMArchS program.

Mr. Kanda, with a team from Kanda Associates, Cambridge, was chosen as one of three winners in the Design Competition for Housing for Families and Older Persons in Agawam, MA, held in September/October 1983. The competition, sponsored by the Massachusetts Executive Office of Communities and Development and the Agawam Housing Authorities, received submissions from 155 firms and practitioners.

Professor Ranko Bon was awarded a grant from funds the Arthur D. Little Company makes available to MIT to support research by young faculty members. Professor Bon's study focuses on building life cycle phases for two MIT West Campus dormitories.

On sabbatical leave this year were Professor N. John Habraken (fall), and Richard Filipowski (spring).

JOHN R. MYER

Department of Urban Studies and Planning

The planning field continues to look to our department for leadership and innovations, which we take as a challenge. During a period of budgetary restraint by the Institute, low research funding by governments and foundations, and abandonment by M.I.T. undergraduates of fields such as ours, we need to be adventure-some to survive. We have embarked upon a process of diversification, some actions within the department, others outside as in real estate, while attempting to concentrate resources on a small number of fields where we have competitive advantage. Some of these changes are taking root under the watchful eye of other institutions.

EDUCATIONAL PROGRAMS

Enrollments in undergraduate subjects remained level, even while the number of Course XI majors continued to decline. This raises the question of whether the undergraduate specialization should be suspended until patterns of undergraduate choice become more balanced, an issue which will be debated in the coming year. Professors Aaron Fleisher and Karen Polenske jointly directed the undergraduate program.

Counterbalancing the undergraduate trend, a decision was made to expand substantially enrollments in our Master in City Planning (MCP) program. A new track has been added for students wishing to study planning in developing countries (MCP/DA) and applications were strong for the first class. Twelve students will begin in Fall, 1984. Faculty devoted time to planning the new core subjects for this program. Fine-tuning continued on the integrated core subjects for the regular MCP program and efforts were devoted to rationalizing methodological subjects required of our students. A practice forum which ran throughout the year served as a regular occasion to debate the value premises of planning practice. Professor Ralph Gakenheimer directed the MCP program during the year, while Professor Phillip Clay served as coordinator of the core subjects.

Much of the year was spent reconsidering the scale and orientation of our PhD program, with the aim of better matching the program to resources likely to be available in the future and ensuring that it parallels the intellectual directions of our faculty. While the discussions will continue into the coming year, several important decisions were taken: to reduce the incoming class from 15 to 10, assuring full tuition support for all beginning students; to admit only students whom at least one faculty member has agreed to mentor and support; and to adjust the degree requirements to encourage an earlier start on a dissertation. A research colloquium was established this year on the theme of "Planning and Democracy." Invited speakers included Peter Marris of UCLA, Manuel Castells of Berkeley, Nathan Glazer of Harvard, Dorothy Nelkin of Cornell, Jane Mansbridge of Northwestern, Michael Piore of the Sloan School, Christine Boyer of Columbia and Joshua Cohen of Linguistics and Philosophy. A dissertation writers' seminar also met monthly. Professor Lawrence Susskind ably directed the PhD program this past year.

During this year, a school-wide Computer Resource Laboratory was formed, with Professor Joseph Ferreira serving as its director. Initially it has a number of microcomputers donated by IBM through the Athena Project, as well as software and special equipment donated by others. It is used for teaching and is the beginning of the network of facilities the school has long sought. The laboratory, located temporarily in the Emerson Room, has quickly become adopted by students from all substantive areas of planning. Computers are now used in at least one quarter of our subjects, and are used by students routinely for papers and assignments.

Equally important to the department's education is the continued experiment with teaching writing skills led by Professor Louise Dunlap. The abilities of all MCP students and most PhD candidates are diagnosed soon after they begin and a set of opportunities to improve skills is suggested. For many, this includes a writing workshop conducted by Professor Dunlap during the spring semester.

Despite cuts in faculty over the past few years, over 80 regular subjects of instruction were offered, by far the broadest range of opportunities available in any planning program.

Worth noting as well is the reemergence after several years of a joint urban design studio taught by Professor Dennis Frenchman with Professors William Porter and Imre Halasz of the Architecture Department. Students tackled a series of areas of Boston, examining ways that physical and programmatic linkages could be reinforced.

The department received a total of 208 applications from prospective students -- 150 for the Master in City Planning program and the new Master in City Planning/Developing Areas options, and the balance for the PhD program. A total of 53 applications were offered admission to the MCP program and twenty to the MCP/DA, hoping to attract 48 students to these programs in September. Of those accepted, one is a joint

architecture/planning candidate and one will be a joint law/planning student, also studying at Harvard's law school. About 23 percent of the incoming class are from abroad, and 10 percent are minority students. Twelve applicants were offered admission to the PhD program and 10 students will be entering this program in September. Two of the incoming class are from abroad, and one is a minority student.

SPECIAL EDUCATION PROGRAMS

The Special Program for Urban and Regional Studies in Developing Areas (SPURS), directed by Professor Lloyd Rodwin, completed its seventeenth year with 14 Fellows in residence. This year's Fellows came from Colombia, El Salvador, Egypt (three), Honduras, India, Israel, Korea, Nepal, Tunisia, Turkey, U.S.A. and Venezuela. Six were Humphrey Fellows. In addition, Ratna Naidu and Padam Sudarsanam of India, and Sadok Zerelli of Tunisia joined the SPURS program as visiting scholars. The weekly SPURS seminar series again served as the occasion for exchange among members of the developing areas community. Speakers this year included: Professors Bernard Frieden, Lynne Sagalyn, Lawrence Susskind, William Wheaton, Arthur Row, William Porter, Ithiel deSola Pool, Kenneth Keniston, Colin MacAndrew, Joseph Weizenbaum, and Lisa Peattie of MIT; Peter Marris of UCLA, Uma Lele and Anthony Churchill of the World Bank; Ratna Naidu of the University of Hyderabad, Thomas Vietorisz of the New School, Jan Kowalski of Universitat Karlsruhe, Ann Markusen and Richard Meier of the University of California, Berkeley; W.R. Effinger of Shapell Industries; and Khalid Salid of Asian Institute of Technology. During the Spring, SPURS Fellows journeyed to Montreal and Ottawa to discuss planning issues and aid to international development with Canadian officials.

The Special Interest Group in Urban Settlements (SIGUS) was founded this year under the leadership of Professor Lisa Peattie of DUSP and Professors Reinhart Goethert and Nabeel Hamdi of Architecture. In addition to sponsoring a regular series of seminars and events, the group organized four intensive one-week workshops during the spring semester, attended by planning, architecture and other students.

Four fellows were appointed in the Community Fellows Program (CFP) to work under the direction of Professors Mel King and Yohel Camayd-Freixas. The year-long fundraising effort which sought to identify new sources of sponsorship for the program did not uncover sufficient resources to allow the CFP to continue in its current form. In the future it will concentrate its energies on discreet projects which further the understanding and identity of communities of color.

Professors Pierre LaConte and Lawrence Susskind presented a special short course this spring on comparative perspectives in environmental mediation by Lincoln Institute of Land Policy.

Five one-week summer sessions were organized and led by faculty during 1984. Two of these were SPURS special programs: the first directed by Professor Arthur Row on urbanization and national urban policies, the second led by Professor Gakenheimer centered on infrastructure planning. A number of faculty and outside guests lectured to the 40 registrants for each program. Professor Susskind led two summer sessions on negotiation and mediation techniques, attended by a large group. About 15 teachers of planning came for a week-long seminar on the teaching of writing in the professional curriculum, organized and led by Professor Dunlap. Professors Mark Schuster and Joseph Ferreira, with other faculty assisting, led a summer session on the use of microcomputers in planning practice, attended by about 20 practitioners from the Boston area. The success of these programs encouraged us to consider an enlarged agenda for coming years.

Finally, several other special occasions are worth mentioning. During January, the Design Methods Group, led by Professor Donald Schon sponsored a two-day conference on "Design as Inquiry." During February, Professors Camayd-Freixas and Schon, assisted by students, led a Search Conference in the North Dorchester/South Roxbury neighborhood to identify issues in need of planning. During March, Professor Gary Hack and Marshall Kaplan, Dean of the School of Public Policy, University of Colorado, Denver, co-chaired a two-day comparative urban policy seminar for students of the two schools. During June, the department co-sponsored the Fifth International Conference on the Conservation of the Industrial Heritage, held in Lowell and at MIT. Professor Schuster represented the department.

RESEARCH

All of the sponsored research by faculty and staff, except that related to curriculum development, was done through the Laboratory of Architecture and Planning (LAP and is reported on elsewhere). Only brief mention is made here of these projects, along with projects funded in other ways.

Professor Schon was principal investigator on a World Bank project to examine what may be learned and codified from experiences of field personnel on development projects. Dean John deMonchoux, Professors Peattie and Martin Rein also participated on the project.

The Design Research Group, which included Professors Schon and Hack from DUSP, and several faculty from Architecture, also continued its work on "Design as Inquiry," funded in part by the National Endowment for the Arts.

Professor Hack and Thomas Piper of LAP completed the project for the Copley Square Centennial Committee to prepare design guidelines for the rebuilding of Copley Square in Boston. During the year, a two-stage competition was held, with the winners announced in May.

Professor Gary Marx continued his study of police undercover work sponsored by the Twentieth Century Fund.

Professors Frieden and Lynne Sagalyn completed the extensive set of case studies of public-private commercial projects in central areas of American cities, supported by the Hahn Foundation. Results were reported at a number of conferences during the year.

Researchers working under the direction of Professors Susskind and Langley Keyes completed work on the impact of Proposition 2 1/2 on local governments and social service systems. The results of the first monitoring period was published this year.

Professor William Wheaton conducted research on three subjects: on aggregation in urban transportation systems, sponsored by the National Science Foundation; on crossnational models of automobile and gasoline demand, sponsored by the World Bank; and on spatial externalities and aggregate land rent.

Professor Robert Fogelson spent much of the year researching the architectural and social history of armories in urban areas, while he completed the publication of his previous study of public employee pensions.

A number of faculty began research and curriculum development for projects funded under Project Athena. Among them: Professor Fleisher working on "looking and inferring when data are multidimensional;" Professor Ferreira's projection computer models for public decisions; Professor Hack's development of a computer-based version of site planning; Professor Polenske's work on transporting models for regional economic analysis to the microcomputers; and Professor Philip Herr's continued work on a computer-based urban impact analysis system.

FACULTY

Two of our faculty -- Professors Phillip Clay and Lawrence Bacow -- were granted permanent tenure during the year, bringing the number of tenured faculty associated with the department to 23. During the year there were five additional untenured faculty and 14 others with lecturer, senior lecturer and adjunct professor appointments. Professor Alan Strout was promoted to the rank of senior lecturer.

Concluding a two year search, Bishwapriya Sanyal, a graduate of UCLA with extensive experience in urban development projects in India and Africa, was appointed assistant professor.

Mark Schuster was also appointed assistant professor after three years of service as lecturer in the department. In Fall 1984, he will become assistant department head.

Professors Tunney Lee and Langley Keyes remained on leave this year, continuing their work in management and policy direction of agencies of the Commonwealth of Massachusetts.

Professor Rein spent the spring semester at the International Institute of Management in Berlin, continuing his research on the welfare state and employment policies.

Professor Peattie was on sabbatical during the spring semester, working on her retrospective book on the planning of Ciudad Guyana and regional development policies in Venezuela.

Professor Susskind was appointed executive director of the Program on Negotiation at the Harvard Law School, dividing his time between that program and teaching in the department.

Mel King, Adjunct Professor, was a candidate for Mayor of Boston, topping the ballot in the preliminary election but losing in the November runoff. His candidacy stirred many new voter registrations and placed issues of race and class on the public agenda. While losing, he may have broken the ground for other candidates of color in the future.

Professor Arthur Row joined the department as director of the SPURS summer program, after many years of teaching at Yale and practice with the United Nations Development Program.

At the end of this year, Professors Suzanne Thomas-Buckle and Leonard Buckle end their teaching and research in the department, which has extended over 10 years and has been of enormous value to all they have taught.

Lisa Peattie, professor of urban anthropology, announced her retirement at the end of the year, deciding to work full time on issues of disarmament and peace. She will become Professor Emeritus and senior lecturer. Professor Peattie's pioneering work in the understanding of urban society, and especially in

the social aspects of urbanization and development, has been a model for much current social research in these fields. She is a unique individual whose contributions cannot be replaced.

The department was saddened by the death during April of Professor Emeritus Kevin Lynch, considered by many to be the most important planner of this generation. His writing provides much of the intellectual underpinnings of the field of urban design and he educated at MIT an entire generation of teachers and practitioners, this writer included.

ALUMNI

Students for this year's graduating class appear to have found jobs easily in governmental agencies at all levels, non-profit organizations and, in increasing numbers, in private sector organizations.

During the year the results of an alumni survey were tabulated and analyzed. It was revealed that private planning firms are the largest employers of our graduates (21.7 percent) followed closely by government (19.4 percent) and universities (16.3 percent). Of the less traditional employers, non-profit organizations employ 9.9 percent, real estate developers 7.8 percent, banks 3.5 percent, and a variety of other organizations made up the balance. These figures are slightly changed from the survey a decade ago, but the ranking of organizational types has remained the same.

LOOKING AHEAD

The coming academic year, 1984-85, will mark the 50th anniversary of our first Master of City Planning degree, and our department now has the oldest planning program in the United States. It will be a time for reflection and a time to assess the directions embarked upon two years ago aimed at "spreading out while digging deeper." The real estate and developing areas programs, first fruits of this effort will enroll their first students, and it is hoped that a decision will be made to launch a new program in the planning and management of public service systems. Each new program should stimulate new research and connect us with new sources of support.

High on the agenda for the coming year will be fundraising for scholarships and space improvements. Without progress in the first area, we run the risk of losing our best students to lower-cost (even of lower quality, we think) public universities. And we are hampered in our education without better library facilities and offices and laboratories for our graduate students.

We will also, in the coming year, be charting a future for our work in the developing areas field, seeking to reflect the emerging issues of Third World urban areas. This will be done jointly with our colleagues in the Department of Architecture, offering promise for a single school-wide grouping of work in this field.

GARY HACK

Center for Advanced Visual Studies

Center for Advanced Visual Studies (CAVS) activities for 1983-1984 were most visible in three arenas: Center projects, individual artistic search and projects, and educational work.

The most encompassing endeavor was the 1983 SKY ART Conference in Munich, Germany, with five sections: The international conference on aspects of sky and space art, in collaboration with the Max-Planck-Gesellschaft, at BMW headquarters; a series of sky events at IGA Park, City of Munich; an outdoor production of the CAVS sky opera, ICARUS, at the Seebuehne, City of Munich; a series of telecommunication/media events; and the exhibition SKY ART, at the BMW Museum. Chairman of the Conference was Dr. Reimar Luest, President, Max-Planck-Gesellschaft. The three major sponsors were the City of Munich; BMW Motor Company, Digital Equipment Corporation (DEC).

CAVS participated with media works and events and with kinetic events and environments in, a.o., two international exhibitions: ELECTRA at the Musee d'Art Moderne de la Ville de Paris and the Sao Paulo Biennale in Brazil, both in the fall of 1983.

In May, 1984, CAVS together with MUSICA VIVA of Boston, presented at Kresge Theater, MIT, the first English-language production of ICARUS in a stage, multimedia indoor production; principal new collaborator was Vienna Staatsoper chief designer and CAVS Fellow, Professor Guenther Schneider-Siemssen.

Three SMVisS theses in the CAVS environmental art program were completed during the academic year: "Computer Animation within Video Scale," by Gloria Simmons; "A Lexicon for Camera Obscura," by Bob Rosinsky; "The Effect of Principles of Dynamic Symmetry on Modern Art and Science," by Eric Begleiter.

Among prizes and honors received by CAVS Fellows and graduate students were a Guggenheim fellowship to Antonio Muntadas; a Deutscher Akademischer Austausch Dienst fellowship to Paul Earls and a WBZ grant to Dr. Earls for new composing work on ICARUS; and Artists Foundation award in sculpture to Fellow Beth Galston and the first two Kepes prizes to Fellow Bernd Kracke and graduate student Bob Rosinsky; among grants to CAVS (besides SKY ART conference sponsorship): New England Foundation for the Arts continuing grant and DEC equipment grants for SKY ART interactive video disc exhibition; MIT Arts Council grants for ELECTRA/Paris and ICARUS at Kresge.

Some individual engagements which supported the national and international visibility of CAVS: Fellows Peter D'Agostino's and Aldo Tambellini's individual participation in the media section of the Sao Paulo Biennale; Fellows Harriet Casdin-Silver's and Sally Weber's individual and group participation in "Licht-Blicke" for the opening of the German Film Museum, Frankfurt, Germany; Fellow Rus Gant's work on "China Disks" and "Project Emperor I," electronic discs archive work with Simmons College and the People's Republic of China government; "Remote Carving" by laser through telecommunication (Joe Davis); four CAVS participants (three graduate students and Fellow Antonio Muntadas) in the Institute of Contemporary Art BOSTON NOW sculpture/environment show; Professor Otto Piene's (with Carman Moore and Elaine Summers) "SKY DANCE-SKY TIME" series of multimedia performances and sky events at the Solomon R. Guggenheim Museum, New York City; and director emeritus Gyorgy Kepes' retrospective exhibition at the International Center of Photography in New York City.

OTTO PIENE

Laboratory of Architecture and Planning

During the year 1984-1985, the Laboratory of Architecture and Planning (LAP) advanced into new areas of research and program development while continuing its commitment to a number of ongoing projects. All research and special programs conducted through the LAP serve its three broad objectives of 1) furthering state-of-the-art practice and teaching in the fields of architecture and planning, 2) linking the School with the activities of practitioners, and 3) encouraging research about emerging issues of concern to society and the professions.

In response to the School-wide planning cycle, the LAP's direction for the next five years will include continued support for all research efforts of the faculty. However, priority will go to the development of building technology research. This will be accomplished through working with faculty members, increasing the research staff and collaborating with other units at MIT and within industry.

The LAP continues to be a partner with other units at MIT such as the Joint Program for Energy Efficient Buildings and Systems for which the LAP Director serves as Associate Director. The LAP, the Joint Program and the Center for Construction Research and Education have entered a long-term agreement for collaborative research with the Korean Institute of Construction Technology, an organization established by the President of the Republic of Korea and funded by the Korean construction industry. The LAP is the initial coordinator for the program. The LAP is also serving as the window to MIT for the creation of a building technology program for the MIT-Harvard Joint Center for Urban Studies and the MIT Center for Real Estate Development.

The East Asian Architecture and Planning Program (EAP) began its activities this year. Among its initial programs was the highly successful First Annual Conference on "The Transformation of Street Life in East Asian Cities" attended by participants from Korea, China, and Japan. A follow-up seminar was held in Tokyo and another is planned for Singapore. Agreement has been reached with Osaka University to co-sponsor the 1985 Conference on waterfront development in Osaka. The 1986 Conference will be co-sponsored by Seoul National University. It will focus on large-scale developments such as the Olympics and world expositions. Another important agreement was reached to hold an urban design studio in Beijing; it will be co-sponsored by the School of Architecture and Planning and Tsinghua University.

During 1983-1984, the LAP served as the base for two major community service projects. The first was "Copley Square: An Urban Design Demonstration Project" involving private, public, and professional interests in the redesign of Copley Square. "The Boston Conference," co-sponsored by the National Endowment for the Arts, The Boston Globe, and the School of Architecture and Planning, was a collaborative effort to examine and guide the pattern of city development in Boston through fact finding, public information and a major conference. Programs building on the Copley Square and Boston Conference projects are under consideration. The LAP also continued to provide an administrative support base to the Aga Khan Program for Islamic Architecture and the Center for Real Estate Development.

RESEARCH

Growing Segments of the US Economy includes a number of projects for identifying rapidly growing segments in the US economy and of their job creation potential in a number of geographic areas of the US. Senior Research Scientist David Birch is the principal investigator for general projects funded by local governments and private industry. One such ongoing project is Developing a Small Business Monitoring System, designed to continuously improve a longitudinal version of the Duns Market Identifier (DMI) to analyze the US economy. The goal is to produce a full, easily incremented DMI file that could yield a continuously rolling data set, to be routinely updated.

Building a Longitudinal Data Base for Canada is an effort to replicate kinds of analyses done in the US based in individual firm histories in Canada to enable the Canadian Government to identify the sources of employment growth within the Canadian economy in great detail. Dr. Birch is the principal investigator.

Jobs for Connecticut's Future will generate research about future job generation and educational needs (Connecticut is a prototype study) in this project for which Dr. Birch is principal investigator.

The Political Economy of State Financial Regulations and Industrial Change is a project based on the development of tabulations on a state-by-state basis reflecting the demographics of business establishments by age and legal status of business during 1969-1976. The research is designed to address the different regulatory environments of states for their financial institutions. Dr. Birch is the principal investigator.

The US Real Estate Market project will identify rapidly growing segments in the US economy and assess their needs for commercial and industrial space. Dr. Birch is the principal investigator.

Research into National Employment Shifts is designed to determine how aggregate employment changes in different parts of the country are caused by the behavior of individual firms. Dr. Birch will direct this detailed study.

The Economic Role of Small Business will focus on the role that small businesses play in creating jobs and bringing about economic change. This project has led to the production of extensive tabulations for each of the ten Small Business Administration regions as well as for each of the 50 states. Dr. Birch is the principal investigator.

Firm Behavior as a Determinant of Economic Change is a study of employment change focusing at the micro level (with a data file of 5.6 million business establishments) and building up to explain change in terms of the activities of these individual parts. Work has proceeded along two levels: 1) national and regional patterns, and 2) changes within metropolitan areas. Dr. Birch directs this research.

Physical Scale Models to Describe Energy Phenomena is a project for investigating thermal, ventilated, and luminous environments. Principles of scale testing are being developed. Professor Harvey Bryan is the principal investigator. The work is funded by the Grunsfeld Foundation, MIT Cabot Solar Fund, the Metropolitan Museum of Art, Lightolier Corporation and the Masonry Institute of America.

The staff of the Downtown Shopping Malls project will prepare case studies of the planning and building process of mixed mall development in downtown locations. Cooperative activities of public agencies and private developers will receive special attention. Professor Bernard Frieden is the principal investigator for this work funded by the Hahn Foundation.

Dr. Karen Polenske is principal investigator for Multiregional Analyses of Transportation Investment, research into transportation budgeting and investment designed to help transportation decision makers in the assessment of infrastructure conditions.

The Planning Urban Infrastructure for Secondary Cities in Egypt project continues to explore the problems faced by Egypt's rapidly growing secondary cities in the area of urban infrastructure planning and the integration of such planning into the overall environmental design objective of those cities. The MIT Technology Adaptation Program has sponsored the project, for which Professor Ralph Gakenheimer serves as principal investigator.

Housing Policy in Sri Lanka is an analysis of housing options from that country, with particular emphasis on opportunities for government investment in infrastructure. Professors Nabeel Hamdi and Reinhard Goethert are co-principal investigators. The work is funded by the National Housing Authority of Sri Lanka.

MIT Solar House V and the new Crystal Pavilion addition, constructed on the MIT campus, continue to demonstrate direct-gain solar space heat through the use of new architectural finishing materials. Principal Research Associate Timothy E. Johnson is the principal investigator. Current work is funded by the Department of Energy and private industry.

The Architectural Case Studies program continues to prepare prototype cases. Accessible design, energy conscious design, and managing the architectural design process are the topics of studies already completed. Staff members are now preparing a case book about case method teaching in architecture. LAP Director Michael L. Joroff is the principal investigator of the project, supported by the National Endowment for the Arts. Joint distribution of the case studies in cooperation with a major architectural school in England is planned.

Michael Joroff is also principal investigator for Research and Development of the Japanese Design and Construction Industry, an analysis of the institutional and organizational factors which impact the research and development process. Case studies of research about industrialized housing and interior environmental quality will be prepared.

The Consistent System project continues to develop a large collection of application software for data management and data analysis. Principal Research Scientist John Klensin is the principal investigator, and the work is supported by private industry.

Klensin is also principal investigator for Algorithms for Preliminary Building Design, an investigation of algorithms for use in early stages of design. Such algorithms emphasize quick computation with a rough estimate of a small number of parameters rather than highly precise results. The project focuses on algorithms of this sort for building design specifically, and on the process of developing them from procedures oriented toward more finished results.

New Orleans in Transition is a two-year film project to record the planning and development for the World's Fair in New Orleans. Professor Richard Leacock is the principal investigator and Glorianna Davenport is the project's director. The work is funded by the National Endowment for the Arts with support from USAir and the Sheraton New Orleans.

The LAP serves as the overall administrative home for the Aga Khan Program in Islamic Architecture, which includes professorships and fellowships located in the Department of Architecture and a documentation project centered in Rotch Library. Summer institutes abroad, a faculty exchange program, publications, student travel grants, and other activities strengthen the program and link it with its counterpart program at Harvard, with other programs here at MIT, and with other institutions and individuals throughout the world. Professor William L. Porter is the Program's director.

The Design as Inquiry project explores and tests the ways in which the process of design can act as a rigorous form of inquiry. A team of planners, architects, and engineers is investigating the distinctions between research of use to design and the use of design as a method of inquiry. Professor Donald Schön is the principal investigator, and the work is funded by the National Endowment for the Arts.

MIT and the World Bank staff are working together developing an Interdisciplinary Approach to Project Design using the case study method. Dr. Schön is serving as principal investigator for this research.

The ongoing Environmental Impact Assessment project continues investigation of the ways in which public agencies can better project and assess environmental impacts of proposed policies, programs, and public investments. Professor Lawrence Susskind is the principal investigator.

The Environmental Mediation Project will continue to develop and analyze techniques for mediating environmental disputes. Case studies of negotiation are being developed for use in training workshops and professional education. Professor Susskind is the principal investigator, and the work is funded by the Hewlett Foundation.

Dr. Susskind is also principal investigator for two other ongoing projects. Subseabed Disposal of High Level Radioactive Waste is an analysis of the institutional obstacles to subseabed disposal of high-level radioactive waste. Alternative management systems will be designed for the long-term operation of a subseabed disposal option.

Uses of Commercial Cable Television for Community Problem Solving and Policy Making involves experiments with commercial and cable television aimed at demonstrating the range of techniques and strategies municipal governments can use to involve large numbers of residents in community problem solving. The politics and legal issues surrounding public access to the local media are analyzed.

This year the Impact 2 1/2 Program carried out by an interuniversity consortium directed by Professor Susskind reached completion. The program monitored the long-term impact of the statewide program of tax and spending reduction authorized by Referendum Proposition 2 1/2 passed in November 1980. The LAP served as the center of operations for nine participating research organizations. The project was primarily funded by the Hyams and Permanent Charity Foundations and the Lincoln Institute for Land Use Policy.

SPECIAL PROGRAMS

In the summer of 1984 the LAP presented a range of special programs to serve alumni and practitioners and to promote the School's research agenda. The continuing education courses taught by faculty and professionals this year included "Effective Downtown Development" (M. Means, P. Herr, B. Cole); "Realities of Historic Preservation" (R. Neilly); "Improving Professional Effectiveness" (W. Ronco); "Design in Housing in Developing Countries" (N. Hamdi, R. Goethert); and the fourth Islamic architecture seminar, "Continuity and Change" (W. Porter).

The LAP's position in regard to continuing education has now changed, reflecting the School Council's decision to decentralize these programs to different units within the School. However, the LAP will continue to provide logistic support services for its own programs and for others in the School, and will concentrate its own efforts on building technology research and East Asian projects.

DISSEMINATION OF RESEARCH FINDINGS

This year the LAP has maintained its commitment to disseminating the findings of research to as large a professional and public audience as possible.

The LAP Publications Program has expanded its offerings to over 40 titles. These include publications produced by the MIT Joint Program for Energy Efficient Buildings and Systems, the Aga Khan Program, and the Program for Public Negotiation. The Environmental Impact Assessment Review, published by Plenum Press and edited by LAP staff member Teresa Hill, under the direction of Professor Susskind, completed its fourth year of publication. The Review's special issue for 1983-84 is on assessing the environmental impacts of offshore oil and gas exploration and development. The environmental design journal Places is edited by Professor William Porter, with associates from MIT and the University of California at Berkeley.

It originated as a LAP-based project funded by the National Endowment for the Arts and is now published by the MIT Press. Open House International, a journal of housing, is published as a joint venture of the SAP group in The Netherlands and the LAP; Professor Nabeel Hamdi is the LAP-based editor.

STAFF

This year Kathleen Reid joined the LAP core staff as Administrative Officer. Thomas Piper became a Principal Research Scientist and Akhtar Badshah became a Research Associate. Judith Rodenbeck and Catherine Abbott became members of the support staff.

Continuing on the LAP's core staff were: Senior Research Scientist David L. Birch; Principal Research Scientists John Klensin and Mona Serageldin; Research Associates Teresa Hill, Mary Jane Luchetti and William Parsons; Research Affiliates Bernard Spring, Hasan Khan, Samir Abdulac and Jennifer Leaning; Administrative staff member Margaret B. Sevcenko, and Administrative Assistant H. Sharon Trohon.

The MIT Center for Real Estate Development began its activities this year under the Directorship of Charles H. Spaulding and with DUSP Associate Professor Lawrence Bacow as Associate Director for Education and Research. Administered through the LAP, the new Center includes staff members Maryann Taylor, Associate Director for Gifts and Grants, Inez Steele, Administrative Assistant, and support staff members Maria Vieira, Marianne O'Donnell and Sandra Bevins, all of whom hold appointments through the LAP.

DEVELOPMENT PLANS AND ISSUES

The LAP has been successful in carrying out last year's stated goal of promoting and developing collaboration with industry and foundations to offset cutbacks in federal funding of research. This strategy promises growing support from such groups in the future. The LAP will continue to promote initiatives that bring together faculty to pursue research topics within the agenda of the School. Practitioners in the field, alumni, members of the School's Visiting Committee and representatives of client organizations will continue to provide advice and assistance to LAP programs.

MICHAEL L. JOROFF

School of Engineering

During the past academic year, the School continued the planning activities which were carried on during the previous two years by the academic departments, centers, laboratories and programs reporting to the Dean. The plans of these units are in their second iterations and are being utilized by the units and by the School in setting priorities for raising and applying resources for maximum effectiveness in the future. For example, decisions on new and replacement faculty, seed and curriculum development funds, space allocations and priorities for fund raising have been made on the basis of these plans.

Following the development of plans by the individual units, the School has this year prepared the first draft of its Long Range Plan which establishes overall goals for the School, identifies critical issues faced and puts forth a series of new initiatives some of which are based in individual departments and others which are interdepartmental in nature. The initiatives which are in the first category are described in the reports of the individual units. Examples of the more important School initiatives include: Project Athena, which is now an Institute-wide experiment to use modern computers with graphics to enhance learning; a joint Engineering/Sloan School of Management initiative in Manufacturing Systems Engineering and Management; a joint laboratory in resource extraction, geotechnical engineering and construction engineering known as the Remergence Laboratory; and the initiative in Cooperative Lifelong Education which is under development by faculty of the Department of Electrical Engineering and Computer Science in conjunction with the Center for Advanced Engineering Study.

In addition, the School plan includes the development of several coherent interdisciplinary areas of research and education including: control, solid and structural mechanics and dynamics, polymers, and biotechnology.

The area of curriculum development, and the preparation of new texts and other educational materials, has been identified as a high priority need for the School, and funds have been raised to support promising projects. This year a significant number of new texts were being prepared with the support of Gordon Curriculum Development Grant and other School funds in almost all of the academic departments.

During the past eighteen months, the School has examined its activities in the area of Technology and Policy, with particular emphasis on its Center for Policy Alternatives and the Technology and Policy Master's Degree Program. The School participated in an interdepartmental, inter-school study of the area of Technology, Policy, and Society. The committee appointed by the Provost to undertake this study will make recommendations this fall on steps to focus, strengthen and coordinate activities between science and technology and society. Based on these studies, the School intends to strengthen its commitment to research and education relating to technology and policy.

The School is participating actively in the first round of funded projects under Project Athena. Twenty-three activities are underway, including such topics as: expert systems for teaching constructed facilities design, computer-aided learning of field phenomena, computational methods in materials science education, enhancement of thermodynamics education, and molecular graphic modeling.

Undergraduate enrollment decreased slightly this year from 2436 in 1982--83 to 2418 in 1983--84, following a long period of growth. However, enrollments in the departments of Electrical Engineering and Computer Science, Aeronautics and Astronautics, and Mechanical Engineering continued to increase. For example the size of the entering sophomore classes in these three departments rose by 10%, 14% and 16%, respectively. These increases were compensated by dramatic decreases in the numbers of sophomores entering the departments of Chemical (50%) and Civil (38%) Engineering. The continuing preferential growth in enrollments, especially in the Electrical Engineering and Computer Science and Mechanical Engineering Departments, already the two largest departments at MIT, continues to place severe pressures on the School. Some additional resources were provided to those departments to aid them in coping with the enrollment problem next year, but in the longer term steps must be taken to achieve a better balance among the enrollments in the various departments of the School. Graduate enrollment, which is controlled by each department, increased by about 4.8% from 2090 in 1982--83 to 2191 in 1983--84.

To improve recruiting and retention of women and minority faculty, the School formed an Affirmative Action Committee including the Associate Dean, the Assistant Dean for Administration, and Professors Mildred S. Dresselhaus and Wesley L. Harris. During the year several meetings were held to identify candidates for positions and to discuss problems facing minorities and women in the School and to formulate positive actions. A School policy of offering "special" positions for outstanding women or minority faculty candidates who do not fit currently authorized slots was instituted and resulted

in two special offers this year. Although neither candidate accepted, the procedure proved useful in increasing the number of potential appointees and will be continued next year.

The Second Summer Program directed by Professor Harris again provided an intensive summer work and educational experience to a group of outstanding MIT minority engineering students following their freshman year. This program, started in 1979 and sponsored by several industrial concerns who also provide summer employment, continues to be highly successful in the career guidance and development, professional encouragement and retention of minority undergraduates.

ENGINEERING INTERNSHIP PROGRAM

In the summer of 1984, 53 sophomores were placed with sponsoring companies in the Engineering Internship Program (EIP), compared with 41 in 1983. The enrollment is now 117, with 31 companies participating. Beginning at the end of the sophomore year, the EIP provides work experiences at a participating company during two undergraduate summers and one graduate summer and academic term. The Program leads to the simultaneous award of the S.B. and S.M. degrees with the thesis done at the company during the graduate work experience under the joint supervision of an MIT faculty and an industry professional.

Overall company response to the Program remains very positive and this year three new companies were added: Texaco, Digital Equipment Corporation, and Advanced Manufacturing Technology of Colorado. The Program has grown at a restrained pace toward a steady-state configuration where the distribution of companies and work experiences is consistent with the student distribution among the disciplines in the School. The expected steady-state level is about 200 students and 45-50 sponsoring companies.

MANAGEMENT OF TECHNOLOGY PROGRAM

This Program, which leads to the S.M. in Management of Technology awarded jointly by the School of Engineering and the Sloan School of Management, is described in Dean Seigel's report. The program is aimed at engineers and scientists with a minimum of five years of work experience, and is designed to prepare these professionals for more senior roles in industry and government where they will establish and manage technology-based endeavors. The enrollment in this 12-month intensive program grew from 13 in 1982--83 to 21 this year and a steady-state goal of no more than 40-50 students per year has been established.

TECHNOLOGY AND POLICY PROGRAM

This program, directed by Professor Richard L. de Neufville, continues to provide a professional master's degree in engineering complemented by policy and economic studies, to prepare individuals who can equally address questions of technology and policy in both the private and public sectors. It is international in scope in both its educational content and in the composition of its student body.

The largest entering class (23) in the history of the program began studies in Technology and Policy in the fall of 1983. The alumni, now over 100, are well placed in many industrial, consulting and government positions in the U.S. and abroad.

This past year two alumni awards were established. The Alumni Award for Excellence and Leadership, which carries a tuition grant, will be awarded annually to the student who exhibits the most outstanding academic accomplishment and professional promise. The Best Thesis Award will be presented for the best thesis or research paper dealing with technology and policy written during the year, and is open to competition from the entire MIT community.

Two additional faculty joined the Program in 1983-84: Associate Professor Judith Kildow of the Department of Ocean Engineering and Associate Professor Lawrence Bucciarelli of the School of Engineering assumed responsibility for the Proseminar course, and will be developing case studies for instruction and for publication. The Program has established an External Advisory Committee of distinguished business leaders, academics and government officials to provide program evaluation and policy guidance to the Dean and the Program Director.

SCHOOL APPOINTMENT AND RESIGNATION

Professor Fernando J. Corbato was appointed as Associate Head for Computer Science of the Department of Electrical Engineering and Computer Science, effective May 1, 1984.

Professor J. Herbert Hollomon, Japan Steel Professor of Engineering, resigned effective June 30, 1983 to accept a position as University Professor and Director of a new Center for Technology and Policy at Boston University.

GERALD L. WILSON

Department of Aeronautics and Astronautics

The Department continues to pursue its objectives with energy and enthusiasm: providing broad education in the philosophy, approach and disciplines of Aerospace Engineering, and conducting research at the forefronts of a wide range of technologies critical to the future development of Aerospace in all its aspects. The vitality of the Department in large measure stems from a continually expanding group of very talented undergraduates committed to careers in aerospace engineering. As the enrollment has grown over the last several years, many of these young enthusiasts have continued as graduate students, and a few as junior faculty. With significant additions of graduate students and young faculty drawn from many outside sources, the result is a very energetic community focused on education and research in aeronautics and astronautics.

With over 400 students, 40 faculty, and some 90 staff, much occurs in a year. Only a few highlights can be reported here, with the hope that they will convey the character of the entire enterprise.

In November 1983, the first NASA - ESA Spacelab was carried into orbit by the Space Shuttle Columbia, and with it Dr. Byron Lichtenburg, our first (and the U.S.'s first) Payload Specialist, to perform with three colleagues a series of experiments designed to elucidate the adaptation of humans to zero gravity. These experiments have been in preparation for nearly ten years in the Man Vehicle Laboratory (MVL) under the direction of Professor Laurence Young and Dr. Charles Oman. A principal finding is that space motion sickness does indeed result from a conflict between the visual and vestibular systems due to loss of the gravity reference by the latter. But there is much more to learn and further experiments by the MVL are now scheduled for three more Shuttle flights, two in 1985 and one in 1987.

Another lengthy effort culminated in May 1984, when Frank Scarabino, an MIT undergraduate, pedaled the human-powered aircraft, Monarch, around a 1500 meter triangular course in less than three minutes, to meet the requirements for the Kremer Speed Prize. The Monarch, built by students under the leadership of two graduate students, Mark Drela and John Langford, is the latest in a series of four human powered aircraft designed and built by Course 16 students. If, as expected, the Speed Prize is awarded to the Monarch group, they will be established as the world's champions in this particular, very demanding area of aeronautical technology.

The Department has refined its Long Range Plan, developed last year as part of the long range planning process of the Institute. A major feature of the Department's Plan is to develop its research and instruction in Astronautics to be comparable in scope and quality to its outstanding program in Aeronautics, while continuing to develop the latter on a broad front. In addition to reaffirming its commitment to its ongoing efforts, the Department identified several Major Initiatives to which it will give special effort. These are:

- A Unified Engineering Textbook
- Computers in Aerospace Education
- Large Spacecraft Technology
- A Center for Aerodynamic Studies
- Space Research
- Information Technology

The 48-unit subject Unified Engineering (UE) is now firmly established as the introductory core of Course 16, in which incoming students are introduced to the fundamental concepts, disciplines, and approaches of aerospace engineering and, equally important, become part of the MIT Aero and Astro community. The objective of UE has been to present a coordinated body of knowledge rather than a set of disparate disciplinary entities. It has been taught by a team of several faculty aided by graduate and undergraduate teaching assistants. We have now undertaken to write a textbook which will reflect both the unity of the subject and the intellectual richness which it derives from the participation of a number of faculty with a broad range of knowledge and viewpoints. Our hope is that the writing of the text will further the unification of the subject matter and provide impetus for further development of the concept of UE. The text itself may facilitate the adoption of this educational technique outside Course 16.

Under the rubric of Computers in Aerospace Education we include a wide range of initiatives designed to ensure that the Department maintains leadership in the burgeoning application of digital computation to aerospace research and to aerospace systems. In the fall of 1983 the Department dedicated the Hall Hibbard Computer-Aided Aerospace Design Facility, donated by Perkin Elmer and Lockheed CADAM. This facility is now in full-time use by students and faculty in a wide range of research activities. An Aerospace Simulation Facility has been established to make possible synergistic use of computational facilities by computational fluid mechanicians, who make heavy demands on central processor time, and by researchers in air traffic control, who need extensive input-output facilities, and only occasionally require high computational power. The Department has established a Microprocessor Laboratory in which Course 16 students can practice the art of applying microprocessors to control of real physical systems.

The Course 16 involvement in Project Athena is extensive. Space in Building 37 formerly assigned to Aeronautics and Astronautics has been dedicated to an Athena Cluster, and several initiatives are underway to make use of Athena capabilities in education. A large-screen projection system is being installed in the lecture hall used for UE to allow use of real time computer generated displays in lectures, for example, of three dimensional and dynamic displays. It is felt this will be an important supplement to the one-on-computer experience supported by Athena work stations. The fluid mechanics faculty has undertaken a broad effort to develop software which will enable the use of Athena facilities in the teaching of fluid mechanics including, for example, the numerical generation of flow fields of airfoils and bodies. Another initiative will produce the capability for real time displays in the classroom of the dynamics of orbital vehicles, thus facilitating understanding of an intuitively difficult subject.

As the capabilities for manned operations in space provided by the Space Shuttle are developed, structures will appear in space which are "large" in the sense that they could not be launched fully assembled or deployed either because of sheer size or because their structure, though adequate for the zero-gravity environment of space, would not survive the accelerations associated with launch. Such structures pose a new set of challenges to the engineer, involving such issues as damping of vibrations in vacuum, and a plethora of modes of vibration which can respond to control stimuli as well as natural excitations. Our objective is to develop a base of fundamental understanding upon which designs of such structures can rest. The approach includes experimental studies of structural behavior in vacuum and zero gravity, both through simulation by free fall in the laboratory and through experiments in the Space Shuttle, and theoretical studies of the structural behavior and of control strategies.

The aerodynamic design of modern aircraft involves compromise between many conflicting requirements for performance in cruise, maneuver, and takeoff and landing. Fundamental understanding is less well developed for the high-lift situations which occur in these latter conditions. The objective of the Center for Aerodynamics Studies (CAS) is to bring the best capabilities of computational fluid dynamics, analysis, and experiment to bear on these problems in a synergistic way. Because of its capability for operation at high Reynolds numbers, the Wright Brothers Wind Tunnel represents an unusual opportunity for progress in the experimental sphere, and the Department is planning, with the aid of industry, to rehabilitate it. With our expanding computational capability, and this experimental facility, a federation of several faculty looks forward to significant achievements in this important area of aeronautics.

In the past, Space Research has connoted usually scientific studies of the near-Earth environment or of the solar system, carried out with instruments and vehicles developed on Earth. With the present orbital capability of the Shuttle and the future possibilities of Space Station, engineering research can and will be conducted in space. The development of orbital electrophoresis is one example, the repair of the Solar Maximum Spacecraft another, and the Space Motion Sickness research described earlier a third in that its ultimate aim is to provide means for alleviating space motion sickness. The Department's Space Systems Lab (SSL) is currently preparing an experiment on human productivity in space, which is manifested for the Shuttle in early 1985. Termed EASE (Experimental Assembly of Structures in EVA), this experiment will establish learning rates for humans in zero gravity through repetitive assembly of a simple tetrahedral structure out of the Shuttle bay. This space experiment developed from experiments conducted by students initially in the Alumni Swimming Pool and later in the large neutral buoyancy tank at NASA's Marshall Space Center. All hardware for the experiment is being fabricated by students in one of the largest of MIT's UROP activities.

The last major initiative, Information Technology, has as its objective the development of a coherent educational and research effort which will establish information acquisition, processing, and use as a disciplinary entity in parallel with the classical disciplines of aerospace engineering such as fluid mechanics, structures, and propulsion. A new undergraduate subject is planned for the near future, and a Center for Aerospace Information Technology is being formed.

UNDERGRADUATE PROGRAM

The undergraduate enrollment of Course 16 continues to increase as indicated in Table 1. As noted above, those relatively large numbers of talented and enthusiastic students represent an opportunity, but at the same time they pose problems for the Department. The challenge is to maintain the close faculty-student relationship which has characterized Course 16, including the involvement of undergraduates in research. The Undergraduate Projects Laboratory has been a principal source of this involvement. It introduces students to experimental research through the conception, design, construction, execution and reporting of an individual experimental project under the guidance of a faculty member. As the successively large classes enter the Laboratory, its resources of equipment, space, and supervisory talent are strained. Nevertheless, our commitment to providing this experience as an essential part of the undergraduate education is undiminished.

Table 1

| | <u>1977-78</u> | <u>1978-79</u> | <u>1979-80</u> | <u>1980-81</u> | <u>1981-82</u> | <u>1982-83</u> | <u>1983-84</u> |
|------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Sophomores | 39 | 53 | 70 | 78 | 91 | 86 | 100 |
| Juniors | 45 | 37 | 47 | 70 | 73 | 86 | 81 |
| Seniors | <u>29</u> | <u>45</u> | <u>41</u> | <u>55</u> | <u>62</u> | <u>85</u> | <u>81</u> |
| Totals | 113 | 135 | 158 | 203 | 226 | 257 | 262 |

Of the 81 seniors, ten chose the Avionics Option, and of the 81 juniors, 14. The sophomore class included 28 women in the total of 100, placing Aeronautics and Astronautics above the Institute average in this regard.

Interest in the Engineering Internship Program continues high, with 24 sophomores applying and 11 accepting offers. They are at work in nine different aerospace companies for the summer of 1984. Ten members of the class of 1985 are in their second summer work period and four fifth year students are in their work assignments.

In the junior and senior years, students elect advanced undergraduate subjects in a number of disciplines. At this level, a distinction between aeronautics and astronautics begins to emerge, whereas Unified Engineering treats both. Thus in fluid mechanics, students can elect 16.02 Aerodynamics or 16.06 Space Gas Dynamics, the latter placing emphasis on the gas dynamics relevant to spacecraft, including hypersonic and molecular flows.

This year a new subject was added to further strengthen the astronautics offerings. Fluid Dynamics of Flight and Reentry Vehicles 16.04 emphasizes the flow phenomena encountered on transatmospheric vehicles.

GRADUATE PROGRAM

Graduate enrollment remains at about 182, limited in part by the financial support and faculty supervisory capacities, but also in part by the pool of acceptable applicants. The size of the pool is tending to increase due to the large numbers of engineering graduates in recent years, and this trend may be expected to continue. On the other hand, aerospace bachelors graduates have attractive employment opportunities, tending to draw them away from graduate school. In balance, the department draws an outstanding group of graduate students, both from its own undergraduate classes and from outside. Of 28 1984 graduates who have decided to continue in graduate school, 22 are continuing in Course 16.

The foreign student content of the graduate school is now below 25 percent, and drawn from a large number of countries.

This year Professors Wallace E. VanderVelde and Bruce K. Walker continued the development of two graduate subjects in Fault Tolerant Control Systems 16.321 and 16.322. These subjects form part of an effort being carried on, in cooperation with Draper Laboratory staff, to make available for educational purposes the knowledge of fault tolerant controls which has been developed jointly by Course 16 and the Draper Laboratory over the last several years. A text is being prepared and is now largely in draft form. This effort is supported by a grant from the Hertz Foundation.

RESEARCH ACTIVITIES

This year saw growth in the research activities of the Department in several areas. The Space Systems Laboratory (SSL) continues to grow in research volume, members of faculty involved, and numbers of students both undergraduate and graduate. Funding is now in excess of \$2 million per year, there are ten faculty involved, seven staff, 32 graduate students and 40 undergraduates. Work on Orbital Productivity under Professor David L. Akin includes the EASE program mentioned above. A Space Dynamic Simulation Facility is being constructed by Professor Edward F. Crawley with the aid of a \$.25 million DOD Instrumentation Grant, in which the dynamic characteristics of simulated large space structures will be studied during free fall in a large vacuum tank. Activities in Space Propulsion and Power under Professor Manuel Martinez-Sanchez are growing rapidly after a long period of relative dormancy of this area. The new work is stimulated by possible applications of electric propulsion to manned activities in space, as well as by the opportunities represented by Space Station.

Activities in the Technology Laboratory for Advanced Composites (TELAC) have grown to a funding level of \$1 million per year, five faculty and six staff, 15 graduate students and 18 undergraduates. The work includes failure and fatigue characterization of advanced composites and studies of their damping characteristics. Much of this research is supported by a grant from the Boeing Airplane Company.

Following the Spacelab 1 success of the Man Vehicle Laboratory, its program has grown to a level of \$1.5 million per year, three faculty, 11 staff, nine graduate students and 15 undergraduates. The Laboratory has scheduled experiments on three future Shuttle flights, two in 1985 and one in 1987. In addition, it pursues a vigorous program in aeronautical human factors including studies of simulation.

Activities in the Gas Turbine Laboratory (GTL) involve five faculty, 22 graduate students, and a research volume over \$2 million per year. This year Professor Alan H. Epstein's Blowdown Turbine Experiment produced the first time resolved measurements of heat transfer in a highly loaded cooled turbine. This work continues to attract strong support from Rolls Royce and the Office of Naval Research. In an impingement cooling experiment the first detailed measurements of internal heat transfer revealed previously unknown effects of rotation on the heat transfer distribution. The effects of mistuning on aeroelastic behavior of compressor rotors is being studied by Professor Crawley in a cooperative program involving NASA, Pratt and Whitney, and Purdue under MIT leadership. Industrial support for the activities of the GTL is high and the staff is working to strengthen the coupling.

Professor Eugene E. Covert has undertaken, with the cooperation of Professors Judson R. Baron, Earl M. Murman, William T. Thompkins and Edward M. Greitzer, to organize a Center for Aerodynamic Studies (CAS) which will bring modern computational and experimental tools to bear on the aerodynamic problems of highly loaded aircraft. Use of the Wright Brothers Wind Tunnel for high Reynolds Number experiments is one important component of this effort.

Professor Baron and Mr. Frank Durgin have made substantial progress to this end by operating the tunnel at reduced and elevated pressures, and at higher power levels than has been customary in recent years. Industrial and governmental support for the CAS is strong and building.

FACULTY AND STAFF CHANGES

The Department was pleased by promotions this year of E. M. Greitzer to Professor of Aeronautics and Astronautics, of A. H. Epstein to Associate Professor of Aeronautics and Astronautics, and of E. F. Crawley to Associate Professor of Aeronautics and Astronautics.

Two Assistant Professors were added to the faculty in September 1983: Professor Steven Bussolari, whose interest is Space Human Factors, and Professor R. John Hansman, whose interest is in instrumentation and spacecraft dynamics. Both are avid pilots and enthusiastic supporters of Monarch.

Professor Covert, who has served for three years as Director of the Gas Turbine Laboratory, has resigned that position to devote his effort to the Center for Aerodynamics Studies.

Professor E. M. Greitzer was on sabbatical for the academic year at Cambridge University. He has accepted the Directorship of the GTL effective July 1, 1984.

Professor Amedeo Odoni has been appointed Associate Director of the Flight Transportation Laboratory (FTL), thus sharing this important responsibility with Professor Robert Simpson.

Professor Jack L. Kerrebrock returned as Department Head after spending two years in Washington, D.C. as Associate Administrator of OAST.

The Department is pleased to welcome Professor R. C. Seamans to Course 16 as a Senior Lecturer effective July 1, 1984. We look forward to Dr. Seaman's participation in Department affairs and to the receipt of his counsel.

Professor Robert L. Halfman, Professor of Aeronautics and Astronautics and Associate Dean for Student Affairs, elected retirement on June 30, 1984. He will, however, continue his involvement in Institute affairs, for which we are thankful.

Three Visiting Scholars, Yu-Zhang Cao, Sigong Chang, and Zhong-an Hu returned to the People's Republic of China, having completed two or more years at MIT.

Sophie Shemer, of Tel Aviv University, completed two years as Visiting Engineer and returned to Israel.

Dr. Hans-Lennart Engquist of the Royal Institute of Technology, Stockholm, joined the Department as a Visiting Research Scientist.

STUDENT AWARDS

The winners of the Department's academic awards for undergraduates for 1983/84 were as follows:

HENRY WEBB SALISBURY AWARD

This award, established in the memory of Henry Webb Salisbury ('33), is given annually to a graduating senior in Course 16 for the highest degree of academic achievement. This year's co-winners are:

| | | |
|----------------------------|----|-----|
| Stephen Nicholas Schwoerke | 16 | '84 |
| Mark Joel Lewis | 16 | '84 |
| Jeffrey Karl Berner | 16 | '84 |

JAMES MEANS MEMORIAL PRIZE

For excellence in Space Systems Engineering:

| | | |
|---------------------|----|-----|
| Marc Thomas DiNardo | 16 | '84 |
|---------------------|----|-----|

LUIS DE FLOREZ AWARD

Awarded to undergraduates who have demonstrated "original thinking or ingenuity" in Aeronautics and Astronautics. This year's winners are:

| | | |
|---------------------|----|-----|
| Stephen Paul Adkins | 16 | '84 |
| Adam Randall Brody | 16 | '85 |
| Russell Don Holtz | 16 | '85 |
| Mark Samuel Kirby | 16 | '84 |

| | | |
|-----------------------|----|-----|
| Francesco Marinoni | 16 | '85 |
| Michael Paul Scardera | 16 | '85 |
| David Gregory Sizoo | 16 | '85 |
| John Motley Wilson | 16 | '84 |

FACULTY HONORS AND ACTIVITIES

Professor John Dugundji received the Course 16 Undergraduate Teaching Award for 1984.

Professor James McCune received the Course 16 Graduate Teaching Award for 1984.

Dr. Charles M. Oman received the A.T. Colwell Award for outstanding papers presented to SAE audiences.

Professor Rene H. Miller gave the Nikolsky Honorary Lecture of the American Helicopter Society.

Professor Wesley Harris has been appointed Chairman of the Army Science Boards Study group on the Light Utility Helicopter (LHX).

Professor Earll M. Murman has been appointed Chairman of the Resource Allocation Committee of Project Athena.

Professors Crawley, Epstein, Thompkins and Kerrebrock, participated in a study conducted by the Aeronautics and Space Engineering Board of the National Research Council for NASA entitled, "Aeronautical Technology in the Year 2000."

Professor Marten Landahl was elected to the Swedish Academy of Engineering Sciences, became a Fellow of the American Physical Society, and also delivered the 27th Ludwig Prandtl Memorial Lecture. This is an especially distinguished lecture, previous lecturers having included Hugh Dryden, M. J. Lighthill, and Hermann Schlichting.

Professor Kerrebrock was elected a Fellow of the American Academy of Arts and Sciences.

Professor Sheila Widnall, Chairman of the Institute Committee on Undergraduate Admissions, has been selected as Chairman of the Advisory Committee on the Search for a Director of MIT Admissions.

A high point of the year was the delivery by Dr. Raymond L. Bisplinghoff of the 20th Lester D. Gardner Lecture, entitled "Historical Evolution of Aeroelasticity" on April 23, 1984. The Lecture outlined the development of aeroelasticity from its earliest days to the present and was outstanding for its scholarship and portrayal of the contributions of many of the pioneers of aviation.

JACK L. KERREBROCK

Department of Chemical Engineering

The recovery of the job market for SB graduates appears to be underway. The undergraduate enrollment has declined from its peak reached two years ago, but the ratio of undergraduate students to faculty in this Department remains the second highest at MIT. The Department has started two new initiatives in constructing a new Undergraduate Process Laboratory and designing a new course, Engineering Concepts and Computer Methods, for freshmen. A new research and teaching area in systems engineering and control has also been added. The processing of electronic materials and devices, such as large scale integrated circuits, is providing growing job opportunities for our graduates and research problems for our faculty.

As a consequence of the rapid growth of biotechnology as it moves toward commercial applications, there is an exploding demand for chemical engineers trained in Biochemical Engineering. At the present time, there are far more job opportunities than can be met by the current work force and we cannot supply sufficient new Masters and Doctoral students to meet the demand by this industry. We currently supervise fifteen Doctoral candidates, including several who are in the Department of Nutrition and Food Science. Our Department will continue to play an important role in training engineers with a multidisciplinary background who can lead in the development of the Biochemical Process Industry. We expect to take the lead role in a proposal to the National Science Foundation for an Engineering Center in Biochemical Process Engineering. The Department is in a unique position to build on its strength in this area and expand its efforts to meet the needs of industry by providing innovative research and training of students. In addition, we expect continued support by industry of our activities in training and student research.

UNDERGRADUATE PROGRAM

Undergraduate enrollment decreased significantly this year due mainly to a large decrease in the size of the sophomore class. This decrease resulted from limited employment opportunities during the two previous academic years. The employment situation has improved during the current year, and no further reduction in class size is expected. The following table shows the trends in undergraduate enrollment:

| | <u>78-79</u> | <u>79-80</u> | <u>80-81</u> | <u>81-82</u> | <u>82-83</u> | <u>83-84</u> |
|------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Sophomores | 98 | 107 | 99 | 127 | 133 | 59 |
| Juniors | 114 | 111 | 109 | 104 | 112 | 105 |
| Seniors | <u>106</u> | <u>117</u> | <u>111</u> | <u>111</u> | <u>111</u> | <u>116</u> |
| TOTAL | 318 | 335 | 319 | 342 | 356 | 280 |

Curriculum development continues. The 10.27 Undergraduate Chemical Engineering Process Laboratory was established during the Spring 1984 semester with the introduction of eight experimental set-ups most of which utilized existing facilities and equipment in the Department. With an enrollment of 24 students, the inaugural offering of this course was highly successful, and this bodes well for its continuing growth as new, more versatile experiments are introduced. Over the next four years it is planned to bring on-line two new experiments per year and thereafter to maintain the vitality of the course through the replacement of these experiments at the rate of one per year. As the course progresses, the students will be exposed to the new technologies of supercritical fluid processing, biotechnology and integrated circuit processing, among others.

The Department is beginning to revise its Undergraduate curriculum with respect to the introduction of Project ATHENA. We have decided to pursue an aggressive plan that will force rapid change in a top-down fashion: A freshman course, 10.01 Engineering Concepts and Computer Methods, is set to go into a trial run in Spring, 1985 and will be given every semester thereafter. This new course will acquaint freshmen with the tools of an advanced computer environment, e.g., computer algebra, creation and editing of text and pictorial information, numerical programming, large system simulators, etc., while teaching them the concepts and methodology of engineering. The course is being prepared by a team consisting of Professors Robert A. Brown, Lawrence B. Evans, Mark A. Kramer, C. Michael Mohr, George Stephanopoulos, and Ulrich W. Suter (who is responsible for the overall project), and its development is supported by the ATHENA Resource Allocation Committee/DEC.

GRADUATE PROGRAM

Graduate student enrollment appears to be levelling off slightly, as shown by the table below. There will be 63 new graduate students beginning in September, 1984.

The number of job offers to graduating students was significantly higher than last year though the number is still a bit low when compared to prior years.

| | <u>78-79</u> | <u>79-80</u> | <u>80-81</u> | <u>81-82</u> | <u>82-83</u> | <u>83-84</u> |
|-------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Total Graduate Students | 202 | 228 | 207 | 230 | 208 | 207 |
| Doctoral Students | 74 | 73 | 77 | 85 | 115 | 132 |

Course 10.382, a new graduate course taught by Professor George Stephanopoulos, was established to reflect our academic response on the following present and future needs of the chemical industry: 1) The existing chemical processes need reorganization and revamping which can significantly improve their economic performance if they are to stay alive in a highly competitive world with deteriorating rates of growth and economic return in traditional production. 2) Revamping of existing processes leads to a higher integration of the operating units. This fact, in turn, leads to more sensitive operations, restrictive range of operations with reduced operability and resilience. Such features are undesired and should be alleviated. 3) Any new plants to come on-stream will be based on novel technological developments and will deviate drastically from traditional patterns. In such cases, existing experience cannot lead to the optimal new designs, and systematic approaches are badly needed. 4) Finally, the emerging revolution in computer-aided engineering can only find an effective outlet when one knows what one wants to do. This implies that the future designer should possess the theoretical preparation and the specific engineering skills to define design problems in a systematic and imaginative way, using the computer to provide simplicity in the quest for solutions. The course aims at bringing together the science of systems theory and the art of engineering practice into a uniform entity which, on one hand, will expand the imaginative power of the designer, while, on the other hand, will provide specific tools and skills. Thus, after the completion of the course, the students should be in a position to synthesize novel solutions to process development-related problems, put together attractive flowsheets for given processes, analyze existing flowsheets, define the scope of retrofit projects and synthesize alternative revamping strategies to improve process economics, analyze the alternative flowsheets, identify potential operability and controllability problems and make the appropriate design modifications, perform a reliability and safety analysis, as well as construct meaningful plant-wide control strategies.

The Polymer Science Laboratory (10.67), first developed 11 years ago by Professor Robert E. Cohen, has been substantially revised in content and format by Professor Cohen and Professor U. W. Suter. The revised content has made the subject much more attractive to the undergraduate students of the Department, thus providing a much-needed 12 unit laboratory elective for the Course X curriculum. Numerous graduate students, particularly those undertaking polymer-related thesis research, also enrolled in 10.67.

Thirty-nine graduate students were enrolled in the Practice School last year with about 50% involved with our doctoral program, and the remaining 50% equally divided between the 5-year program for MIT undergraduates and normal SM Practice School program. Students participated in project work at our Albany, Brookhaven and Bethlehem stations. The Albany station completed its seventh year of operation under the sponsorship of the General Electric Company at its Silicone Products Plant in Waterford, NY and its Noryl Products Plant in Selkirk, NY. The Bethlehem station is now in its third year of operation at the steel plant and research laboratories of Bethlehem Steel Corporation's operation in Bethlehem, PA. The Brookhaven station completed its first summer of operation at Brookhaven National Laboratory which is operated by Associated Universities, Inc. for the US Department of Energy. Projects at the Albany station focus on process improvement, development and design in a number of polymer production operations. Projects at the Bethlehem station are coupled to on-going process development and improvement work associated with steelmaking, coke formation, and by-product recovery. In addition, many projects deal with waste water treatment and air pollution as well as energy conservation. At Brookhaven, projects last summer dealt with synthetic fuel production via Fischer-Tropsch reactions, high temperature electrolysis, cyclic gas adsorption, and localized corrosion. Students usually attend two of the three stations during a single semester. Station directors for last year included Assistant Professor George A. Huff who directed the Bethlehem station, and Assistant Professor Montgomery M. Alger who directed the Albany station during the Fall term and returned to Cambridge for the Spring term to assist with the undergraduate laboratory course, and Assistant Professor Christopher J. Guzy who replaced Professor Alger as the Albany station Director. Professors T. Alan Hatton and Jefferson W. Tester jointly directed the Brookhaven station during its first year of operation.

RESEARCH

Combined interdisciplinary and Departmental research for which Department faculty were responsible totaled approximately \$5.9 million in 1983-84, compared to \$5.3 million in 1982-83 and \$5.8 million in 1981-82. The research volume generated by the Department alone was approximately \$2.9 million compared to \$2.3 million in 1982-83 and \$2.0 million in 1981-82.

FACULTY AND STAFF

During the past year, Christopher J. Guzy was promoted to Assistant Professor and Director of the Practice School Station at General Electric replacing Montgomery M. Alger, who returned to Cambridge in January. In January, George Stephanopoulos joined the Department as a full Professor, greatly strengthening our chemical process control and design capabilities.

Departures from the active faculty include Assistant Professors George A. Huff and Montgomery M. Alger who resigned to accept positions at Shell Development Company and General Electric Company, respectively. There are also two retirements this year, Professor J. Edward Vivian and Dr. William C. Rousseau.

Internationally distinguished visiting scientists and scholars to the Department included Professor Rakesh K. Jain (Carnegie-Mellon University), Professor Henri Renon of Ecole des Mines at Paris, and Professor Hans E. Grethlein (Dartmouth College).

Guest speakers for the Department's annual seminar series were: Dr. Meredith Thring (Queen Mary College, University of London), Professor Rakesh K. Jain (Carnegie-Mellon University), Dr. Giorgio Carta (University of Delaware), Dr. R.W.H. Sargent (Imperial College, University of London), Dr. Joel Koplik (Schlumberger-Doll Research), Dr. Eduardo Glandt (University of Pennsylvania), Dr. Manfred Morari (California Institute of Technology), Dr. Raymond Baddour (MIT), Dr. Eduardo Wolf (Notre Dame University), Dr. Irving Glassman (Princeton University), Dr. Dudley Saville (Princeton University), Dr. Klavs Jensen (University of Minnesota), Dr. Norman Li (UOP, Inc.). The Warren K. Lewis Lectureship was presented by Dr. Andreas Acrivos (Stanford University).

HONORS AND AWARDS

Professor John F. Brady received the Graduate Student Council 1984 Outstanding Teaching Award.

Professor Robert A. Brown has received the American Association for Crystal Growth's Young Author Award for contributions to the field of theoretical and numerical analysis of crystal growth processes and phenomena. Professor Brown was also awarded the Camille and Henry Dreyfus Teacher-Scholar Grant for 1984.

Professor Robert E. Cohen was awarded the 1984 Robert W. Vaughan Memorial Lecture Award at the California Institute of Technology for his research accomplishments.

Professor Charles L. Cooney was awarded the AIChE Food, Pharmaceutical and Bioengineering Division Award.

Professor William M. Deen was awarded the Department of Chemical Engineering's 1984 Outstanding Professor Award.

Professor Hoyt C. Hottel was listed as an Eminent Chemical Engineer at the AIChE Diamond Jubilee meeting.

Professor Jack B. Howard was awarded the 1983 Henry H. Storch Award of the ACS Division of Fuel Chemistry.

Professor Edward W. Merrill was awarded the Alpha Chi Sigma Award for research in biomedical engineering and polymers.

Professor Robert C. Reid was awarded the 1983 Phillips Petroleum Company Lecture Award.

Professor Kenneth A. Smith was inducted as a new member of the National Academy of Engineering as of November, 1983.

Professor Daniel I. C. Wang was awarded the Marvin J. Johnson Award from the Division of Microbial and Biochemical Technology of the ACS.

Professor James Wei was listed as an Eminent Chemical Engineer at the AIChE Diamond Jubilee meeting in 1983. He was also named the Stanley Katz Lecturer at the City University of New York in 1984, as well as the M. Van Winkle Lecturer at the University of Texas at Austin in 1983.

The Department's 1984 Awards Day ceremony was held on May 2, 1984. Professor Wei presided over the ceremonies at which the following awards were made: The Eastman Kodak Scholarship was given to Karen Lee (sophomore) for academic and personal excellence; the Chevron Scholarship was awarded jointly to Clifford J. Eskey and Thomas Foo (juniors) for their high degree of professional promise as chemical engineers; the Dow Outstanding Junior Award was given to Thomas F. Morse (junior) who has had a balanced record of achievement in academic and campus professional and social organizations, as well as work experience on or off campus; the American Institute of Chemical Engineers Annual Chapter Scholarship Award was given to Maheswaran Surendra (junior) who is a member of the AIChE student chapter with the highest scholastic performance through the first two years in Chemical Engineering; the Uniroyal Research Grant was awarded to Anne Quaadgras (junior). This award is intended to support the research efforts of first-time UROP students in the physical, chemical and engineering sciences and consists of a grant to replace UROP funding already given; the Robert T. Haslam Cup was awarded to Richard A. Register (senior) for outstanding professional promise in Chemical Engineering; the Roger DeFriez Hunneman Prize, the oldest prize in the Department, was given to Jeffrey L. Collett, Jr. (senior) in recognition of outstanding scholarship in Chemical Engineering; the Association of MIT Alumnae Senior Academic Award was given to Joyce Whang (senior) on the basis of her academic excellence; Phi Beta Kappa chose to initiate three Chemical Engineering students who have an outstanding academic record and a greater than average commitment to the humanities and science. The recipients are Thomas C. Ransohoff, Douglass S. Kalika and Srikanth Chary (seniors); the 1984 Student Award of the American Institute of Chemists Student Research and Recognition Foundation was given to Douglass S. Kalika (senior) based on his demonstrated record of leadership, ability, character and scholastic achievement; the Department's Special Service Award was given to one undergraduate and jointly to two graduate students in appreciation of unselfish contribution to the success of departmental activities. The award went to Edwin Oh (senior) and Jeffrey J. Derby and Julia A. DiCorleto (graduate students); the Rosemary J. Wojtowicz Memorial Prize in Chemical Engineering was awarded jointly to Gregory Gaudet and Randy Field (graduate students) for exhibiting exemplary performance in his or her project work at the Practice School; the Outstanding Employee Award was given for the first time this year to an employee of the Department who has provided exceptional service to the Department and its students. The first recipient was Ms. Fran Patelis. The Outstanding Professor Award was given to Professor William M. Deen.

JAMES WEI

Department of Civil Engineering

This past year the Department published "Civil Engineering at MIT," a 100 page book which describes the research and education activities of the Department in some detail. This is the first time since 1963 that we have attempted to develop a comprehensive description of our programs, and we hope it will provide a helpful window into the Department for colleagues, alumni, students, the professional community, and the construction industry. Copies are available through Civil Engineering Department Headquarters. The opening paragraphs of this book represent a strong statement of our philosophy and directions:

"The civil engineering profession is currently faced with an extraordinary set of challenges. The decay of the nation's infrastructure, the need to control toxic wastes and to improve productivity in construction, natural resource development and the changing transportation environment are all receiving priority attention. At the same time, we face a potential undersupply of civil engineers equipped to deal with those issues. Addressing these challenges and others will require the active participation and cooperation of the education and research communities working in partnership with those in professional practice.

"At MIT, we are striving to meet those challenges. Among our areas of concern:

- the rebuilding and redevelopment of the nation's infrastructure
- the more effective use of computers in practice, research and teaching
- the continued development of experimental facilities and analytic approaches to study the behavior of complex engineering and natural materials
- the development of new approaches to the problems of toxic and hazardous waste through a deeper understanding of physical transport processes, and aquatic chemistry and biology
- the continued development of a rational methodological core in transportation systems with added emphasis on analysis of private transportation concerns
- the improvement of the planning, design, construction, operation and maintenance of the large-scale projects which are the hallmark of the profession

"Through these efforts and others, we hope not only to educate a new generation of engineers but also to play a substantial role in the redefining of the profession so that it can continue its contribution to society into the next century.

"Approaching major challenges such as these is in the department's tradition. Among the education and research undertakings in the last twenty years which we feel have helped provide important direction to the profession are the application of computers to civil engineering problems, the use of probability and statistics in civil engineering, the development of an integrated supply-demand framework for transportation systems analysis, and the development of an environmental teaching and research activity based on aquatic science. We take as part of our mandate the responsibility always to develop new opportunities and by pursuing them to help further the continuing development of the field."

UNDERGRADUATE PROGRAM

This past year saw a gratifying 100 percent rise in the size of the sophomore class (the year in which students indicate a major) to 30 students. Initial data for next year's sophomore class of 1984/5 indicates that additional modest growth is possible. As highlighted in previous annual reports, with the leadership of Professor David Marks, the Undergraduate Officer, the faculty has put a good deal of energy into raising the level of understanding of Civil Engineering among MIT undergraduates, and we are pleased there has been some response to these efforts.

We continue a variety of activities aimed at providing opportunities for undergraduates to participate in our program, including an active Undergraduate Research Opportunities Program, under the direction of Professor Harold Hemond; a lively Student Chapter of the ASCE, under the direction of Professor John Slater; the offering of a number of undergraduate seminars, several special programs such as the Harvard Bridge Contest described elsewhere in this report, redevelopment of Subject 1.00 in computation, also described elsewhere, and special subject offerings focusing on civil engineering issues of local interest, as the Central Artery reconstruction.

During this past year, the Constructed Facilities Division (CFD) has instituted a new undergraduate program of subjects aimed at exposing each student to a broader background in civil engineering subject matter.

The former program built upon the Sophomore Core of basic subjects in mechanics, hydrodynamics, and systems analysis provides three parallel concentrations in the CFD area among which a student could choose. These were, respectively, in structural engineering, geotechnical engineering, and project management. Each parallel concentration shared a common junior year, but each differed at the senior year.

The new program continues to build upon the Sophomore Core, but has a unified CFD program in the junior and senior years. In the junior and senior years each student takes a three-part series of subjects in mechanics and structural engineering and a three-part series in geotechnical engineering and engineering geology. These two series share a newly developed common first subject, 1.51 Mechanics of Construction Materials. Also, 1.53 Constructed Facilities Project Laboratory, a new laboratory subject has been developed as a major component of this program. In addition, in the senior year each student may take elective subjects in construction management and materials of construction.

The principal motivation for the change is threefold:

- To provide greater programmatic breadth in subjects directly associated with the civil engineering of constructed facilities.
- To provide greater programmatic intensity in both principal disciplines of civil engineering related to constructed facilities (i.e., structural and geotechnical engineering).
- To eliminate the branching division of students to the three CFD options and thus eliminate the need for subjects with limited enrollment.

While the proposed program presents a workable change in our offering, we think it is an important structural change which will provide needed direction to CFD undergraduates, and provide a simultaneously broader and deeper foundation in the disciplines underpinning the civil engineering of constructed facilities. Further, we think this can be accomplished with a more efficient use of faculty resources than the present, less directed program affords.

GRADUATE PROGRAM

The graduate program of the Department continued to be strong with 220 students enrolled in our programs in the Constructed Facilities Division, Water Resources and Environmental Engineering Division, Transportation Systems Division, and the Center for Construction Research and Education. We continue to develop our academic programs. Specific new subject developments include the following:

Professor Eduardo Kausel developed a new subject in 1.133 Geomechanics.

Professor Clifford Winston developed a new experimental subject in 1.965 Economics of the Construction Industry.

Professor George Kocur did extensive development work on his subject in 1.204J Computer Algorithms in Transportation.

Professor Amr Azzouz enhanced his subject in 1.368 Computer-Aided Analysis in Geotechnical Engineering with the implementation of various computer codes.

Professors David Marks, Erik Vanmarcke, Robert Logcher, and Mr. Michael Markow developed a new subject in 1.44 Analysis Methods in Construction Engineering and Management.

Our graduate program strongly interacts with our research programs, several aspects of which are described in the following section.

RESEARCH

The research program of the Department is considered an essential component of our educational program, providing an exciting environment for both our graduate and undergraduate students. The program spans the interests of the faculty and continues to be a mechanism through which the frontiers of the field of civil engineering are expanded.

In this year's report, we highlight two major research initiatives of the Department, abstracting from materials prepared for our Visiting Committee meeting in March 1984.

I. Center for Scientific Excellence in Offshore Engineering - A Summary

Introduction

The Standard Oil Company of Ohio (SOHIO) entered into an agreement effective September 1, 1983, with the Massachusetts Institute of Technology (MIT) to establish a Center for Scientific Excellence in Offshore Engineering. The five year grant provides \$400,000 per year to support coordinated research in collaboration with SOHIO to develop the technology necessary for an overall evaluation of alternative structural concepts for offshore exploration and production platforms to recover oil and gas under the extreme environmental conditions encountered in the American Arctic. This interdisciplinary effort encompasses basic and applied research on ice and structural engineering, geotechnical engineering, risk and reliability, and hydrodynamic aspects of Arctic offshore engineering.

MIT is one of five institutions awarded a \$2 million grant in a national competition sponsored by SOHIO to encourage innovative university-based research in partnership with industry. The universities were free to submit multiple proposals in any field. Criteria used to evaluate the nearly 1000 preliminary proposals and to select five from among 35 finalists stressed excellence in the area of study, support, and education of students, collaboration with SOHIO, and innovative research on problems of national significance.

MIT's grant is shared by the Department of Civil Engineering and the Department of Ocean Engineering, where more than 20 faculty members have been engaged in various aspects of offshore engineering for the past decade. Establishment of the Center furthers MIT's goal of playing a leadership role in education and research by extending and directing the offshore program into the rapidly developing field of Arctic engineering and by expanding a necessary partnership with industry. The opportunity is especially important since: 1) the American Arctic is emerging as one of the world's major sources of petroleum reserves; and 2) resource development in this geographic frontier presents unique technological problems for offshore structures due to the severe environment, massive ice floes, and weak ocean sediments.

Specifically, the Center will undertake three tasks over the five-year period of the grant:

1. Conduct coordinated research on ice and structural engineering, geotechnical engineering, risk and reliability, and hydrodynamic aspects of offshore engineering in the Arctic with the primary objective of developing the technology necessary for an overall evaluation of alternative structural concepts for offshore exploration and production platforms.
2. Provide support to graduate students engaged in Arctic offshore engineering research.
3. Develop a scientific interchange program between MIT and SOHIO involving technical collaboration on research projects, the establishment of a personnel exchange program, and a program of symposia, seminars, and short courses.

The program is under the direction of Professor Charles C. Ladd of the Department of Civil Engineering. Participating faculty include Professors Amr Azzouz, Gregory Baecher, Mohsen Baligh, Oral Buyukozturk, Jerome Connor, Herbert Einstein, Ole Madsen, Chiang C. Mei, W. Kendall Melville, S. Shyam Sunder, Daniele Veneziano, Drs. John Germaine and Robert Martin of the Department of Civil Engineering; and Professors Tomasz Wierzbicki, Paul Xirouchakis, and J. Kim Vandiver of the Department of Ocean Engineering.

II. Groundwater Research and Education

Background

Just as the quantity and quality of surface waters was the dominating issue in the 1970's, the present decade is dominated by concerns with our groundwater resources. From a quantity viewpoint, over-exploitation of subsurface water supplies has led to dropping water tables in many parts of the country. The Ogallala aquifer in the Arizona region exemplifies a crisis of major proportion.

The quality of groundwaters is also a public, worldwide issue. Past disposal activities of the exotic materials which support modern society has led to an alarming incidence of contamination of subsurface waters. Since the Love Canal incident, thousands of aquifers have been found to present serious threats to human health due to past contamination. The problem is particularly serious in the Northeast region of the United States. Underground disposal of high level and low level radioactive waste is also an imminent activity that may endanger large regions of our groundwater resources and ultimately also affect our surface waters.

One of our challenges is to find methods which effectively limit the effect of past mistakes in our use of groundwater and to control future activities in ways which minimize adverse impacts. To do this requires more knowledge of the physical, chemical, and biological processes which control the transport and fate of hazardous substances in underground waters. We need to develop quantitative methods for predicting the effectiveness of control measures under highly variable natural conditions over extended periods, in some cases ranging up to several centuries. Control measures should be managed in ways which best use the available resources, and regulation must realistically recognize social and economic constraints.

The Water Resources and Environmental Engineering Division of the Civil Engineering Department is responding to this challenge as a priority area of endeavor. The addition to our faculty of Professors Lynn Gelhar and Philip Gschwend over the past several years has formed a nucleus of experts in the area of groundwater quality and quantity. Professor Gelhar brings expertise in physical groundwater hydrology and in problems of contaminant transport. Professor Gschwend specializes in the fate of organic chemicals in the aquatic systems. They join several other faculty with interest in the problem, particularly Professor Hemond who is interested in the issues of field sampling technology and the biochemical interactions in subsurface systems. Our long-term goal is to develop a team capable of dealing with the many aspects of groundwater problems and offer students and sponsors an unmatched breadth of experiences and expertise. Faculty members currently participating in our groundwater activities include Professor Gelhar, Professor Gschwend, Professor Hemond, Professors Rafael Bras, Sallie Chisholm, Peter Eagleson, Ole Madsen, and Francois Morel.

Our research activities are healthy and growing, and include programs in the following areas:

Subsurface Solute Transport: Development of Stochastic Theories and Development of a Field Testing Facility.

Stochastic Analysis of 1) Solute Transport in Unsaturated Soils, 2) Dispersive Contaminant Transport, 3) Flow in Heterogeneous Rocks and 3) Transport Processes in Heterogeneous Porous Media.

Agricultural Hydrology in Egypt.

On Line Control of Irrigation Systems.

A Coupled Model of Carbon, Nitrogen, and Sulfur Transport and Transformation in an Ombrothropic Bog.

Porewater Turnover in the Salt Marsh Ecosystem.

Mass Transport of Toxic Chemicals Between Bed and Water.

Sponsors of groundwater related research sponsors include the Electric Power Research Institute, U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency, Sandia National Laboratories, National Science Foundation, Centre National de la Recherche Scientifique (France) Agency for International Development through the MIT Technology Adaptation Program.

INITIATIVES IN COMPUTATION

This past year saw substantial activity in the field of computation, an area that the Department sees as critical for its future.

1. Computer-Aided Teaching for the Design of Constructed Facilities

The faculty of the Constructed Facilities Division developed a successful proposal to Project Athena, the major new initiative at MIT in computers and education. This work is concerned with the development of a system for Computer-Aided Teaching (CAT) that will significantly increase our effectiveness in providing students with:

a) an understanding of fundamental concepts, principles, and analytical techniques of mechanics applicable to physical systems encountered in the engineering of constructed facilities,

- b) an intuitive or physical feel for the mechanical behavior of structures and foundations,
- c) the ability to reduce complex physical systems to models for engineering analysis, and
- d) an in-depth exposure to the concept generation, preliminary design and optimization stages of engineering design through the solution of realistic design problems.

The CAT system will be based on techniques of interactive-adaptive computer graphics, data-base management, and expert systems. The development of the CAT system will lead to a major improvement in the teaching of seven undergraduate subjects and many of the graduate subjects offered by the principal investigators and their colleagues in the Constructed Facilities Division of the Department of Civil Engineering. In addition, it will allow implementation of a new graduate program in Computer-Aided Structural Design which includes the development of a project oriented structural design subject of interest to upperclass undergraduate students as well.

Participating faculty include: Professors Azzouz, Baecher, Connor, Victor Li, Logcher, Slater, Shyam Sunder, and Robert Whitman.

2. Subject 1.00

For 15 years, the Department has offered Subject 1.00, a popular introductory computer subject at MIT. This subject has evolved substantially over that period of time. Over the past year, under the leadership of Professor Kocur and Professor Steven Lerman, this subject has been modified extensively to focus more on software and engineering applications and less on hardware issues. The changes in 1.00 were actively publicized, and the enrollment in 1.00 jumped four-fold to over 100 in each semester. About 80 students in each semester are freshmen, affording the Department some access to these students prior to selection of a major, which fits nicely with our goals of expanding the size of our undergraduate program. We have made a substantial resource shift in the Department in terms of teaching assistants and computer time to accommodate the changed scale of this important offering.

Currently, 1.00 covers topics in numerical analysis, data structures and data management, algorithm design and graphics. Applications are drawn from engineering and scientific fields, including civil engineering, and build upon basic elements of mathematics, physics, and computer science which are common to all computer applications. Many concepts are introduced, such as recursion and lists, which are not a part of traditional first level computer subjects. Areas include elementary algorithms, characteristics of mathematical functions, numerical integration, data structures, searching and sorting, geometric algorithms, matrices and linear equations, deterministic and probabilistic simulation.

3. Facilities

This past year saw the establishment of the Civil Engineering Computer-Aided Design and Drafting (CADD) Facility. This facility contains hardware contributed by Apollo Corporation and software developed and made available to the Department by Louis Berger International, Inc., for integrated computer-aided design and drafting. Hardware includes two Apollo high resolution graphical workstations, which are powerful single user computers with one-and-one-half Mbyte of memory, and one Apollo file server/computer server of similar capabilities. These computers are networked together and to other computer facilities on campus. Software provided for the facility includes structural and highway design packages and the CANDID drafting and graphical data base system. This system is being used to provide students with experience in CADD and how to adapt design and drafting systems to specific situations. The facility will also be used for research in computer-aided preliminary design to front-end CADD systems and in knowledge based data structures for design coordination.

Also, the Department is proud to house the first fully operational cluster of Athena terminals. These terminals, on the first floor of Building 1, directly opposite the Department's Undergraduate Center, are expected to provide convenient access to Athena facilities for the students and faculty of the Department and for the Institute-at-large.

In addition, several current facilities, including the Joint Computer Facility and the Transportation Computation Laboratory were substantially enhanced.

FACULTY/STAFF

The following faculty members were promoted during this past year. Dr. Rafael Bras, Dr. Mohsen Baligh, and Dr. Ole Madsen to full Professor; Dr. Harold Hemond and Dr. Yosef Sheffi to tenured Associate Professor; Dr. Amr Azzouz and Dr. Clifford Winston to Associate Professor, all effective July 1, 1984.

Mr. Michael Markow was promoted to the rank of Principal Research Associate, effective June 1, 1984.

Effective September 1, 1984, two new faculty members join the Department. They are Dr. Lorna Gibson in the area of materials and Mr. Dennis McLaughlin in the area of water resource systems. The Department continues its active search for first-rate people to join its faculty.

During this past year, the Department accepted the resignation of two faculty members: Dr. Marvin L. Manheim to accept a chaired position at Northwestern University and Dr. Michael Meyer to enter government service.

Mr. Edward E. Newman retired on January 31, 1984, as Senior Lecturer after 25 years of service. He was heavily involved in the computer activities of the Department during this time, including the ICES effort and the Joint Computer Facility.

This year two of our senior faculty were honored by being named to chairs. Professor Peter S. Eagleson was named the Edmund K. Turner Professor of Civil Engineering, and Professor Fred Moavenzadeh was named the first William E. Leonhard Professor of Engineering. They join Professor Donald R.F. Harleman, Ford Professor of Engineering, as chaired senior faculty in the Department.

Professor Lerman was appointed the first Director of Project Athena, a major new Institute initiative in computers and education. Professor Frank E. Perkins, Professor of Civil Engineering and Associate Provost, was named to the additional post of Dean of the Graduate School.

Professor Frederick J. McGarry, Professor of Materials Science and Engineering and Civil Engineering, was named Director of the MIT Summer Session.

Other senior faculty of the Department continuing in major Institute assignments are Professor Moavenzadeh (Director, Technology Adaptation Program), Professor Daniel Roos (Director, Center for Transportation Studies), Professor Richard de Neufville (Director, Technology and Policy Program), and Professor Ann Friedlaender (Head, Department of Economics).

Professor Bras became head of the Water Resources and Environmental Engineering Division and Director of the Ralph M. Parsons Laboratory, effective August 1983. He replaces Professor Harleman who served in both capacities for ten years and requested a return to full time teaching and research. Professor Harleman's leadership during his term contributed to substantial intellectual growth in the activities of the Division as well as increased level of research support, faculty size, and enrollment. His exceptional contribution to the Division, Laboratory, Department, and Institute is gratefully acknowledged by all his colleagues.

Professor Nigel Wilson became head of the Transportation Systems Division on February 1, 1984, replacing Professor Lerman who had served for two-and-one-half years and stepped aside to assume his new duties as Director of Project Athena. Professor Ladd replaced Professor Wilson as Graduate Admissions Officer, also effective February 1, 1984.

Professors Bras, Wilson, and Ladd, together with Professor Baecher, Head of the Constructed Facilities Division, Professor Moavenzadeh, Director of the Center for Construction Research and Education; Professor Morel, Graduate Officer; Professor Marks, Undergraduate Officer; Mr. Trond Kaalstad, Senior Administrative Officer; and Professor Joseph Sussman, Head of the Department, form the Department Council, which considers matters of Department policy, resource allocation and faculty development, and advises the Department Head on issues facing the Department.

Three members of the faculty were on sabbatical leave. Professor Whitman worked on new research directions while at the Norwegian Geotechnical Institute (NGI) in Oslo and the University of California at Davis. Professor Keith Stolzenbach worked on new research initiatives while in residence at the Woods Hole Oceanographic Institution and participated in an oceanographic cruise to the Pacific hot vents. Professor Chisholm worked on new research directions while in residence at the University of Colorado and the Horn Point Environmental Laboratory, University of Maryland.

Professor Erik Vanmarcke was awarded the Huber Research Prize of the American Society of Civil Engineers for notable achievement for contributions to reliability analysis in geotechnical and structural engineering.

Professor Eagleson was elected President of the American Geophysical Union. He will serve two years as president-elect and formally takes office in 1986.

Professor Melville was a visiting scientist at the University of Sydney, Australia, in February 1984, conducting deep water experiments in the region.

Professor Daniel Roos served as the State Chairman in Massachusetts for National Transportation Week, a week-long series of transportation seminars and meetings involving more than 1000 participants.

A number of the faculty keynoted major professional meetings during this past year. Professor Logcher gave the keynote address at the International Conference of Microcomputer Software in Engineering, Venice, Italy, speaking on "New Directions in Engineering Computation." Professor Vanmarcke keynoted two major conferences. He spoke on "Random Fields: New Concepts and Engineering Applications" at the ASCE Specialty Conference on Structural Reliability and Engineering, at the University of California at Berkeley, and on "Risk Management to Improve Dam Safety" at the International Conference on Dam Safety held at Coimbra University in Portugal. Professor Sussman gave the keynote address at the International ICES Users Group meeting in Boston, Massachusetts, on "Computers and Education" and also keynoted the 50th Anniversary Symposium of the Finnish Society of Civil Engineers (RIL) in Helsinki, speaking on "Civil Engineering Education in the Year 2000." Professor Harleman gave the keynote address at the session on Stratification Mixing and Dispersion at the 1983 ASME Meeting.

Professor Henry Irwig received the President's Award for Leadership of the Boston Society of Civil Engineers Section of the ASCE in May 1984.

Professor Wilson was named to serve as the School of Engineering representative on the Committee on Educational Policy, the senior faculty committee at the Institute.

Under the direction of Professor Einstein, the REMERGENCE Laboratory, a joint activity of the Department of Civil Engineering and the Department of Mechanical Engineering, began taking shape. Major space renovations were accomplished, various equipment was acquired, and a major fund raising activity was initiated.

Many of the faculty served the professional community through their memberships on advisory committees at other academic institutions. These include Professor Connor (University of California at Irvine), Professors Harleman and Marks (Stanford University), Professor Sussman (University of New Hampshire), Professor Logcher (University of Pennsylvania), Professor Irwig (Wentworth Institute of Technology), Professor Ladd (ABET accreditation team at Johns Hopkins), and Professor Gelhar (Butler University).

Professor Winston received the Transportation Research Forum Award for best paper on the topic of intercity bus transportation.

Professor Madsen received the Department's Effective Teaching Award, winning it for the third time in the 13 year history of the award, truly an outstanding continuing record of teaching excellence. Also, he gave the 20th Annual Shaw Lecture on "Waves and Shores" at North Carolina State University in November 1983.

Dr. Eric Adams continued as the program manager of the Environmental Management Program Area of the MIT Energy Laboratory.

As part of the Department's program of faculty development and as a component of the Athena effort, Professors Kocur, Li, Logcher, Shyam Sunder, and Slater, attended a special two-week offering of 6.001 Structure and Integration of Computer Programs, held during IAP, January 1984.

Professor Kausel is the editor of the proceedings of the symposium held at MIT in honor of Professors Emeriti Robert Hansen, Myles Holley, and John Biggs. The Proceedings were entitled, "Structural Engineering: Research, Education, and Practice."

Ms. Pat Dixon, Administrative Assistant of the Parsons Laboratory and Water Resources and Environmental Engineering Division, won the Murphy Award for distinguished service to MIT.

The following students were recognized:

Mr. Nabil Fares was awarded the winner of the Richard Lee Russel Award, given to an outstanding senior in Civil Engineering who plans to continue with graduate studies at the Institute.

Mr. Gianpaolo Trella was awarded the Steinberg Prize, given to an undergraduate student for academic achievement and demonstrated interest in construction management.

The Department was pleased to have the following as visiting faculty during the past year:

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|---------------------------|---|
| Professor Wayne Bialas | State University of New York at Buffalo |
| Professor Antonio Camara | New University of Lisbon, Portugal |
| Professor Yao Song Chen | Peking University, People's Republic of China |
| Professor Gordon Fielding | University of California at Irvine |

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| Professor Josef Jelinek | Technical University of Prague, Czechoslovakia |
| Professor George Noutsopoulos | National Technical University of Athens |
| Professor Michael Soulie | Ecole Polytechnique, Montreal, Canada |
| Dr. Michael Stiassnie | Technion, Haifa, Israel |

Professor William Stanley, Professor Emeritus of Civil Engineering, died in LaGrange, Illinois, on September 29, 1982. Professor Stanley was well-known for his work in sanitary engineering and served the Department and the Institute with distinction as a member of the Civil Engineering faculty from 1944 to 1962.

VISITING COMMITTEE

The Corporation Visiting Committee of the Department of Civil Engineering met on March 15 and 16, 1984.

The meeting focused on several Department initiatives, including computation, the new undergraduate program in the Constructed Facilities Division, the Center for Scientific Excellence in Offshore Engineering, groundwater research and education, and a progress report on the Center for Construction Research and Education.

Completing their term as Visiting Committee members on June 30, 1984, are Mr. William H. Mills, Mr. E. Alfred Picardi, and Major General Hugh G. Robinson. The Department thanks all these outgoing members for their guidance and counsel over the past several years.

Mr. E. Kirkbride Miller, a member of the Civil Engineering Visiting Committee and the MIT Corporation died on June 12, 1984. The Department expresses their sympathy to his family and gratefully acknowledges the contribution that Mr. Miller made to the Visiting Committee deliberations.

The Department welcomes the following new members, effective July 1, 1983.

Mr. LeRoy N. Callender, P.E., President, LeRoy Callender Consulting Engineers

Mr. Edward H. Linde, President, Boston Properties

The Department notes with great pleasure the election of Dr. Harl P. Aldrich, Jr., Chairman of the Visiting Committee, to the National Academy of Engineering.

SEMINARS AND PROGRAMS

The faculty of the Department participated in a variety of programs and seminars at MIT during the past year. Among the most notable are the following:

During the Independent Activities Period, the Department sponsored a series of lectures on Civil Engineering and the Oceans, organized and led by Professor Melville.

Also during IAP, Professor Slater, assisted by Professor Buyukozturk, organized a design contest focused on the Harvard Bridge, a distressed structure immediately adjacent to MIT. Students from across the Institute developed design concepts, built models, and tested their structures to failure in Lobby 10 before several hundred interested observers.

Mr. Fred Salvucci, Secretary of the Executive Office of Transportation and Construction, State of Massachusetts, and formerly a lecturer in the Department, spoke at the annual Student/Faculty Dinner on the "Ups and Downs of Boston Area Transportation" before the best attended such dinner in recent memory.

Mr. Charles Helliwell, Deputy Director of the Center for Construction Research and Education, organized and hosted a meeting of the New England Construction Users Council which focused on the educational aspects of the recent Construction Industry Cost Effectiveness Project of the Business Roundtable. This meeting attracted almost 100 academics from around New England.

Under the leadership of Professor Marks, a faculty seminar was organized around the theme of "The Analysis of Management Alternatives for Aging Infrastructure Systems." This involves faculty and some advanced graduate students from all areas of the Department. This seminar focused on some of the new intellectual issues at the heart of the "Rebuilding America" area and has led to two new subjects being offered Spring 1984, these being "Analysis Methods in Construction Engineering and Management" and "Economics of the Construction Industry." Also, a summer short course in this area is planned for August 1984.

The Department together with the Center for Transportation Studies hosted the annual meeting of the Railroad Planning Officers Group in April 1984.

The Department hosted a major meeting on "New Perspectives on the Safety of Dams" in July 1983. Professor Vanmarcke directed this seminar and workshop, co-sponsored by the Department of Civil Engineering at Stanford University, which attracted 80 people from around the world.

The Water Resources and Environmental Engineering Division and the Ralph M. Parsons Laboratory of the Department hosted the ASCE Hydraulics Division Specialty Conference in August 1983, which attracted about 311 participants. Professor Harleman was the chairman of the organizing committee, and a number of the Division's faculty participated.

In March 1984, a number of the faculty and staff participated in a symposium on "Transportation Policy, Planning, and Management in Egypt" at Cairo University. Professors Ralph Gakenheimer, Henry Marcus (Department of Ocean Engineering), Moavenzadeh, Wilson, and Messrs. Brian Brademeyer and Markow gave papers. Professor Sussman gave the keynote address.

Professor Sheffi organized an Industrial Liaison Program seminar on Transportation and Logistics held at MIT in March 1984.

On behalf of MIT, the Department hosted two lecture series, sponsored by the Boston Society of Civil Engineers Section of the ASCE, one on "Structural Details in Steel and Concrete Buildings" and one on "Computer-Aided Design and Drafting."

JOSEPH M. SUSSMAN

Department of Electrical Engineering and Computer Science

The Department was the focus of much attention at the Institute and nationally during the past year. The reason for all the attention was the growth in our undergraduate enrollments. The number of undergraduate Electrical Engineering and Computer Science (EECS) majors grew to 1149 in the Fall of 1983. Especially noteworthy was the growth of the size of the sophomore class to 380 from 345 in the previous class.

The Department urged the Institute in the Spring of 1983 to limit undergraduate enrollments in EECS in order to achieve a better balance in our activities between undergraduate instruction, advising, and bachelor's thesis supervision, and graduate instruction, thesis supervision and research.

The President decided that the issue of limitation of undergraduate majors should be determined by the entire MIT faculty. Of course no one is enthusiastic about such a major break with MIT tradition, but given the serious need to take some significant action, the Department's faculty was largely in favor of a limit placed upon entering freshmen before they arrive at MIT. The Committee on Educational Policy (CEP) recommended, however, placing a limitation after students have been at MIT for at least one year. The major argument against an after policy is that it would frustrate many MIT students who could not become EECS majors, especially at a time when many nationally ranked departments of EE and CS are refusing to admit any more transfer students. A major argument against a before policy is that it forces 16- and 17-year olds to make career decisions before most of them have relevant experience to do so.

The CEP proposed a motion, at a special meeting of the MIT faculty in December 1983, to limit Departmental access to students who would be accepted to MIT in the Spring of 1984 (the class of 1988) after they have arrived at MIT. The Department moved to substitute instead a motion for a before policy for that Class. That substitution passed with ease. After a second Department amendment was offered on the mechanism for administering a before policy, and after much discussion, centered in part on the issue that MIT would be changing the admission process in midstream, the revised main motion was roundly defeated for the Class of 1988.

The defeat of a motion for an enrollment limitation for the Class of 1988 nevertheless led to several useful results. The Department obtained a modest increase in its budget for the coming academic year. Other departments have offered to help us by permitting a number of their faculty to teach our undergraduate sections. A relatively large number of faculty and staff members in other departments have offered to supervise bachelor's theses of EECS students. A number of departments have campaigned aggressively for more undergraduate majors. The Tech, in particular, had a series of 17 articles that tried to convince freshmen to major outside of Course VI. It was decided to admit no additional college-transfer students into Course VI. Fortunately, it was also decided for other reasons to reduce the size of the next incoming freshman class (the Class of 1988) by 50.

The Department and the CEP continued to work to further define the nature and scope of the problem posed by the large number of undergraduate majors. The Department recommended enrollment targets of 350, 310, and 270 for the next three EECS sophomore classes. This was accepted in principle by the CEP. At the May meeting of the MIT faculty, the CEP proposed a "sense of the meeting" motion to continue to refine a plan for a before policy that would be triggered if the target figures are not met. This plan is to be presented to the faculty early in the Fall of 1984. This motion passed without dissent.

At this point it is not clear what the effect will be of all the actions that have taken place this year. The designation of majors by the current freshmen appears to lead to a sophomore class of about 350 in the Fall of 1984. The percentage designating EECS is the same as last year. The class would, however, be smaller than this year's class because no transfer students will be admitted and because the current freshmen class is slightly smaller than the previous one. Even if the incoming class size meets the target figure of 350, it is not at all clear whether the subsequent targets can be met. Furthermore, given the numbers of students already in the system, it is almost certain that the overall number of EECS majors will grow further.

On other fronts, we are pleased to report that the Institute dedicated the new EG&G Education Center in October, 1983. This Center, which is funded by our long-time friends, Esther M. and Harold E. Edgerton, Pauline S. and Kenneth J. Germeshausen, and Dorothy J. and Herbert E. Grier, and the Company they founded (EG&G), is located between Buildings 38 (Electrical Engineering and Computer Science Headquarters) and 36 (Research Laboratory of Electronics). Since the building had to have an even number, it is called Building 34. During Dedication Week, we had a party for our students that was attended by nearly 1,000. We also had a party for the donors at the Faculty Club. Finally, the Institute had a formal dedication following the regular October meeting of the Corporation.

In the lower two floors of the building is an auditorium, called Edgerton Hall, that seats 330. Edgerton Hall has a rear video projection screen and much other audio-visual equipment. Appropriately, "Doc" (Edgerton) gave the opening lecture in the Hall. It was a magnificent lecture. The third floor has four classrooms. Both the Hall and the classrooms are usually scheduled for EECS subjects. The fourth floor is a conference room with a capacity for about 120. This Grier Conference Room has been the site of our departmental faculty meetings. The room can also be split into two smaller rooms. It has been heavily used in both modes in the past year. The upper floor, the Germeshausen laboratory, contains 75 Hewlett Packard 9836 computers. Approximately two thirds have been used in our introductory computer subject, 6.001, Structure and Interpretation of Computer Programs. The remaining third are being used in our computer architecture subject, 6.004, Computation Structures. The 6.004 lab also used about two dozen oscilloscopes donated by Tektronix.

The EG&G Education Center has been immensely useful to us and the Institute in the past year. We can not now imagine how we could have functioned without it.

The Department continued to implement the concept of Lifelong Education that was announced at its Centennial Celebration in 1982. Our introductory programming course, 6.001, that was taken by about 750 MIT students this past year, was taped in the Summer of 1983. These tapes are now being shown in Tutored Video Instruction mode in industry. The usefulness of these tapes will increase when the SCHEME language (a variant of LISP) that is used in the course is reimplemented to run in the UNIX operating system. In the Summer we shall tape some of our special summer courses, such as VLSI design, with the goal of broadcasting these tapes over the educational channels in Eastern Massachusetts during the coming year. The educational channels are currently operated by the Archdiocese of Boston and by Northeastern University. We intend to make arrangements with one of these organizations in the coming year. Lincoln Laboratory expects to make available to us microwave dishes that would permit us to broadcast live seminars, such as the VLSI seminar, over the same educational channels.

UNDERGRADUATE PROGRAM

Enrollment of undergraduates averaged 1,130 in 1983-84, with about 65 percent in the Electrical Engineering Program and 35 percent in the Computer Science Program. The total represents an increase of about 30 students from the previous year.

The first year of full-scale utilization of the new EG&G Building was highly successful. Apart from expanded classroom and lecture facilities, the Germeshausen laboratory on the 5th floor, available full time, greatly relieves the computational load on the Department's DEC 20 and enables us to support in excess of 400 students in 6.001 Structure and Interpretation of Computer Programs and 200 students in 6.004 Computation Structures every semester.

In the Fall, the Department hosted a visitation of representatives of ABET, the Accreditation Board for Engineering and Technology, to consider a renewal of accreditation of our undergraduate programs in EE and CS. The ABET team was most pleased with the very strong emphasis on undergraduate education in the Department, but urged us to highlight design experiences more explicitly in the curriculum. Final results on accreditation are not yet available.

The following prizes and awards were won by our students. The Ernst A. Guillemin Prizes for outstanding S.B. theses in Electrical Engineering were awarded to Lloyd Hey of Oyster Bay, NY (first prize), David K. Gerber of Albuquerque, NM (second prize), and Ira H. Leventhal of Dix Hill, NY (third prize). Honorable mention went to James B. MacArthur of Elenmont, NY, Cyrus S. Bamji of New South Wales, Australia, and Neal G. Kavesh of Whippany, NY. The William A. Martin Memorial Prize for the outstanding thesis in Computer Science was won by Van-Duc Nguyen of Cambridge, MA, and the runner-up was Brad Kuszmal of Merriam, KS. The Computer Systems Thesis Prize was presented to Kenneth Traub of South Bend, IN. An engineering school-wide Rodman McClintock (1921) Award for an outstanding undergraduate thesis was awarded to Howard S. Gordon of Poughkeepsie, NY. A special prize was given to Robert C. Zak of Mililani, HA, as the winner of a contest in subject 6.004 for the fastest implementation of a specified instruction set using only parts contained in the course lab kit. The prize consisted of the lab kit itself, and the winning computer constructed from it.

The following special scholarships were awarded to our students for academic excellence: General Motors Scholarships to Brett Miwa of Urbana, IL, and Alexander Wang of Des Plaines, IL; and the Kodak Scholarship to Victor Abrash of Walnut Creek, CA, with runner-up Jeffrey Arenberg of Los Angeles, CA. Charles Selvidge of Wichita, KS, received the Honeywell Award for outstanding academic achievement in engineering and science.

GRADUATE PROGRAM

In September, 1983, there were 598 graduate students enrolled in the Department. Of this number 214 were newly admitted students. About 20 percent of the total were foreign nationals. The Department supported 235 Research Assistants, 111 Teaching Assistants, and awarded 37 fellowships. In addition, there were 25 National Science Foundation Fellows and 16 Hertz Fellows. The remaining students had industrial or foreign government support or were using their own funds.

During 1983 the Department awarded the following graduate degrees: 145 masters of science, 27 electrical engineers, and 33 doctorates.

The Department received 1,668 applications for the 1984-85 year. The applicants were generally excellent and 294 were admitted, of whom we expect 214 to register for next fall.

For excellence in teaching: graduate students Leo F. Casey, Andrew F. Goldberg and Jeremy H. Nussbaum were given the Frederick C. Hennie, III Award, an award funded by Proctor and Gamble; the Carleton E. Tucker Award was won by Poh-Leng Leong; the Harold L. Hazen Award, funded by an anonymous donor, was won by Soon Yun Poh; and Daniel J. Van Hook was promoted to Instructor-G.

One of our graduate students, Michael Eisenberg, has written a play, "Hackers", which appeared on Broadway this Spring. The New York Times review said "...the play at the Manhattan Punch Line is deftly designed to amuse theater goers, even those who are not yet tuned to the computer age."

VI-A PROGRAM

Spring 1984 saw 228 students (56% of Course VI sophomores) apply for admission to the VI-A Program. Our participating companies came up with 146 offerings, their largest number yet.

These two circumstances, though, posed a significant problem for the Department in light of its continuing attempt to bring down the total VI-A enrollment to about 250. It was 299 last summer. Under this restrictive mode the incoming class should number about 85-90 new students. With a great deal of effort, however, new company offerings could only be pared down to 113, of which 104 were ultimately matched. Thus, the total VI-A enrollment for the summer of 1984 should be about 288.

The withdrawal of two facilities from the Program (AVCO-Everett Research Laboratory and Naval Surface Weapons Center/White Oak Laboratory) allowed the substitution of one new company and two new divisions or related portions of current companies. The ROLM Corp. joined the Program with assignments at its Office Systems Division in Santa Clara, CA. Professor Carl E. Hewitt, who was instrumental in completing arrangements with ROLM for joining VI-A, will serve as their first VI-A Faculty Advisor.

At the request of our supportive VI-A alumnus, Cecil H. Green '23, one of the newly selected Texas Instruments (TI) students chose to have his assignment at Geophysical Services, Inc. (GSI), TI's parent company in Dallas, TX, thus bringing that entity on board. Faculty Advisorship coverage for GSI will for the present remain with those serving TI/Dallas.

Also, as had been agreed previously with another VI-A alumnus, Raymond S. Stata '57, founder of Analog Devices, Inc. (which joined VI-A in 1982) based upon success at their Semiconductor Division in Wilmington, MA, positions were opened at their Measurement & Control Division in Norwood, MA. Professor L. Rafael Reif, Analog's present VI-A Faculty Advisor, will also cover the Norwood facility.

For the first time in a number of years VI-A has a student assigned to an overseas location. Specifically, a TI second-assignment student is going to their Bedford, England facility this coming summer ('84) to work with his first-assignment manager who's been transferred there.

A significant jump of 12% (to 86%) in the percentage of VI-A seniors gaining admission to the graduate phase of the Program took place in 1983, and essentially maintained itself (84%) for 1984. The increase shows up mainly in the numbers admitted for SM-only; the figure for those being granted 'Regular' admission remains constant at about 33%.

RESEARCH

Most research of our faculty is performed in departmental or interdepartmental laboratories. We estimate the total FY84 research volume on projects of which our faculty or research staff members are in charge to be approximately \$42 million, of which only \$3.2 million takes place within the Department proper. The bulk of the balance is allocated among the following interdepartmental laboratories associated with EECS:

| | <u>\$ million</u> (estimated) |
|--|-------------------------------|
| Artificial Intelligence (AI) Laboratory | 7.7 |
| Laboratory for Computer Science (LCS) | 8.9 |
| Laboratory for Electromagnetic and Electronic Systems (LEES) | 2.2 |
| Laboratory for Information and Decision Systems (LIDS) | 1.9 |
| Research Laboratory of Electronics (RLE) | 7.5 |
| Plasma Fusion Center (PFC) | 10.7 |

In addition to the laboratories noted above, faculty research is also performed in other interdepartmental or MIT-affiliated laboratories, namely: Energy Laboratory, Operations Research Center (ORC), Center for International Studies (CIS), Center for Materials Science and Engineering (CMSE), Lincoln Laboratory, Francis Bitter National Magnet Laboratory (NML), and Biomedical Engineering Center for Clinical Instrumentation (BEC) (see HST Research Activities).

Information on the work of all the interdepartmental laboratories mentioned above appears in other portions of this report, dealing separately with each one. However, the MIT Microsystems Program and MIT Stroboscopic Light Laboratory are departmental in organization and therefore report below the highlights of their research for the past year.

MIT Microsystems Program (Professor P.L. Penfield, Jr.)

The MIT Microsystems Program is an interlaboratory, interdepartmental enterprise administered by the Department. It was started in about 1978 to bring MIT forcefully into the broad field of modern (integrated) electronics. This year the level of research effort exceeded \$6,400,000, and the technical areas of interest include electronic materials, submicron structures, integrated-circuit processing and devices, design automation, architecture, and VLSI theory. Virtually all of the research is reported separately in the various other Laboratories associated with the Department, but occasionally a highlight deserves special mention here. The new MIT Microsystems Technology Laboratory is scheduled for completion during early 1985. This new facility will support research in both VLSI and submicron structures technologies. A dedication is planned for the Spring of 1985.

The Semiconductor Research Corporation, a funding agency supported by industry, has established a program of research in Multi-Layer Integrated Circuit Technology at MIT, with nine related projects, many dealing with low-temperature fabrication steps.

During the year we reported the first fully self-aligned joint-gate CMOS logic gate. In this structure, an n-channel and a p-channel device are physically located above one another, and the gate electrode is located between them. This structure is expected to make possible integrated circuits which are more than twice as dense as present ones.

We are starting a major new effort of research in computer-aided fabrication (CAF) of integrated circuits; this involves the design and use of computer systems to manage the information associated with integrated-circuit fabrication and research. Such a system is crucial to successful manufacturing automation.

One component of a VLSI design system is a program to automatically place and route subsystems on a chip. The PI program, under development at MIT for several years for this purpose, is now reaching the state of maturity that should enable its practical use soon. Many advanced heuristic algorithms are used to solve problems that are essentially impossible to program thoroughly.

The computer-aided design (CAD) frame known as SCHEMA is now under advanced development at MIT. This system will be both a framework into which to fit individual CAD tools, and also (when such tools are inserted) a practical design environment.

Stroboscopic Light Laboratory (Professor Harold E. Edgerton)

There are 31 students enrolled in 6.163 Strobe Project Laboratory taught by Charles Miller. About half of the students were from Course VI and the other from various departments.

The Nebraska Educational TV Network made a VHS color tape of the activities of the Strobe Lab. This tape is currently being offered to MIT alumni.

Six theses in the following areas were carried out in the Laboratory under supervision of either H. Edgerton or C. Miller: splash of a milk drop; development of photography system for recording wildlife in an aqueous environment; loudspeaker evaluation using bubbles and high speed photography; analysis and application of a PLZT electro-optic shutter; a wireless terminal for the VIC-20; a VOR mapping navigation system for light aircraft.

Special projects by research staff included work on 3-D by physiological time multiplexing (Krikor Bexjian), and work on the characteristics of small water drops (Peter Mui).

Discussions were held on whale-sonar research off Stillwagon Bank. Some of the sonar equipment is being taken to Alaska by Bill Dolphin of BU for whale monitoring, and other such equipment will be taken by student Mark DeCew to Loch Ness this coming summer for recording wildlife there.

FACULTY

Faculty promotions this year included Alan J. Grodzinsky, Berthold K.P. Horn, John G. Kassakian, Gerald J. Sussman, and Alan S. Willsky to full professor; and Charles E. Leiserson, Bernard C. Levy, Tomás Lozano-Pérez, and John L. Wyatt to associate professor.

Dr. Jeffrey H. Lang was named Esther and Harold E. Edgerton Assistant Professor of Electrical Engineering for two years, and Dr. William M. Siebert, in recognition of his innovations in engineering education and his breadth of interest, will succeed Dr. Robert M. Fano as Ford Professor of Engineering.

Joining our faculty this year were Shafrira Goldwasser, who received her Ph.D. from the University of California, Berkeley, now Assistant Professor of Computer Science and Engineering; Thomas F. Knight, Jr., formerly a research assistant with the Artificial Intelligence (AI) Laboratory at MIT, now Assistant Professor of Computer Science and Engineering; Raphael C. Lee, previously a clinical instructor at Harvard University, a fellow in plastic surgery at Massachusetts General Hospital, and a Research Associate at MIT, now Assistant Professor of Electrical Engineering; Silvio Micali, formerly an assistant professor in computer science at the University of Toronto, now Assistant Professor of Computer Science and Engineering; Ramesh S. Patil, previously a research associate in the Laboratory for Computer Science (LCS) at MIT, now Assistant Professor of Computer Science and Engineering; Martin F. Schlecht, formerly a postdoctoral fellow in the Electric Power Systems Engineering Laboratory (EPSEL) at MIT, and now Assistant Professor of Electrical Engineering; and Christopher J. Terman, previously a research assistant in LCS at MIT, and now Assistant Professor of Computer Science and Engineering.

A number of faculty achievements during the year deserve special mention: Dr. Michael Athans, Professor of Systems Science and Engineering, was elected a Distinguished Member of the Institute of Electrical and Electronics Engineers (IEEE) Control Systems Society. He was also awarded an IEEE Centennial Medal and Certificate for outstanding and dedicated service to the IEEE and to the profession; Professor Arthur B. Baggeroer became MIT director of the MIT/Woods Hole Oceanographic Institution (WHOI) Joint Program in Oceanography and Oceanographic Engineering; Dr. Dimitri P. Bertsekas, Professor of Electrical Engineering, was elected a Fellow by the IEEE for his contributions to optimization, data communications networks, and distributed control; Dr. Jack B. Dennis, Professor of Computer Science and Engineering, was presented the annual Eckert-Mauchly Award by the IEEE and the Association of Computing Machinery for his seminal work in the area of data flow architecture; Dr. Mildred S. Dresselhaus, Abby Rockefeller Mauzé Professor of Electrical Engineering and Physics, received an honorary Sc.D. degree from New Jersey Institute of Technology for her support of women's involvement in the sciences, and was named by the Secretary of Energy to the Energy Research Advisory Board of that Department; Institute Professor Emeritus Harold E. Edgerton received an LHD from Franklin Pierce Law Center for his pioneering research in electronic speed flash photography, and an LHD from the University of Lowell for his contributions to education; Dr. Shafrira Goldwasser, Assistant Professor of Computer Science and Engineering, received one of the newly established two-year IBM Faculty Development Awards for untenured faculty; Dr. Hermann A. Haus, Elihu Thomson Professor of Electrical Engineering, received the Quantum Electronics Award of the IEEE for his contributions to optical waveguide devices and laser modelocking. Dr. Haus was also awarded a Fulbright grant to teach an optoelectronics course at the Technical University of Vienna during his forthcoming sabbatical leave. Dr. Erich P. Ippen, Professor of Electrical Engineering, was elected a Fellow by the IEEE for his contributions to picosecond optics and optical instrumentation; Dr. Raphael C. Lee, Assistant Professor of Electrical Engineering, received a Whitaker Health Sciences Fund grant for his work in biomedical research; Professor Thomas H. Lee, previously director of EPSEL, assumed the directorship of the Laboratory for Electromagnetic and Electronic Systems (LEES), a new interdepartmental facility that combines the Continuum Electromechanics Laboratory, the High Voltage Research Laboratory, and EPSEL; and Professor James R. Melcher, formerly associate director of EPSEL, was named associate director of LEES; the 1984 Graduate Student Council Departmental Award for excellence in teaching was awarded to Dr. Jae S. Lim, Associate Professor of Electrical Engineering, who also received the Harold E. Edgerton Award which is bestowed on a junior faculty member for distinction in teaching, in research, and in scholarship; Dr. Allen V. Oppenheim, Professor of Electrical Engineering, was awarded the IEEE Centennial Medal and Certificate for his contributions to the

Acoustics, Speech and Signal Processing Society of the IEEE and its areas of interest; Dr. Ronald R. Parker, Professor of Electrical Engineering and Associate Director of the Plasma Fusion Center, was honored by the American Physical Society's Division of Plasma Physics by being among the first recipients of the Society's Award for Excellence in Plasma Physics research and for his direction of the Alcator A project; Dr. L. Raphael Reif, Associate Professor of Electrical Engineering, was among the first recipients of the Presidential Young Investigator Awards, established by the White House, through the NSF, to help assure the vitality of American research universities for the development of the next generation of technical leaders; Dr. Thomas F. Weiss, Professor of Electrical and Bioengineering, was selected for a Javits Neuroscience Investigator Award for his substantial contributions in the neurosciences and for his anticipated productivity in research over the next seven years; in May 1984, Dr. Joseph Weizenbaum, Professor of Computer Science and Engineering, was awarded an honorary Doctor of Science degree at Adelphi University in recognition of his outstanding achievements in computer science; and, on behalf of the Department, Professors Robert M. Fano and Louis D. Smullin, who co-chaired the Department's Centennial Celebration Committee, accepted from the Alumni Association the 1983 Presidential Citation award for distinguished service to MIT and to the Alumni Association, for their tireless leadership and sterling efforts in producing a year-long centennial celebration embodying an unique mixture of intellectual programming, a sense of friendship, and collegial partnership.

The Department was pleased to welcome the following visiting faculty during the academic year: Dr. Violet B. Haas, Visiting Professor of Electrical Engineering, on sabbatical from Purdue University and a recipient of a National Science Foundation grant for Women in Science and Engineering, who conducted research on optimal control and contributed to the "monitoring" of women students at MIT; and Dr. Michael A.G. Jenkins, Visiting Professor of Electrical Engineering and Computer Science, on leave from Queen's University, Ontario, who conducted research on the design of a computer to interpret the high-level language Nial and also taught a seminar on Nial.

Department faculty who were away during the year included Professor Peter Elias, on sabbatical for the academic year to conduct research and teach a course on information theory at Harvard University; Professor Clifton G. Fonstad, Jr., on sabbatical for the spring term to carry out research in the field of III-V micro- and opto-electronics at the Thompson CSF laboratories in France; Associate Professor Michael Hammer, continuing his previous leave of absence to establish a consulting company; Professor Alan V. Oppenheim, on sabbatical for the academic year at the University of California, Berkeley, to write a second edition of his book on digital signal processing; Professor William T. Peake, on sabbatical for the academic year at the Eaton Peabody Laboratory of Massachusetts General Hospital to devote full time to his research on the signal transmission properties of the middle ear; Assistant Professor David P. Reed, on leave of absence to Software Arts, Inc. for the academic year; Professor Kenneth N. Stevens, on sabbatical for the spring term to work on a book on speech acoustics and phonetics; and Associate Professor Gerald J. Sussman, on sabbatical for the academic year to teach and conduct research on computational astrophysics (with Richard Feynman) at the California Institute of Technology.

Professor Robert R. Tenney has resigned from the faculty, but will retain a Lecturer appointment in the Department.

Professor Robert M. Fano, who was Ford Professor of Engineering, retired after thirty-seven years as a member of the faculty, but will continue on a part-time basis his activities in the Lifelong Cooperative Education programs, started during the Department's Centennial Year.

JOEL MOSES

Department of Materials Science and Engineering

INTRODUCTION

During the academic year 1983-1984 the Department continued its forward momentum, and a broadening of its programs. At the undergraduate level, the Department continued its program of major curriculum redevelopment. The curriculum changes that have been made reflect the growing unity of the field of materials science and engineering, including the emergence of an increasing body of fundamental ideas and principles that cut across the four major materials classes: electronic materials, ceramics, metals, and polymers. A cornerstone of this new curriculum is a two-tier laboratory sequence, the implementation of which has begun but can be fully completed only after substantial acquisition of new equipment.

At the graduate level, the new degree program in electronic materials is functioning fully. The graduate program as a whole has been greatly strengthened by the incorporation of two subjects into the cores of all degree programs. These subjects, thermodynamics and kinetics, are expected to be taken by all doctoral students.

Essential to the academic progress of the Department has been the acquisition of three new junior faculty members: two in electronic materials and one in ceramics.

A gratifying development over the past two years has been the increasing number of sophomores electing our Department. In 1982-1983 we reached a low point for recent years with a sophomore enrollment in the mid-twenties. This year it is in the mid-thirties, and next year we project an increase to the mid-forties - an approximate doubling in two years. This increase has occurred in spite of the continuing increase in students choosing to major in Electrical Engineering and Computer Science. We believe our success has resulted from increased faculty involvement in undergraduate teaching and recruiting, and from the broadening of the Department to include increased emphasis on materials other than metals.

In both our teaching and our research activities we have been making strong efforts to develop ties with faculty from other departments. We have had notable success in this regard with faculty from Electrical Engineering and Computer Science and intend to develop additional joint activities with faculty of that and other departments.

The Department of Materials Science and Engineering traditionally has been a strong research department and remains so today. Research volume is approximately \$12.1 million per year, supervised for the most part by individual faculty or by groups of faculty. This research is administered through the Department (52%), the Materials Processing Center (29%), the Center for Materials Science and Engineering (5%), and the Energy Laboratory (10%).

We have major research efforts underway in each of the different classes of materials: ceramics, metals, polymers, and electronic materials. An alternative method for categorizing our research activities is without regard to materials classes and is:

| | | | |
|----------------------|---|--|----------------------------|
| Materials Science | { | Structure and Transformations Structure/Property Relations Structure/Processing Relations Property/Performance Relations Process and Systems Modelling | } Materials Engineering |
|----------------------|---|--|----------------------------|

A great strength of the Department is that we have programs underway in each of the above five categories in many, if not all, of the materials classes. Raising adequate research funds for well recognized objectives has not in general been a problem for our faculty, and from a departmental standpoint, our strategy is to encourage research programs that (1) most strongly enhance our teaching programs, (2) contribute most effectively to national and societal needs, and (3) otherwise most effectively contribute to our long range objectives.

The strengthening of the Department and the broadening of its programs has been made

possible in large measure by the continued financial support of industry, and the continued interaction of the Department with industry. Seven of our faculty now hold named chairs, of which two are endowed and five are term. In addition, four junior faculty members hold important industrial career development grants. Industrial and individual support for other aspects of the Department's academic and research programs has also been generous; this includes undesignated funds, funds for scholarships and fellowships, and funds for laboratory equipment. Finally, industry and alumni have been most generous in contributing to the John Chipman Memorial Professorship. This fund has grown at a pace beyond our expectations. We are now reaching the two thirds mark progressing towards our goal of \$600,000. The chair is to be held by a junior (non-tenured) faculty member and we hope to be able to initiate the chair in 1985.

THE UNDERGRADUATE PROGRAM

During the academic year 1982-1983 studies were undertaken by appropriate committees of the Department of Materials Science and Engineering which resulted in the following recommendations relating to the undergraduate program:

1. A major revision and upgrading of the undergraduate program with specific emphasis on (a) development of new core subjects in materials science and engineering that cut across materials classes and (b) establishment of a series of restricted elective subjects in each of the four major materials classes (electronic materials, ceramics, metals, and polymers).

This curriculum revision has now been largely carried out. Of 23 required materials subjects and restricted elective subjects in the curriculum for 1984-1985, ten are totally new since 1982, and five have been substantially revised in content.

2. Establishment of a two-tier undergraduate laboratory sequence. This was partially instituted on a trial basis in 1983-1984. The trial was a clear success and the Department now wishes to proceed expeditiously to fully institute this laboratory sequence. To do this, substantial investment in facilities and equipment is required.

3. A concerted effort to raise the number and quality of sophomores choosing to major in this Department, and of graduates applying to the Department. The program to do this was fully successful, and the sophomore enrollment in the fall of 1984 is expected to be approximately double the enrollment in 1982. This success, of course, places its special burdens on the new curriculum, including the new laboratories.

The revised undergraduate curriculum contains a strong core of required subjects that comprises the foundation of a materials science and engineering education. The materials portion of this core consists of lecture subjects in thermodynamics and kinetics; mechanics of materials; structure development; mass, heat, and fluid transport; the chemical physics of materials; and an introductory laboratory subject. The core has been constructed in such a way that the subject matter cuts across all materials classes, and serves as the foundation on which later materials specific subjects are constructed.

The restricted electives in the new curriculum build upon the core. Here a degree of specialization is allowed and encouraged. Subjects in the restricted elective areas come from the four major materials classes: electronic materials, ceramics, metals, and polymers. The delineation of these four materials classes is unique to this new curriculum. Each materials class has three or four offerings, at least one offering each in the areas of: materials science, materials engineering (with emphasis on materials processing), and a materials laboratory.

THE GRADUATE PROGRAM

We have now completed our first full year with the new graduate program, in which we offer Master's and Doctor's degrees in six different areas of specialization: ceramics, electronic materials, metallurgy, polymers, materials science, and materials engineering. Our graduate "core", common to all degree programs, is a pronounced

success, providing a common base for the six programs, and unifying the Department and its graduate programs.

In September 1983 there were 243 graduate students enrolled in the Department, up from 209 the previous year. Of this number, 64 were newly admitted students; an additional 14 were admitted in February 1984. Of the total graduate students in the Department, 64 percent were supported by research assistantships, 10 percent by teaching assistantships, and 22 percent by fellowships. The remainder relied on their own funds or on outside sources. Approximately 67 percent of the graduate students were from the United States, up slightly from the previous year.

The students were divided among the Degree Programs in February, 1984, as follows:

| <u>Percent</u> | |
|-----------------------|----|
| Ceramics | 21 |
| Electronic Materials | 12 |
| Metallurgy | 26 |
| Polymers | 11 |
| Materials Science | 16 |
| Materials Engineering | 13 |

FACULTY

Three new assistant professors joined our faculty this year. They are Professors Carl Thompson and David Rudman in electronic materials, and Professor Eric Barringer in ceramics. Professor David Clarke left to accept a position in industry.

Professor W. David Kingery was appointed Kyocera Professor of Ceramics, a five-year term chair, and Professor Donald R. Uhlmann was appointed the Cabot Professor of Ceramics and Glass, a three-year chair. Professor Heather Lechtman was awarded a John D. and Catherine T. MacArthur Foundation Fellowship. Professor Gretchen Kalonji received one of the first of the Presidential Young Investigator Awards; it will provide support for her research for a five-year period. Professors Ring and Wnek received IBM Faculty Development Grants, which are expected to be two-year continuing grants.

The Department hosted two Visiting Professors during the last year, Visiting Professor Derek Birchall from Imperial Chemical Industries, England, and Visiting Associate Professor George P. Scherer of Corning Glass. Professor Frederick J. McGarry assumed duties as Director of the Summer Session, while also continuing teaching and research within the Department.

Numerous other awards were received by departmental faculty. Professor Allen received a National Science Foundation Creativity Extension Award and again received an ARCO Career Development Award. Professor Bowen received the Robert Browning Sosman Award and the Ross Coffin Purdy Award, both of the American Ceramic Society. Professor Coble received a Humboldt Award for Study in Germany. Professor Kingery was elected to the American Academy of Arts and Sciences. Professor Morris Cohen delivered the honorary Alpha Sigma Mu lecture at New Mexico Institute of Mining and Technology. Professors Eagar and Szekely shared the Charles H. Jennings Memorial Medal of the American Welding Society. Professor Elliott was again appointed American Iron and Steel Institute Distinguished Professor. Professor Flemings was elected an Honorary Life Member of the Japan Foundrymen's Society and Professor Gatos was given an Honorary Doctorate by Indiana University.

Professor Grant was Distinguished Lecturer at New Mexico University and at Oregon Graduate Center. Professor Latanision, Shell Distinguished Professor of Materials Science, delivered the Henry Krumb Honorary Lecture for 1984. Professor Sadoway received the Dow Chemical Company Professional Development Award and also the Graduate Student Council Award for Teaching. Professor Tuller was appointed visiting Fellow at Imperial College during his sabbatical there and also appointed Fellow of the American Ceramics Society. Professor Witt was awarded a citation by the American Association for Crystal Growth for accomplishments during his terms of Presidency, 1975-1981.

Awards received by Research Associates included a NSF Creativity Extension Award to Dr. Gregory B. Olson. Dr. Olsen was also Distinguished Lecturer at Sandia Laboratories, and Dr. John S. Haggerty was elected a Fellow of the American Ceramics Society.

STUDENTS

Brigitta Brott was awarded the Departmental Prize for Outstanding Thesis and William F. Doyle, the Rodman McClintock Award for Outstanding Research Project. Adam S. Helfant was given the Morris Cohen Award by the Boston Section of the American Institute of Mining, Metallurgical, and Petroleum Engineers as the Outstanding Junior in Materials in the Boston area. Stanislaus A. Zygmunt was awarded Darmara Materials Achievement Award as Outstanding Senior in the Department of Materials Science and Engineering. Both Stanislaus A. Zygmunt and William C. Mohr were elected to Phi Beta Kappa. Among the graduate students, Stephen C. Semken was given the John Wulff Award for Excellence in Teaching. Karl W. Reid received the Karl Taylor Compton Prize and was elected Chairman of the National Society of Black Engineers.

In March a student lounge was opened on the fourth floor in Building 8 to provide a studying and gathering place for the undergraduate students. Keys have been issued to all undergraduates desiring one, and this is one of a number of factors leading to a growing sense of identity among the undergraduates, particularly this past year's sophomore class.

Following commencement exercises in June, we held a departmental reception, including a sandwich lunch, for graduates and their families and friends. This first time experiment proved successful and we intend to repeat it next year.

RESEARCH

Professor Samuel Allen developed a new experimental technique for studying the kinetics of interfacial migration in alloys, by observing the motion in-situ using a heating stage in the transmission electron microscope. The technique allows interfacial velocity/driving force relations to be determined directly under a wide range of experimental conditions.

Professor Averbach is broadening his studies on magnetic materials, particularly on thin film magnetism and applications in magnetic recording, while continuing his studies on application of fracture mechanics on a microscopic scale to fatigue and fracture of bearing and tool steels. Professor Ballinger's research remains active in corrosion fatigue behaviour and in advanced data reduction and analysis techniques in mechanical testing. Professor Balluffi's current work focuses on the structures and properties of grain boundaries and interphase boundaries. The relationship between interphase energy and crystal misorientation is being calculated and compared with experiment, and various phenomena involving fast "short-circuit" diffusion along grain boundaries are under investigation.

In addition to serving as Director of the Materials Processing Center, Professor H. Kent Bowen supervises the large and highly regarded Ceramics Processing Laboratory; his current research involves experimental and theoretical studies in the areas of powder synthesis, colloid and surface chemistry, and microstructure development during thermal processing. One example of his recent research includes synthesis of pure doped monosized powders of a variety of oxides. Professor Eric A. Barringer works closely with Professor Bowen; his research is focused on generating a basic scientific understanding of ceramics processing and of assessing processing-microstructure-property relationships. Professor I-Wei Chen's work emphasizes defects and their connection with irradiation effects and mechanical behavior of materials. He has recently presented an innovative method of studying the nucleation and toughening mechanism of the important martensitic transformation in zirconia.

During the past year, Professor Clark has developed a strong industrial support base for his research on analysis of the relationship between technology and economics in materials and materials processing industries. A typical question which can be addressed within the framework of his research is: how will the future costs and properties of new materials (e.g. polymers, composites, ceramics, light-weight steels, and aluminum magnesium alloys) affect the competitive positions of existing materials industries, and how will they impact end-use markets (e.g. the automotive, airframe, highway, and building construction markets)?

Professor Coble's major accomplishments during the last year are related to the

development of laboratory procedures to reduce the contamination in ceramics processing from receipt of the powder through to the sintered ceramic. He also has underway efforts to reduce the contamination in the native powders, by various refinement procedures.

In collaboration with Dr. Gregory B. Olson, Professor Morris Cohen's research on martensitic transformations has now led to a general nucleation theory for this type of solid-state reaction, which combines both classical and nonclassical paths and which defines the conditions that favor each path. Considerable progress has also been achieved in quantitatively modeling the subsequent growth step, including the acceleration, steady-state, and deceleration stages. The enhancement in plasticity and fracture toughness which accompanies deformation-induced martensitic transformations has been analyzed in detail, and is being applied in the design of new high-performance steels. In other research with Dr. Olson and Professor John B. Vander Sande, the fundamental cause of the novel grain-growth resistance in rapidly solidified steels has been definitively established as a grain-boundary-pinning phenomenon due to stable second-phase dispersions.

Professor Thomas W. Eagar and his students have been investigating resistance welding of high strength galvanized steel under sponsorship of General Motors, Bethlehem Steel, and the International Lead Zinc Research Organization. They discovered several process modifications which improve weldability by as much as a factor of two. This development has now been tested and implemented in production by General Motors, providing an excellent example of fundamental university research leading to rapid industrial use.

Research directed to greater conservation of energy in the production of steel by Professor John F. Elliott and his students has shown that there is a strong tendency for a steelmaking slag to penetrate the porous structure of direct reduced sponge iron. Vigorous foaming of the slag can result, which in turn is very important to efficient use of energy in electric melting operations in mini-steel plants. Evaluation of the phenomena in an industrial plant is being planned by the U.S. Department of Energy.

Professor Merton Flemings' research continues in the broad field of solidification processing including strip casting of steel, solidification of undercooled metals, and solidification of composite materials. Work on a variety of important aspects of metal matrix composites is increasing significantly under the direct supervision of Dr. James A. Cornie, Research Associate.

As gallium arsenide becomes of increasing commercial importance, the pioneering work of Professor Harry C. Gatos is becoming widely recognized. During the last year, he and his coworkers discovered a new means for controlling dislocation density in gallium arsenide and obtained dislocation-free melt-grown and epitaxial crystals. They identified a compensating center associated with oxygen. Both findings are of fundamental importance for gallium arsenide integrated circuitry.

Professor Nicholas J. Grant studied and developed a process to produce sheet and plate of rapidly solidified alloys by liquid dynamic compaction directly from the melt, bypassing the intermediate powder production and processing stages. This has resulted in high density as-deposited products requiring very little additional deformation for full densification. The highly refined structures have yielded outstanding properties in a number of alloy systems.

Professor Linn W. Hobbs' program on radiation effects in ceramics is currently the only major program in a U.S. university investigating radiation stability of ceramic materials for nuclear applications. Significant progress has been made this year in understanding the topological constraints involved in the particularly deleterious crystal-glass transition offered by many ceramic solids as a consequence of atom displacements in a radiation field. Professor Keith H. Johnson's recent research studies include molecular orbital calculations of metal clusters, metal surfaces, organo-metallic molecules and enzymes. Professor Gretchen Kalonji's new and rapidly growing research activities already include studies in the broad areas of rapid solidification of ceramic materials, defects in crystalline solids, and atomistic computer simulation. Professor King continues his work in chemical process metallurgy with a recent study being on the kinetics of reactions between gases in an arc plasma and liquid metals. Professor Kingery is intensely pursuing his studies on segregation of solutes at grain boundaries, and their influences on a variety of properties, both

in oxides and in silicon carbide. He published, with Mr. Yet-Ming Chiang a seminal paper relating to grain boundary segregation, demonstrating for the first time the relative importance of strain energy and electrostatic phenomena.

Research by Professor Latanision and coworkers has shed new light on the role of grain boundary solutes in the embrittlement of iron and nickel by absorbed hydrogen. Molecular orbital calculations emphasize the importance of separating the electrochemistry of hydrogen absorption from the solid state chemistry of embrittlement (disbonding) which occurs when interactions occur among host metal atoms-segregated solutes-and absorbed hydrogen. In short, not all species which increase atomic hydrogen absorption will induce embrittlement and, indeed, some appear to strengthen bonding interactions.

Professor Lechtman has continued her comparative studies of copper-arsenic and copper-tin alloys, both of which were bronzes used prehistorically in the Old and the New Worlds. She is investigating the mechanical properties of these alloys as well as the methods by which early Andean peoples smelted copper ores. Her research has drawn the attention of Peruvian metallurgists and mining engineers who seek to develop their rich resources of copper for modern industrial purposes. Professor Masubushi's research group has been selected by the National Aeronautics and Space Administration as one of 18 research groups to perform experiments in the Space Station as part of the Innovative Utilization of the Space Station Program.

Professor Frederick J. McGarry has accomplished a ten-fold increase in the resistance to flatwise impact damage of advanced composite materials (graphite fiber/epoxy composites) for aircraft, by depositing very thin coatings (~ 700 Angstroms) of elastomeric material on the surface of each fiber. This has required special considerations of physical and chemical factors in the deposition process and a micromechanics analysis to optimize the effect. Also included between layers of the composite are thin films ($\sim .001$ inch) of elastomer-modified adhesive. A number of patent applications have been prepared covering this development. Professor Walter S. Owen continued his studies on the strengthening mechanisms operative in high-nitrogen austenitic stainless steels, and on the development of microstructure during processing of microalloyed steels and ultra-low carbon "bainitic" steels.

Professor Robert M. Rose has found that the stress dependence of the wear of polyethylene, as it is used for orthopaedic applications, depends parametrically on the molecular weight. Radiation sterilization shifts the wear-contact stress curve in a manner similar to the above. Consequently, the suitability of such materials for, e.g. total joint replacements, depends on the relationship of the polymer structure to the contact stress. Additionally, Professor Rose's research group has found new scaling laws for filamentary superconductors. Professor Roylance has continued his experimental and theoretical studies of processing-structure-property relations in polymers and polymer-matrix composites, emphasizing mechanical properties.

Professor Russell completed his monograph "Phase Stability Under Irradiation", which will be published near the end of 1984. Professor Russell's book is a comprehensive, critical review of theory and experiment in the response of alloy microstructures to neutron, electron, proton, γ -ray, and heavy particle irradiation. Particular attention is paid to alloy response under fusion reactor and breeder reactor conditions. His monograph is the first ever written in the field of irradiation-altered phase stability.

With the aid of a Dow Chemical Company Professional Development Award, Professor Sadoway has begun broadening his research in molten salt electrolysis of light metals to the electrodeposition of refractory metals. In his work Professor Sadoway uses powerful non-electrochemical techniques of investigation such as Raman spectroscopy to study high-temperature electrochemical phenomena, in order to learn about melt chemistry and electrode kinetics during metal deposition. Professor Szekely continued his research on the mathematical and physical modelling of electromagnetically driven flows in metals processing, e.g., in welding, induction furnace operation, in metals refining, and in crystal growth. Recent important milestones include the modelling of electric furnace systems, supported by extensive measurements, and the design of a Space Shuttle Experiment scheduled for early 1985.

Professor Carl V. Thompson, new to our faculty this year, is investigating materials issues associated with the production, stability, and properties of sub-1000 angstrom structures. As part of this program he is investigating solid-state kinetic processes

in ultra-thin films of semiconductors and metals.

Professor Harry L. Tuller accomplished the first successful growth of single crystals of a high-temperature phase of tantalum oxide shown earlier by his group (with Dr. J. Haggerty) to be a new fast oxygen ion conductor. He also made the first reliable experimental determination of the frenkel defect product in a cubic fluorite-like oxide and the first measurement of oxygen interstitial diffusion in a cubic fluorite-like oxide other than uranium oxide (with Professor Brian Steele's group at Imperial College, London). Professor Uhlmann continued his research activities on the critical conditions required to form glasses of various materials, on nucleation and growth in glass forming systems and on various structure-property-processing aspects of polymeric materials. In a new initiative in sol-gel derived glasses and ceramics, he is concerned with a range of innovative processes and materials.

Professor John B. Vander Sande with his coworkers have generated a novel microstructure in the aluminum-lithium-zirconium alloy system. Through rapid solidification of this alloy and a two stage heat treatment process, "composite" precipitates consisting of a zirconium-rich core surrounded by a lithium-rich envelope have been produced with diameters as small as 10 nm. It is expected that composite precipitates of this type will have a profound influence on the mechanical properties of this high specific strength alloy. Preliminary mechanical testing results support this expectation.

Professor A. F. Witt completed construction and testing of his computer operated Bridgman growth facility which operates with quantifiable thermal boundary conditions. He has undertaken a major government and industry sponsored research program on growth of gallium arsenide with magnetic field induced melt stabilization. In a collaborative effort with Professor R. A. Brown of Chemical Engineering, he has also undertaken to quantify growth and segregation behavior in Bridgman type furnaces. Professor Garry E. Wnek continues his research on the synthesis and characterization of conductive polymers having desirable physical and mechanical properties.

In a program directed towards determination of the origin of fast-ion conduction in solid-state electrolytes employed in battery systems, Professor B. J. Wuensch has performed neutron diffraction analyses of the structural changes which accompany silicon substitution in the "NASICON" solid solution series. The results reveal unsuspected distortion of the structure which satisfactorily explains anomalies in the lattice constraints and the four-order-of-magnitude increase in ionic conductivity, which makes the material of technological interest. In another study of transport properties, Professor Wuensch and his student have obtained the first time-dependent solutions to the equations governing thermomigration.

Over fifty severely burned patients have been treated with the Stage I Artificial Skin developed by I. V. Yannas since 1979. The biodegradable experimental polymeric membranes were prepared in Professor Yannas' laboratory. Professor Yannas intends to start clinical studies on his "Stage II Artificial Skin" within several months. In this case, wound tissue is caused to synthesize new skin by grafting onto full thickness wounds a porous, biodegradable polymeric template composed of a cross linked collagen-glycosaminoglycan network. Prior to grafting, the porous membrane is seeded with autologous basal cells.

Senior Research Associates, Drs. Haggerty and Lagowski and Principal Research Associates, Drs. Bristowe, Mandell, O'Handley, Olson and Sung have provided leadership during the past year in a number of research initiatives that have added much strength to the Department's program.

MERTON C. FLEMINGS

Department of Mechanical Engineering

INTRODUCTION AND PERSPECTIVE

The mechanical engineering profession is broadly concerned with energy, motion and materials, and the design, production, and management of systems to meet the needs of society. The profession will have a central role in addressing the challenges of the 1980's and beyond relating to the supply and efficient utilization of energy, manufacturing and productivity, safe and efficient transportation, defense, enhancement of the environment, and health care and human rehabilitation.

Mechanical engineering is derived from basic disciplines in mechanics and dynamics, materials, and the thermal-fluid sciences and from the practice of the processes of analysis, experimentation, design, and manufacturing. The profession is changing rapidly due to the increasing capabilities of information processing/control technology, continued development of the fundamental disciplines, the growing ability to synthesize new materials and processes, and improved understanding of the life sciences and human factors. These rapid changes provide both significant challenges and opportunities to the profession and for the education of future engineers.

Student interest in mechanical engineering has grown substantially in the last decade with increases in undergraduate enrollment from 212 students in 1974 to 463 students in 1984 and in graduate enrollment from 238 students in 1974 to 478 students currently. The Department has the second largest undergraduate enrollment at MIT. The faculty number has also increased during the decade by 18 percent to reach 59 faculty in 1984. The demand for students graduating with SB and SM degrees has remained strong throughout the last five years. The demand for PhD graduates interested in engineering education, particularly in the manufacturing and design areas continues to be strong as universities respond to the national educational and research needs in these areas.

In two recent reviews of the Department educational programs, the undergraduate program leading to an SB in Mechanical Engineering has been recommended for full accreditation by the Accreditation Board for Engineering and Technology and in the recent study by the National Academy of Sciences rating graduate professional programs at US universities, the Department graduate program was ranked as first in the nation.

This past year special emphasis has continued to be placed upon undergraduate laboratory curriculum development. Continued upgrading of equipment and instrumentation has occurred in the manufacturing, project, and materials laboratories. A coordinated effort has been initiated to integrate real time data acquisition and analysis techniques into the undergraduate laboratories. Attention has also been focused upon strengthening computational capabilities for both undergraduate and graduate subjects under the auspices of Project Athena.

Faculty effort in identifying and developing research programs in the past year has been notable, particularly in light of the overall support/cost picture. Sponsored research has grown in the last year by four percent to reach a level of \$20.1 million. Approximately one-third of the research is administered directly by the Department and two-thirds by interdepartmental laboratories and centers with which faculty are affiliated. During the last year, the decline in support for energy, environmental, and transportation research which was experienced in the last three years has changed and small increases in research activity in these areas have occurred. Growth has continued in research related to manufacturing and design, while support for biomedical engineering research has remained relatively constant.

During the year faculty in the fluid and thermal sciences area have strengthened research programs in computational fluid mechanics and turbulent reacting flows, the thermal-fluid processes controlling growth of electronic materials, energy efficiency in buildings and systems, and biofluid mechanics. Faculty in the mechanics and materials areas have developed research in high performance metals, fibers and polymeric materials, and continued major programs in geomaterials and biomaterials. Faculty in manufacturing, design and control have established a coordinated laboratory in robotics and extended investigations into basic manufacturing processes. Faculty in the biomedical engineering area have continued to make significant progress in developments related to treatment of cancer patients using ultrasound, evaluation of artificial skin for burn victims, and in understanding the biomechanics of joints and limbs as well as basic fluid processes related to diseases of the cardiovascular, pulmonary, and ocular systems.

As a result of a generous donation by the Martin Foundation, the Martin Center for Engineering Design has been established. This facility which is currently under construction and planned for completion in September of 1984 will house a prototype development laboratory, an interactive classroom, and special seminar rooms for design education and research. These facilities will provide a unique opportunity for design education which incorporates computer-aided engineering techniques from concept generation through

prototype development. A laboratory facility for resource extraction (oil, gas, and coal), geotechnical and construction engineering, has been established in a joint effort with Civil Engineering. This facility, designated the REMERGENCE Laboratory, will provide a significantly increased capability for research related to resource extraction.

PROGRAMS OF INSTRUCTION

Objectives

The Department instructional programs strive to educate mechanical engineers for leadership roles in professional practice and engineering education, and to provide a broad flexible background for entering related fields such as medicine, law, management, and public policy. Programs emphasize a basic foundation in the engineering sciences combined with a strong design orientation and extensive laboratory experience which couples theory and analysis with the physical world. At both the undergraduate and graduate levels, involvement of students with faculty in research at the forefront of engineering practice-- through special projects, the Undergraduate Research Opportunities Program (UROP) and theses--is a hallmark of the Department.

UNDERGRADUATE PROGRAMS

Degree Program and Enrollment

The Department undergraduate program leads to the SB in Mechanical Engineering (Course II), which is accredited by the Accreditation Board of Engineering and Technology (ABET) or the SB without specification (Course II-A), which is non-accredited. Course II-B, the Engineering Internship Program, leads to the SB and SM in Mechanical Engineering with industrial experience as an integral part of the program.

The Department enrollment continued to grow this past year and has reached a total of 463 undergraduate students. The new sophomore class of 151 included 48 women, 31 percent of the class, and 17 black students. Approximately 21 percent of the class are minorities.

Course II-A provides an alternative to the regular mechanical engineering program and is intended for those students who wish to design a special program coupling such areas as biomedical engineering, management, and energy policy with mechanical engineering. About 33 students were enrolled in II-A.

The Department has been heavily involved in the School of Engineering Internship Program since its inception in 1977-78. This past year, out of a total of 41 sophomores from seven departments who were placed in 36 companies, 22 were Mechanical Engineering students. Currently the Department has 45 students in the Program out of a total of 101: seven graduate students, 16 seniors, and 22 juniors. In 1983-84 the Department awarded 147 SB degrees (129 in Mechanical Engineering, 13 without specification, and five in II-B).

Undergraduate Curriculum Development

The Department Academic Policy Committee has reviewed the content and cohesiveness of the undergraduate curriculum and has broadly defined the evolutionary development of the undergraduate curriculum over the next five years in the three areas - (1) development of an integrated laboratory sequence starting with an introduction to instrumentation and measurement and leading to computer-aided data acquisition and analysis, (2) an increased coupling of analysis and design, and (3) a strengthening of the basic disciplinary subjects with improved computational techniques. In the past year Professors C. Forbes Dewey, Jr., Derek Rowell, and William C. Unkel have defined the laboratory curriculum development. It is planned that in the fall of 1984 several new trial laboratory sessions will be offered in which students utilize digital data acquisition and analysis equipment in undergraduate laboratories. In addition, effort has continued in the development of materials subjects by Professors Lallit Anand, David M. Parks, Ali S. Argon, and Frank A. McClintock. Effort has also been directed to the development of the new textbook for manufacturing subjects by nine faculty with Professors Nathan H. Cook and Nam P. Suh providing editorial coordination and review.

Student Organizations

The Student Chapter of the American Society of Mechanical Engineers under the leadership of its officers: Robert B. Lezec, President; Ruth M. Heffernan, Vice President; Robert L. Adams, Treasurer; and Mark J. Madson, Secretary, continued to make strong contributions to Department and professional activities with a membership of 140 students. The Chapter was deeply involved in the ASME winter annual meeting in Boston in providing aides for technical sessions. Professor Bruce M. Kramer served as Faculty Advisor.

Black ME is an organization of black students which provides a supportive environment for minorities in the Department. Membership in Black ME continued to grow and approached nearly 40 students. This past year the organization provided academic support in subject reviews, sponsored corporate presentations and had professional engineers make presentations for its membership. The organization was ably led by Neil V. Hamblin, President; John B. Hammond, III, Vice President; Rita R. Edmonds, Secretary; and Bryan E. Watson, Treasurer/Lounge Officer. Professor Stephen H. Crandall served as the Faculty Advisor.

Pi Tau Sigma, the mechanical engineering honorary society, continued its strong tradition of fostering student-faculty relations and serving the Department through its course and instructor evaluation program. Activities during the year included chapter meetings, classroom evaluations at mid-term and end-of-the-term, and a spring banquet to honor newly elected members. The organization was led by: Lee F. Mallett, President; Beverly G. Farris, Vice President; Mia (Maria L.) Paget, Treasurer; and Deborah A. Summa, Secretary, with Professor Warren P. Seering acting as Chapter Advisor.

Student Awards

Many undergraduates in the Department were recognized for academic and athletic excellence, engineering creativity, and community service.

Four seniors received athletic awards: Kevin T. Coffey received the Harold J. Pettigrove Award in recognition of his outstanding service to intramural athletics; Amy B. Smith was selected for the Pewter Bowl Award for the senior who has shown the highest qualities of inspiration and leadership in contributing to women's athletics; and Karen E. Welch received the Burton R. Anderson, Jr. Award for being the outstanding manager of the year for the women's intercollegiate team. Louise Jandura was named to the 1983 College Sports Information Directors of America College Division Women's Softball Academic all-American first team. She is the first MIT woman ever to receive a berth on an Academic all-America team. She also won the Malcolm G. Kispert Award for being the senior scholar-athlete of the year.

Elaine Lee and Andrew Mutz were elected to Phi Beta Kappa. Elaine Lee was also the recipient of the 1984 Association of MIT Alumnae Senior Academic Award in recognition of outstanding academic achievement.

Michael J. Ambrogi received the Scott Paper Award for a high level of scholarship, noteworthy success in extracurricular activities and outstanding athletic ability.

Jeremy E. Verba received the William L. Stewart, Jr. Award for his contributions to extracurricular life at MIT.

Lee F. Mallett, a senior, received the Student Service Award for his service in leading and organizing Department undergraduate activities.

Several students were recipients of the Departmental De Florez Award for innovation and creativity: Mark R. Brent won first prize for his regenerative braking system for bicycles, Cheryl S. Walter won second prize for her preme super shield for premature babies, Michael J. Ambrogi won third prize for his instrument to measure the range of motion of the ankle and Derek C. Leck also won third prize for his instrument to measure the angular position of and force on a rowing-tank oarlock.

Robert B. Lezec was the recipient of the American Society of Mechanical Engineers Outstanding Student Certificate in recognition of outstanding efforts and accomplishments in behalf of the ASME Student Section at MIT.

Mark J. Schlueter was the "PACTHING" winner for the annual design contest in 2.70 Introduction to Design.

GRADUATE PROGRAMS

Organization

The graduate program has been directed by Professor Warren M. Rohsenow for the past 24 years during which time the program has grown substantially in stature and in size. Professor Rohsenow will step down from the graduate office in July 1984 and Professor Ain A. Sonin will assume responsibility for graduate policy and registration and Professor Carl R. Peterson will assume responsibility for graduate admissions.

Degrees

The Department offers the SM in Mechanical Engineering, the undesignated SM, the degree of Mechanical Engineer, and the doctorate in Mechanical Engineering. The undesignated SM allows students to design special interdisciplinary programs with thesis research performed in the Department, while the Mechanical Engineer program is intended as an alternative to the doctoral program for students who wish to emphasize applications and/or design, including economic and social aspects.

Enrollment and Degrees Granted

Graduate enrollment continued to increase and reached 428 students in 1983-84. In the fall of 1983 there were 28 women, five black, six Hispanic, and 19 Asian-American students in the graduate program. In September 1983, 252 new students were admitted from 546 applicants and 140 students registered.

In 1983-84 the Department awarded 134 SM degrees (of which seven were combined SB/SM degrees), two Mechanical Engineer degrees and 23 doctoral degrees.

In 1983-84 74 percent of all graduate students received support from the Department, MIT funds, fellowships, the government or industry. Fifty-four percent of the graduate students were supported by the Department through research and teaching assistantships.

Graduate Curriculum Development

During the year, the graduate programs in the areas of design, robotics, and computational methods have been strengthened with the addition of four new subjects: (1) 2.835 Design and Analysis of Robotic Manipulators, (2) 2.05 Kinematics and Dynamics of Mechanisms and Manipulators, (3) 2.944 The Idea/Product Transformation, and (4) 2.274 Computational Fluid Dynamics. In addition, plans were formulated for the development of five new subjects which will be offered next year, 2.272 Physicochemical Hydrodynamics, 2.68 Theory and Application of Modern Diagnostics, 2.781 Biomedical Instrumentation Electronics, 2.822 Processing of Polymeric Composites and 2.850 Theory and Practice of Machine Tools. A substantial portion of the curriculum development activity will take place in the summer of 1984 so that these subjects may be offered in the fall and spring terms next year. Also, Professor David Gordon Wilson has completed a textbook entitled, The Design of High-Efficiency Turbomachinery and Gas Turbines which will be used in 2.275 Turbomachinery Design.

Student Awards

Luu T. Nguyen was honored with a Department Student Service Award for outstanding dedication and service in assisting Department students while Jagannath Raju was honored with a Department Student Service Award for outstanding dedication and service in graduate teaching activities.

Four projects entered by graduate students in Professor Seering's course, 2.731 Advanced Engineering Design, were granted awards by the James F. Lincoln Arc Welding Foundation of Cleveland in its annual Student Engineering Design Contest. They included Louis G. Tarricone, Hari Das, Michael Caine, Michael G. Kelly for an automated test fixture fabrication system using three-axis cartesian robot; Neil Singer, Hugh M. Costello, Gontran Kerwood, Marie-Luise Murville for the design of programmable parts feeder; Brian D. Jacobs, Thanasis Molokotos, Bill Townsend, Robert G. Chave for a film testing machine; Akim Lenhoff, Steven Judson, Sam Landsberger, and David Serrano for a roller bearing hone.

RESEARCH

Support Level and Distribution

The total volume of sponsored research for 1983-84 is estimated at \$20.1 million, representing a growth of four percent from the research volume last year. Approximately one-third of the total research is administered through the Department and two-thirds through interdepartmental laboratories and centers. The Department sources of research support are derived from a wide spectrum of government agencies and industries. The trend of the last few years has continued with an increasing portion of research supported by industry so that this year approximately 25 percent of the research administered through the Department has been through industry sources. Several laboratory groups derive 50 percent or more of their industrial support from industry including the Resource Extraction Laboratory, the Innovation Center, the Laboratory for Mining and Systems Development, the Laboratory for Manufacturing and Productivity, and the Computer-Aided Design Laboratory. The decline in research support over the last few years from sources such as the Department of Energy, the Department of Transportation, and the Environmental Agency has moderated and small increases in support from these agencies have occurred in the last year.

Several companies and foundations continue to provide grants of unrestricted funds to the Department and funds to support the career development of young faculty. These discretionary funds have been used as seed funds to initiate new research areas, to enhance the development of young faculty careers, and to acquire equipment for education and research. Several young faculty are supported this year by the TRW Foundation Faculty Fellowship, the IBM Grant based on excellence in materials and manufacturing research, the duPont Engineering Grant and Faculty Fellowship, and the Rockwell International Assistant Professor Fellowship. These grants have provided significant assistance in initiating research activities by young faculty and the commitment they represent from industry to education is most encouraging.

Research in the Department varies from very basic, fundamental research to the conception, design, and prototype evaluation of innovative systems to serve the needs of society. Approximately half of the faculty is explicitly involved in basic research and almost every research project the Department has is a component of fundamental research. In research applications the fraction of faculty involved in the four major application areas are: manufacturing, materials and mechanics, 35 percent; energy and environment, 45 percent; biomedical engineering, 22 percent; and systems, including transportation, 18 percent.

Research Accomplishments

Manufacturing, Materials and Mechanics

The Department's major activities in manufacturing and processing are associated with the Laboratory for Manufacturing and Productivity. This interdepartmental laboratory, which has grown substantially under the leadership of Professor Suh, involves faculty from the Department in major program areas of computer-aided manufacturing and robotics, metals processing, polymer processing, flexible materials, and tribology. Significant progress has been made in the robotics area through the research of Professors Haruhiko Asada, Neville Hogan, and Seering. Development of direct drive motors by Professor Asada, techniques for obstacle avoidance through impedance matching of robot characteristics to the environment by Professor Hogan, and improved structural elements for robot arms by Professor Seering have all been encouraging. The research in polymer processing has been highlighted by a symposium to honor the 10th year anniversary of the MIT-Industrial Polymer Processing Program and has featured the work of Professors Suh, Lewis Erwin, Timothy G. Gutowski, and Ming-Kai Tse. In the area of metals processing, Professor Kramer has continued his research in identifying materials which will provide improved tool wear performance in machining of advanced metals including titanium, while Professor David E. Hardt has continued research to improve welding processes and metal bending processes through direct application of automatic control techniques. A new initiative in the tribology area has led to the establishment of an industrial consortium under the direction of Professors Ernest Rabinowicz and Dr. Nannaji Saka to pursue basic research in tribology related to magnetic recording devices, fuel efficient engines and the mechanisms of friction and wear. The research program in flexible materials developed by Professor Stanley Backer and James H. Williams, Jr. has developed an improved understanding of the behavior of fibrous rope materials.

In the Mechanics and Materials area, a new computation facility has been established by Professors Parks and Anand along with Professors Argon and McClintock. The facility will provide the capability to develop a better quantitative understanding of the wide variety of processes involved in the mechanical behavior of materials including inelastic deformation, fracture, and thermo-mechanical coupling effects. Applications of the fundamental analytical techniques have been applied to the analysis of hot-forming of metals, inelastic response of glassy polymers, development of physically-based models of creep damage, mixed-mode elastic plastic crack propagation and interfacial behavior in metal matrix composites.

A number of faculty are directing their research to problems associated with advanced analytical and experimental techniques in dynamics. Professor Klaus-Jürgen Bathe has led the development of finite element models for fluid-structural interactions. Professor Crandall has developed analytical formulations and experimental techniques to identify the dynamic behavior of rotor-shaft dynamic systems as well as multi-dimensional plate behavior. Professor Richard H. Lyon has extended his development of techniques for analyzing vibration signatures as diagnostic tools for the identification of the performance of rotating equipment including automotive engines. Additional research in the mechanics area has been performed by Professor Triantaphyllos R. Akylas who has made significant progress in developing analyses for dynamic wave behavior interacting with coastal shore lines with application to problems of beach erosion.

Energy and Environment

During the year, substantial progress was made in research programs related to the combustion and lubrication in internal combustion engines, resource extraction, heat and mass transfer, and energy conservation. Space has been renovated for the experimental facilities of the REMERGENCE Laboratory, a laboratory facility developed under the joint auspices of the Mechanical and Civil Engineering Departments. This laboratory will provide facilities for experimental work conducted by Professor Michael P. Cleary in evaluating rock fracture related to oil and gas extraction and for Professor Peterson in research directed to improving mining systems.

In newly developed research in the heat and mass transfer area, Professors Anthony T. Patera and Bora B. Mikić, as well as Professor Paul K. Houpt, have defined research programs related to the processing and growth of electronic materials. This project which is conducted in cooperation with the Department of Materials Science and Engineering and Electrical Engineering and Computer Science is defining the factors which influence quality during crystal growth.

Research in the Sloan Automotive Laboratory has been undertaken with the support of an industrial consortium to evaluate the uses of ceramic materials in engines. This effort involves Professors John B.

Heywood and Wai K. Cheng and is complemented by basic research in lubrication conducted by Dr. David P. Hoult. Fundamental studies related to the characterization of combustion have been extended to consideration of turbulent combustion by Professor Tau-Yi Toong.

Several new research programs have been initiated in the Cryogenics Laboratory under the direction of Professor Joseph L. Smith, Jr. and Dr. Yukikazu Iwasa. Major progress has been made in the development of a prototype superconducting generator and in the development of cooling systems for high performance magnets which have application to medical imaging.

In the Chemical Dynamics Research Laboratory, Professors James C. Keck and Unkel have continued the development of a basic understanding of chemical interactions and energy exchange processes associated with electrical discharge phenomena with application to spark ignition laminar burning and homogeneous explosions of combustible gas mixtures and arc welding.

Experimental studies to characterize two-phase gas-liquid flows associated with power systems have been conducted by Professors Peter Griffith and Rohsenow with particular application to emergency cooling of nuclear reactors.

Research in the area of turbomachinery has been initiated by Professor Maher A. El-Masri with emphasis on exploration of liquid cooling for gas turbines. In addition, Professor Wilson has continued research in developing design algorithms for turbomachinery.

Research directed to energy conservation associated with improved heat transfer performance of building insulation materials has shown considerable progress under the direction of Dr. Leon R. Glicksman in a program conducted jointly with the Department of Architecture. In addition, Professor Thomas P. Bligh has recently completed a major project to acquire operating data determining the utilization of solar energy in residential buildings.

A number of fundamental research studies have been conducted this year which are of special significance. A basic research effort in experimental, analytical, and numerical techniques to characterize pressure fluctuations in turbulent boundary layers has continued under the leadership of Professors Patrick Leehey, Patera and Akylas in cooperation with Professor Steven A. Orszag of the Department of Mathematics. Fundamental research in the quantum mechanic foundations of thermodynamics has been continued by Professors Gian Paolo Beretta and Elias P. Gyftopoulos. Professor James A. Fay has developed basic methods of characterizing the dispersion of gases in the atmosphere with application to acid rain. Experimental research to determine transport of heat and mass transfer into turbulent free liquid surfaces has been continued by Professor Sonin. Professor Ronald F. Probst has defined a new research program in the control of ground water flow at hazardous waste sites.

Biomedical Engineering

In biomedical engineering research, encouraging progress has been made in areas related to human mobility and sensory aids treatment of tumors via hyperthermia, development of artificial skin and development of an understanding of the fluid mechanics related to the cardiovascular, pulmonary, and ocular systems.

In the Eric P. and Evelyn E. Newman Laboratory for Biomechanics and Human Rehabilitation, research to understand the underlying principles involved in the mechanics associated with joints and, in particular, with arthritis related degeneration, has been made with the development of an instrumented hip-joint prosthesis that will allow determination of the pressure profiles across human joints. This research directed by Professor Robert W. Mann has recently led to the development of an instrumented hip joint for evaluation in human patients. Studies conducted in the laboratory by Professor Woodie Flowers have continued the development of a microprocessor-based biofeedback and gait analysis system for training above-knee amputees in the use of prostheses.

Research conducted by Professor Ioannis V. Yannas in collaboration with Dr. John F. Burke of Massachusetts General Hospital has completed the evaluation of the development of a Stage 1 biocompatible artificial skin in severely burned patients. The encouraging results of this research have led to the development of a new Stage 2 artificial skin for which clinical trials will be conducted in the fall of 1984.

In the Laboratory for Medical Ultrasonics, Professor Padmakar P. Lele and his colleagues have progressed to the patient treatment evaluation stage of research in which tumors are treated through controlled hyperthermia using focused ultrasound.

Biomedical research in the fluid mechanics laboratory has shown significant progress in the recent work of Professor Roger B. Kamm in developing a basic understanding of the hydrodynamics of ocular solutions in the eye related to diseases such as glaucoma. Professors Ascher H. Shapiro and Kamm are collaborating on research involving theoretical and analytical studies of the flow in collapsible tubes related to arterial flows. Also, research by Professor Dewey on identifying genesis of arteriosclerosis has continued in the experimental quantification of the effects of shear stress on arterial flows.

Systems Research

In systems and transportation, research is concentrated in the Man Machine Systems Laboratory, the Computer-Aided Design Laboratory, the Vehicle Dynamics Laboratory, the Machine Dynamics Laboratory, and the Innovation Center.

Professor Thomas B. Sheridan and Dr. Dana R. Yoerger of the Man Machine Systems Laboratory have made significant progress in the development of undersea remote manipulation with the establishment of an experimental test capability to evaluate and modify an undersea manipulator in research coordinated with the Woods Hole Oceanographic Institute.

Professor David C. Gossard and his colleagues in the Computer-Aided Design Laboratory have developed automatic scaling techniques for mechanical assemblies which allow scaling to be performed on the basis of design and prescribed constraints in objective functions. This research is complemented by efforts to develop, using expert systems technology, designer machine interfaces which enhance the iterative design functions.

In transportation technology, a major new program has been initiated under the auspices of the Center for Transportation Studies in which MIT has been designated as an Association of American Railroads Affiliated Laboratory. This program, directed by Professor David N. Wormley, includes participation from the Mechanical Engineering Department by Professor J. Karl Hedrick who is investigating the dynamic performance and energy consumption of advanced rail vehicles and has participation by members of the Department of Civil Engineering in areas related to railroad system productivity and automation.

The Innovation Center, under the leadership of Dr. David Jansson, has continued both basic research into the processes of innovation and developmental research applied to industrial and consumer products. The increase in national emphasis on entrepreneurship has been reflected in both increased student interest and industrial support of research in the Center.

Within the Machine Dynamics Laboratory, Professor Steven Dubowsky continued research to develop analytical techniques for evaluating the limits to high speed machine performance. In a new research effort in the Laboratory, Professor James E. Hubbard, Jr. initiated research to develop active damping techniques for distributed structures such as occur in aircraft and ground transportation vehicles. In this research an experimental facility has been developed for the evaluation of innovative-active damping techniques for distributed structures.

FACULTY AND STAFF

Size and Composition

On July 1, 1983 there were 59 active faculty: 32 professors, 15 associate professors (six with tenure), and 12 assistant professors. Nine faculty are minority group members: a black professor and assistant professor and seven Asians. The teaching, research, and technical staff fluctuates at around 70, more than half of whom are part time people whose principal base is either in another department or outside MIT: many of these part time faculty serve without stipend. Among the staff are six Asians, one Hispanic, and three women. Of the six administrative staff four are women, and of the 34 support staff one is a man and two are black women. The Department has 14 hourly staff, including two black men.

Notable Accomplishments and Awards

Professor Asada has been selected to receive one of the Society of Manufacturing Engineer's 1984 Outstanding Young Manufacturing Engineer Awards in recognition of significant achievements and leadership in the field of manufacturing as a young engineer.

Professor Bathe received the Walter L. Huber Research Prize of the American Society of Civil Engineers for his contributions in nonlinear computational mechanics.

Professor Bligh received, with his collaborators, the Outstanding Engineering Achievement of 1983 by the American Society of Civil Engineers for work on the Civil and Mineral Engineering Building at the University of Minnesota.

Professor Cheng has been named by the Society of Automotive Engineers as one of 34 engineering educators to participate in SAE's 1984 Ralph R. Teetor Educational Award Program for excellence in educational and professional activities.

Professor Cook received the Irwin Sizer Award presented by the Graduate Student Council for the most significant improvement to MIT graduate education.

Professor Crandall, Ford Professor of Engineering, was the recipient of the Jacob P. Den Hartog Distinguished Educator Award for 1983 for excellence in teaching mechanical engineering which has served as an inspiration for students and has fostered the development of physical insight and engineering judgment. He presented the Jacob P. Den Hartog Award Lecture on December 9, 1983 entitled, "Rotor Dynamics." Professor Crandall was also the recipient of the Graduate Student Council Teaching Award presented by the Graduate Student Council for his teaching of graduate subjects.

Professor Heywood was awarded the Doctor of Science degree from the University of Cambridge for his original contributions made by his research publications. He also won the Homing Memorial Award for 1983 presented by the Society of Automotive Engineers for his SAE paper, co-authored with Anthony J. Giovanetti, and Dr. Jack A. Ekchian, entitled, "Analysis of Hydrocarbon Emissions Mechanisms in a Direct Injection Spark-Ignition Engine," as the best example of an outstanding original contribution to knowledge in the field of engine/fuels interaction.

Professor Kramer and Paul D. Hartung (SM, 1981) were selected to receive the 1984 F.W. Taylor Medal of the International Institution for Production Engineering Research (CIRP) for their paper entitled, "Tool Wear in Titanium Machining." Professor Kramer has also been elected to an associate membership in CIRP.

Professor Mann, who was a recipient of the 1983-84 James R. Killian, Jr. Faculty Achievement Award, which recognizes extraordinary accomplishments by MIT faculty members, delivered the Killian Award Lectures entitled, "Engineering Design," on April 9, 1984 and April 12, 1984.

Professor Henry M. Paynter received the 1984 Education Award presented by the American Automatic Control Council in recognition of outstanding contributions and distinguished leadership in automatic control education.

Professor Rabinowicz received the Ragnar Holm Award from the Holm Conference on Electrical Contacts for his research on electrical contacts.

Professor Shapiro, Institute Professor, was presented with the Fluids Engineering Award by the American Society of Mechanical Engineers for his worldwide contributions to fluid mechanics through his articles, books, and teaching films, in addition to his well-known and extensive research in propulsion, turbomachinery, and biological systems, and for his organizational achievements in the teaching of fluid mechanics.

Professor Sheridan was awarded the Centennial Medal by the IEEE for his service to the profession.

Professor Smith was elected to the National Academy for Engineering for his pioneering contributions to the analysis, design, and fabrication of superconducting synchronous alternators.

Professor Suh was selected as the US editor of the new international journal entitled "Robotics and Computer-Integrated Manufacturing."

Professor Wilson has been named president of the International Human Powered Vehicle Association (IHPVA) for 1984.

New Faculty and Staff

Dr. Ahmed F. Ghoniem joined the Department on July 1, 1983 to be affiliated with the Thermal and Fluid Sciences Division as an Assistant Professor. He has established research programs in the fundamental aspects of turbulent flow and has taught in the areas of fluid mechanics and thermodynamics.

Visiting Faculty

The Department had five visiting faculty during 1983-84. Dr. Richard E. Garrett, Director of CAD/CAM Research at Control Data Corporation continued his close association with Professor Gossard. Dr. Carl H. Durney, Research Professor of Bioengineering at the University of Utah, collaborated with Dr. Lele in the areas of research related to cancer treatment. Dr. Turgay Erturk, Associate Professor in the Metallurgical Department of the Middle East Technical University, Ankara, Turkey, collaborated with Professor Argon on research in the mechanisms of transformation toughening and its application to glassy materials. Dr. Susan Finger, Assistant Professor in the Department of Manufacturing at Boston University, continued her collaboration with Professor Suh in the Laboratory for Manufacturing and Productivity developing research in the areas of computer-aided manufacturing. Dr. Steven W. Rauch, Associate Professor at the University of New Brunswick, collaborated in computer-aided design research with Professor Gossard.

Other Visitors

The Department hosted 18 visiting scientists/scholars/engineers from nine different countries during the academic year: five from the People's Republic of China, four from Israel, two from Japan, two from Korea, and one from Canada, France, Italy, Switzerland, and Yugoslavia.

Retirements

Professor Kenneth B. Wadleigh, who most recently served as Dean of the Graduate School and Vice President at MIT, retired this past year. Professor Wadleigh first joined the Department in 1949 and made substantial contributions to Department educational and research programs in the thermal-fluid design area. He taught and performed research in the Department until 1961 at which time he assumed the duties of Dean of Students and then in 1969 became a Vice President of the Institute and in 1975 assumed the duties of Dean of the Graduate School and Vice President.

Several of the Department staff members have retired this year. Among them are: Karl H. Benner, Project Technician in the Cryogenics Engineering Laboratory, who joined the Department in 1946; Frederick R. Johnson, Project Technician in the Undergraduate Laboratory, who came to MIT in 1950; Grace H. Kelly, Executive Assistant to the Department Head, who began working with Department Heads in 1961 and continued to advise four successive Department Heads through 1984; Aubrey R. Rigby, Instrument Maker for the Student Shop, who joined the Department in 1952; and Natalie D. Speckmann, Administrator, who joined the Department in 1938. These staff members have earned the respect and admiration of the faculty, staff, and students alike and their dedicated service to the Department has been extraordinary.

Deaths

Professor Samuel C. Collins, Professor Emeritus, died on June 19, 1984 at the age of 85. Professor Collins made seminal contributions to cryogenic engineering. He was internationally known as the father of practical helium liquefiers and was the founder of the Cryogenic Engineering Laboratory. He was also known for developing, in collaboration with a surgeon at the Veterans Administration Hospital in West Roxbury, a compact heart-lung machine.

Ralph H. Whittemore, an Instructor in Mechanical Engineering, died on August 23, 1983 at the age of 59. He had been employed in the Department since 1946 and was a joint Murphy Award winner in 1981 and a joint Holt Award recipient, also in 1981, for outstanding service to the Department. He shared these awards with his long time colleague Frederick H. Anderson.

DAVID N. WORMLEY

Department of Nuclear Engineering

The Nuclear Engineering Department serves the Institute through four major objectives: 1) by providing education, through teaching and research, to individuals from the U.S. and abroad interested in the peaceful uses of nuclear reactions, 2) by identifying and developing new scientific and engineering approaches to the practical application of nuclear phenomena, and translating these approaches to educational programs, 3) by contributing to a thorough understanding of nuclear energy and radiation in the national and international communities, and 4) by contributing to a thorough understanding of the issues which will determine the role of nuclear power in meeting domestic and world energy needs.

The Department's undergraduate and graduate teaching activities focus around the following disciplines: Fission Reactors, Controlled Fusion, Radiation Physics, including Biomedical Applications and Radiological Sciences, and Energy Technology and Resources. Research is carried out by faculty and students as an integral part of our educational program. An important component of the educational strategy is the writing of textbooks and the communication of teaching and research results through professional publications and oral presentations. The demand for public service activities in the Nuclear Engineering Department involving questions of public policy with respect to the commercial application of fission energy and the direction of the fusion research program is strong. This demand is met by testimony on proposed legislation for the Government, short courses and consulting for industry, membership in committees of professional societies, and volunteer work for educational and other non-profit institutions. The following annual report for the period ending June 30, 1984, highlights our recent activities in each of these discipline areas in fulfilling the foregoing Department objectives.

ACADEMIC PROGRAM

During the academic year 1983-84, the Department maintained a graduate enrollment of approximately 155 students. As of the Fall term 1983, 27 students were participating in our undergraduate program. Five freshmen, who elected nuclear engineering during the past year, will join the Department next September.

Recruitment of domestic graduate students continued to be successful during the past year. Approximately 225 individuals requested information about the nuclear engineering field. Forty-five domestic applications were processed for September 1984 admission. Of these 45 applicants, 37 qualified for admission and 28 of these were approved for financial aid. Subsequently, several (5) have been awarded fellowships from outside funding groups such as the Department of Energy (DOE), the National Science Foundation (NSF), and the General Electric Foundation (GE).

The Department awarded 29 doctorates, 11 nuclear engineers, and 38 master of science degrees during the academic year 1983-84 -- a total of 78 advanced degrees. Also, 9 bachelor of science degrees were awarded.

The Engineering Internship Program, which offers undergraduates the opportunity to have significant on-the-job experience as part of their overall education, has been successful since it was initiated in the summer of 1978. A total of 9 students -- two graduates, four seniors, and three juniors -- are now in the program. Companies which have placed students from our Department include Brookhaven National Laboratory, Commonwealth Edison, EG&G Idaho, Stone & Webster Engineering Corporation, and Los Alamos National Lab.

The radiological sciences doctoral program under the direction of Professors Gordon L. Brownell and Alan Nelson, supported by the National Institutes of Health (NIH), is currently under development. The objective of this program is to educate students in the various applications of radiation in medicine and correspondingly to expand the research frontiers in this area. Academic and research objectives may be pursued in one of three specialty areas: medical therapy, imaging and diagnostic technology, and radiation biophysics. The laboratory resources of the Whitaker College have been made available for research in radiological sciences.

A master's program in the area of health radiation physics had a very successful first year. This program, developed by Professor Otto Harling, is designed to combine a strong engineering background with course work and thesis research in the principles of radiobiology, radiation dosimetry, radiation measurement and radiation risk exposure management. The MIT Reactor, the Bates Accelerator, and various facilities in Boston area teaching hospitals provide significant experience in radiation management. A new laboratory course, Health Physics II, has been developed to complement the recommended course curriculum. The first pilot student, who received financial support from a nuclear utility grant, has been awarded a master's degree. Five students participated in this program during its first full year, and enrollment is expected to increase further. Another nuclear utility has promised full support for a student and the Institute for Nuclear Power Operations (INPO) will provide a fellowship for the coming academic year.

Professors Sidney Yip and Gretchen Kalonki, a member of the Department of Materials Science and Engineering, introduced a new subject, Computational Methods in Materials Science and Engineering, as a joint offering by the two Departments. This subject treats current methods for determining materials properties and behavior, ranging from atomistic simulations to continuum models.

During the fall term, Professor Richard Lester and Professor Dietmar Winje, a visitor from the Technical University of Berlin (TUB), introduced a new graduate course entitled, Nuclear Energy Policy Analysis.

Professor Andrei Schor has been involved in a major revision of two courses on numerical methods offered by the Department. The objective of this effort is the development of a broad, integrated and up-to-date curriculum in this area.

Several participants in the Center for Advanced Engineering Study (CAES) special program were registered in nuclear engineering courses during the spring term. In particular, three students from the country of Mexico were enrolled in Nuclear Fuel Management, and other related courses.

Special summer session courses were offered by several members of the Nuclear Engineering faculty. During the summer of 1983, Professors Norman Rasmussen and Neil Todreas directed a session entitled, Nuclear Power Reactor Safety. Ninety-five attendees from seven countries participated in this two-week program. During June 1984, a program entitled Human Factors and Computer Aids in Nuclear Power and Industrial Control was presented under the direction of Professors Thomas Sheridan, of Mechanical Engineering, and David Lanning. Twelve people from 5 countries attended.

STUDENT ACTIVITIES

The MIT Student Branch of the American Nuclear Society (ANS) has completed another productive year. Activities have included departmental seminars, student/faculty meetings, departmental steak fries, and and course evaluations.

Honors and Awards

At the 30th annual meeting of the ANS, held in New Orleans earlier this month, Jerry Martin, an undergraduate, was named recipient of the John LaMarsh Scholarship Award for outstanding efforts and academic achievements.

At the eastern regional student conference of the ANS, "best paper" awards were presented to three of our graduate students. Rene LeClaire received an award for his presentation in the area of fusion; Victor Iannello in the area of thermal hydraulics; and Vittorio Pareto in the reactor research and design area. This conference was held at the University of Lowell last April.

Cynthia Sheeks, an NED graduate student, was awarded first prize in a competition of graduate student papers sponsored by the Materials Technology Institute of the Chemical Process Industry.

Seventeen graduate students and one undergraduate student were inducted into Alpha Nu Sigma, the national honor society for nuclear science and engineering. Mr. John Zwick, an undergraduate, was elected to the MIT chapter of Phi Beta Kappa in honor of his outstanding scholarship in the liberal arts and sciences. The Department initiated two undergraduate awards this year. Jay Elson was chosen to receive The Irving Kaplan Award for the Outstanding Junior in Nuclear Engineering. The second award, The Roy Axford Award for the Outstanding Senior in Nuclear Engineering, was presented to John Zwick.

In recognition of his outstanding thesis, Thomas Drennen, an undergraduate, was selected to receive The Rodman McClintock (1921) Award.

During the past academic year, several of our graduate students were honored with national fellowships. Five students were awarded Department of Energy (DOE) Magnetic Fusion Energy Fellowships. They were James Doyle, Deborah Hanchar, Scott Haney, John Massidda, and Craig Petty. Other DOE-sponsored fellowship holders included Anthony D'Amico (Nuclear Science & Engineering Fellowship) and Margarita Crocker (Health Physics Fellowship). The Hertz Foundation awarded their fellowship to Thomas Downar for his doctoral studies. Recipient of a National Science Foundation (NSF) Fellowship was Michael Izenson.

Jon Anderson continued as a Schlumberger Fellow in Radiation Physics for the second year. The Department received for the first time an IBM Fellowship for graduate research in materials science; this fellowship was awarded to Cynthia Nitta. The first Graduate Fellowship in Health Physics, funded by the Consumers Power Co., was held by Susan Reilly. Robert Witt was appointed a Rockwell International Graduate Fellow for 1983-84.

Other Student Awards

During the academic year, approximately 73 percent of our graduate student body was appointed to the graduate student staff, receiving financial aid in the form of full and part-time research and teaching

assistantships. Included in this percentage was Thomas Downar, who was appointed a graduate Instructor G.

The Department was pleased to award the Theos J. Thompson Memorial Fellowship to Peter Laughton. Raymond Coxe received the Sherman Knapp Scholarship, which is funded by Northeast Utilities. The initial fellowship in honor of our first department head, Professor Manson Benedict, was presented to Robert Witt.

Other forms of graduate financial awards were presented to several members of the graduate student body. These included: Warren Krueger, a NASA fellowship; Ray Gamino, a GEM award; and Carl Malbrain, support from the DeCorte Fund. Approximately eight students received financial assistance from the Department's two MIT-endowed tuition scholarships.

RESEARCH

The Department conducts research in the areas of 1) fission reactors (reactor engineering, reactor physics and fuel management, nuclear materials, and reliability and risk analysis), 2) controlled fusion (applied plasma physics and fusion reactor technology), 3) radiation physics, including biomedical applications (condensed matter sciences, biomedical and radiological sciences), and 4) energy technology and resources. During the fiscal year ending June 30, 1983, Departmental faculty supervised a research volume of \$3,065,383, including research funded through the Department, the Department of Materials Science and Engineering, the MIT Energy Laboratory, the Harvard-MIT Division of Health Sciences and Technology, the Whitaker College of Health Sciences, Technology, and Management, the Nuclear Reactor Laboratory, the Plasma Fusion Center (PFC), and the Research Laboratory of Electronics.

Continuing Research Projects

Professors Lanning and John Meyer, working closely with the Charles Stark Draper Laboratory staff, are continuing their research on the problems of instrumentation control and information processing for nuclear power plants. In the area of reliability analysis, Professor Rasmussen completed a study on the economic consequences of nuclear accidents and the reliability of standby safety systems. Under the sponsorship of the Electric Power Research Institute (EPRI) and Fauske & Associates (FAI), Professors Mujid Kazimi, Meyer, and Carolyn Heising have continued their research in the area of PWR severe accident analysis. Under the supervision of Professor Heising, progress has been made in the areas of common cause and human reliability analysis. Professor Elias Gyftopoulos is continuing his work on the foundations of quantum thermodynamics, including an equation of motion for quantum physics and the distinction between quantal and nonquantal uncertainties.

In the reactor physics area, Professor Allan Henry and his students have continued work in the area of reactor physics modelling. Some of the numerical methods developed in this effort are now being embodied by EPRI and by Nuclear Utilities Services (NUS) into production computer programs for thermal reactors. During the past year, Professor Michael Driscoll's students continued research on improved LWR fuel management methods.

In the area of nuclear materials, departmental research continues to be active. Professor Harling is continuing a major program in this area. This effort concerns development of improved nuclear structural alloys for the critical fusion reactor first-wall application. Theoretical and experimental studies on defect aggregation in irradiated alloys are progressing under the supervision of Professor Kenneth Russell. Professor I-Wei Chen recently completed a study of the effects of a stress field on the dimensional and the phase stability of ferritic steels under intense irradiation. He also directs a theoretical study of the impurity effects in void nucleation. An experimental program on zirconia transformation continues into its second year.

Professor Ronald Ballinger has several research projects ongoing, one of which explores the environmental effects on fatigue and stress corrosion cracking performance of materials used in power systems. In addition a new program has been initiated to develop analytical models, checked against experimental data, of the aqueous environment in a dynamic fatigue or stress corrosion crack. The experimental laboratory for his research has been expanded with the addition of a new servohydraulic fatigue machine and additional computer equipment for real time control.

Professor Ballinger is continuing his efforts in the area of predicting LWR fuel performance using advanced deterministic and probabilistic techniques and is adapting the same methodology for use in materials-related areas including alloy development and component life prediction.

He has also been active in research related to Three Mile Island. An examination was conducted at MIT to determine the character and morphology of deposits found on control rod drive system parts after the accident. His findings were used to develop a better understanding of the accident scenario and to establish clean-up procedures and methodology.

The Department continues its broad activities in the area of thermal hydraulics and fluid flow. Professors Kazimi, Lanning, Schor, Neil Todreas, Michael Golay and Meyer have contributed individually and jointly to studies of natural convection and sodium boiling behavior in Liquid Metal Fast Breeder Reactor (LMFBR), PWR

steam generator modeling, Light Water Reactor (LWR) containment flows, single and two-phase flow in light water reactors, and thermal problems in fusion devices. In the computational thermal-hydraulics area, Professor Schor continues his research on advanced numerical methods, aimed at providing efficient, multi-dimensional analytical tools. Investigations of the especially severe nonlinear effects characterizing the two-phase flows are being actively pursued.

In the fusion area, research has continued over a wide range of topics. Professor Jeffrey Freidberg is continuing studies of the macroscopic equilibrium and stability properties of plasmas using the magneto-hydrodynamic model. Specific problems are being investigated relating to stellarator, stellarator/tokamak hybrids, and tandem mirrors. The important problem of plasma turbulence and the resulting anomalous transport, particularly in tokamaks is being further studied by Professor Kim Molvig. This work focusses on drift wave turbulence and the calculation of saturated states and frequency and wavenumber spectra. Research on nonlinear ordered and stochastic systems with various applications to laboratory and astrophysical plasma turbulence has been continued by Professor Thomas Dupree.

Professor Ian Hutchinson has renewed his collaboration with members of the PFC in experiments on the Tokamak Alcator C. His major areas of interest are plasma diagnostics and MHD instabilities.

Professor Meyer has continued engineering analysis work applied to first walls, blankets, and steam turbines in tokamak fusion system studies. Professor Kazimi continued his studies of fusion reactor safety, with major emphasis on the development of a methodology for assessment of reactor design impact on safety.

Professors Sow-Hsin Chen and Yip lead the Department's efforts in the area of applied radiation physics. Professor Yip is now primarily interested in computer simulation studies of materials behavior and properties. In the area of nuclear medicine, Professor Brownell is continuing his program on the study of boron neutron capture therapy with emphasis on development of track etch technique for the determination of boron distribution in tissue. In conjunction with the Massachusetts General Hospital, an extensive program of medical imaging continues. The emphasis in this program is on positron tomography and the development of instruments and radiopharmaceuticals as well as biological and medical applications.

In the area of radiological sciences and radiation biophysics, Professor Nelson is continuing several research efforts. The effects of ionizing photons and particles on embryos are being investigated in collaboration with the Lawrence Berkeley Laboratory. In conjunction with the Harvard Medical School, study continues on the effects of ionizing radiation on vasculature. This project is directed toward improved methods of tumor treatment. Professor Nelson is also continuing various investigations in micro-structure of organisms and materials, and in laboratory automation and digital image analysis.

Professor Lester is continuing his work in the area of radioactive waste management and disposal; during the past year his research has been directed toward the thermal design, economic evaluation, and risk assessment of geologic repositories for high-level radioactive waste.

Professor David Rose and Dr. Marvin Miller, together with Professor Carson Agnew of Stanford University, completed a substantial study of global energy futures, particularly as they relate or respond to climate change induced by buildup of carbon dioxide in the atmosphere (the "global greenhouse" effect). The report, based on new technology assessments combined with a global energy model developed by the Institute for Energy Analysis, describes "CO₂-benign" energy options. These involve increased energy efficiency, increased non-fossil energy technologies, and other activities, many of which are attractive in their own right, besides ameliorating the CO₂-greenhouse problem. This work was supported by the National Science Foundation (NSF).

Dr. Miller is also continuing research in the area of nuclear safeguards. Projects completed during this year include: an evaluation of the U.S. program in support of IAEA safeguards (with Professor Rasmussen), development of a safeguarding approach to heavy water production plants (with Professor Manson Benedict), and an assessment of the potential for upgrading safeguards at research reactors fueled with highly enriched uranium. In addition, Dr. Miller, along with Professors Rasmussen and Gyftopoulos, has been working on a methodology to aid in the assessment of the requirements for sabotage protection at nuclear plants.

New Research Projects

Several new projects have been initiated by Department faculty. Professor Golay has devoted much of his time to launching the LWR innovation project. Efforts for development of a methodology for systems simplification, and for implementation of a non-prescriptive process of reactor safety regulation have been investigated. Other efforts which are part of the innovation program involve use of new technology, improvement of troublesome plant components (i.e. valves, pumps and heat exchangers) and surveys of important experience. Negotiations have been pursued with the USDOE, EPRI and leading nuclear utilities. This process is incomplete, but results to date are promising. Another portion of the innovation project is being conducted by Professors Lawrence Lidsky and Lanning. They are studying the design and potential benefits of Modular High Temperature Gas-Cooled Reactors (MHTGR's). These reactors combine passive safety features with high temperature capability and potentially economic power production by factory

fabrication. Initial funding for the MIT studies in this MHTGR area has been received through the Energy Laboratory Utility-Sponsored Program. Also as part of the innovation project, Professor Lester is directing a study of alternative Federal policy options for advanced reactor development and commercialization, supported by the NSF. Professors Golay, Lanning, and Lidsky are also participating in this work.

New research in the area of flow behavior in systems of parallel channels has been initiated by Professor Todreas. Funding for work on improved instrumentation and controls has been granted by the NSF for a project entitled Fault-Tolerant Systems Approach Toward Closed-Loop Digital Control of Nuclear Power Reactors, a two to three-year program beginning in July 1984. This effort will be under the direction of Professor Lanning.

Professor Lester has initiated a new research project to analyze the sources of international variations in industrial performance in nuclear power plant construction and operation. This work is supported by the Andrew W. Mellon Foundation.

Professor Rasmussen has started a project in conjunction with EG&G, Idaho, on accident source term.

Professor Nelson has launched a major effort to convert his laboratory to a National Center for Computer-Aided Microscopy and Image Technology (CAMIT) with a multi-million dollar support proposal to NIH. Professor Molvig has received a contract from the Office of Naval Research to develop a theory for the emission of Whistler radiation in the magnetosphere.

FACULTY

Ian Hutchinson joined the department as associate professor of nuclear engineering last September. He specializes in the area of experimental plasma physics.

Dietmar Konrad Winje has returned to the Technical University of Berlin after completing a two-year appointment as a visiting associate professor.

Professor Driscoll enjoyed a sabbatical leave during the past year. During this period, he prepared the first draft of a monograph on nuclear fuel management. He represented the US at the IAEA/AESJ-sponsored International Meeting on the Recovery of Uranium from Seawater, held in October 1983, in Tokyo, Japan. He also visited Taiwan in May 1984 to consult with INER, Taipower and Tsing Hua University on the nuclear fuel cycle at their invitation.

During the spring term 1984, Professor Lanning was on half-time leave from MIT, in order to study the present status of the High Temperature Gas-Cooled Reactor Technology (HTGR) at GA Technologies in San Diego, California.

Professor Rose continued his joint appointment with the East-West Center in Honolulu during the period January through April. Among other things, he collaborated in a study on present and future electric power systems for the regions of east and southeast Asia, an activity involving the East-West Center, EPRI, MIT, and the principal electric power authorities of the region.

Several faculty members served in an administrative capacity within the Department during the past year. These included Professor Ballinger in charge of recruiting, and Professor Yip as financial aid officer. Professor Henry continued to represent the Department to the Committee on Graduate School Policy (CGSP). Department admissions were reviewed by Professor Lanning and by Professor Kent Hansen during Professor Lanning's absence. UROP activities were coordinated by Professors Lanning and Kazimi. The Committee on Undergraduate Students was chaired by Professor Mayer. He also served as the faculty advisor for both the honorary Alpha Nu Sigma Society and the ANS Student Branch.

Many faculty members continued participation in both Institute-related and non-related activities. Professor Rasmussen continues to serve as Chairman of the MIT Committee on Reactor Safeguard, as well as Chairman of the MIT School of Engineering Committee on Energy Systems. He was recently appointed a member of the Ad Hoc Committee on Technology Policy and Society Studies at MIT. At the EG&G Idaho National Engineering Laboratory, he is chairman of both the Scientific Review Committee and the Fusion Safety Committee. He also holds an appointment to the National Science Board.

Professor Harling continues to direct the interdepartmental Nuclear Reactor Laboratory. Professor Lester chairs the MIT School of Engineering Committee on Energy Education. Professor Henry was selected a member of the MIT Advisory Committee on Shareholder Responsibility. He is also the CGSP representative to the Committee on Educational Policy (CEP).

Professor Lanning continues as a member of the MIT Committee on Reactor Safeguard, the Safety Audit Committee at Northern States Power Co., the Nuclear Safety Review and Audit Committee at Boston Edison, and the Source Term Review Group for Stone & Webster Engineering Corporation. The Nuclear Heat Transfer Committee of the American Institute of Chemical Engineering is chaired by Professor Kazimi. He is also on the Advisory Committee of the DOE Fellowship for Magnetic Fusion Energy Technology. Professor Freidberg

continues on the Executive Committee of the Stellarator Advisory Panel for the DOE. He also serves as the Group Leader of the Theory and Computation Group at the PFC. In November 1983, he was an invited speaker at the American Physical Societies' Division of Plasma Physics Meeting.

Professor Todreas continues to serve on the Executive Committee of the ANS. He is also serving on the DOE-sponsored panel evaluating the National Light Water Reactor Research and Development Programs and as chairman of the EG&G TMI-2 Accident Analysis Industry Review Group. He is a member of the editorial board of the thermal design section of the Journal of Nuclear Engineering and Design. Professor Henry is a member of the editorial review board for Nuclear Science and Engineering.

Professor Rose serves on the Advisory Committee of the Congressional Office of Technology Assessment. This committee deals with the future of conventional nuclear power. He also serves on the American Association for Advancement of Science's Committee on Climate, with particular emphasis on CO₂-climate problems. Professor Meyer is a member of the Review Committee for the Applied Physics Division at Argonne National Laboratory.

Several workshops were conducted under the direction of NED faculty members during the past year. Professor Yip organized a two-week session on the use of atomistic simulations to study solid state diffusion. This workshop was jointly sponsored by NATO and the European Center for Atomic and Molecular Calculations and was held last August at the University of Paris, Orsay, France. Professor Harling planned a highly successful international symposium on the uses and development of low and medium flux research reactors. Participants from 21 centers, worldwide, presented over 140 papers which have been incorporated into a special volume of the international journal, Atomkernenergie-Kerntechnik.

Two nuclear workshops were held in the Energy Laboratory's Electric Utility Program which involved NED faculty. The workshop on LWR Longevity Extension was led by Professor Golay; the session on Modular HTGR Technology was led by Professors Lidsky and Lester. Both sessions were well attended and aided in building constituencies for research programs in their respective areas.

Professor Russell's nuclear materials monograph, "Phase Stability Under Irradiation," is presently in press; the book will appear later this year.

Honors and Awards

Department faculty recognized with honors during the past year included Professor Driscoll. He was elected to the Executive Committee of the Fuel Cycle and Waste Management Division of the ANS. Professor Rasmussen was selected to chair the EPRI Nuclear Accident Source Term Committee. The Student Branch of the ANS presented its annual outstanding teacher award to Professor Nelson.

SUMMATION

The twenty-fifth anniversary celebration of the Nuclear Engineering Department, held October 7-8, 1983, was an overwhelming success. The weekend activities included a cocktail/registration party; a symposium entitled Future Directions in Nuclear Science and Engineering: Opportunities for Nuclear Engineering Education, organized by Professor Elias P. Gyftopoulos featured keynote speakers: Dr. N. J. Palladino, Chairman, U.S. Nuclear Regulatory Commission, Professor J. M. Deutch, Dean, School of Science, MIT, and Dr. G. H. Vineyard, Scientist, Brookhaven National Laboratory; a technical open house featuring exhibits, laboratory visits, and seminars by departmental faculty; and a gala banquet in honor of Dr. Manson Benedict, who was guest speaker together with Dr. James R. Killian, Jr., former MIT president, Dr. Edward A. Mason, Vice President for Research, Standard Oil Company (Indiana), and Mr. James J. O'Connor, Chairman and President, Commonwealth Edison. The evening's gala was hosted by Professor Kent F. Hansen. To commemorate this occasion in addition to establishing the Manson Benedict graduate fellowship in Nuclear Engineering, the Department published the book Nuclear Engineering at MIT, The First Twenty-Five Years.

The reactor innovation project, one of the four major goals of the Department's long-range plan, continues to generate enthusiasm both in the public and private sectors, and the Andrew Mellon Foundation has recently awarded funds to the Department in support of this major research undertaking to study the organization and technological performance in the nuclear power industry. Professor Richard K. Lester will supervise this project.

And finally, the Department now prepares for a meeting of its Visiting Committee, October, 1984.

NEIL E. TODREAS

Department of Ocean Engineering

The Department's long-range plan, prepared in the fall of 1982 and updated in 1983, called for the following initiatives:

- (1) more emphasis on professional education in the Department's curricula, especially at the undergraduate level,
- (2) reorganization of our programs in ocean systems management,
- (3) expanded program in the area of design,
- (4) development of Arctic studies.

Progress has been made in all of these in the present year. In addition, we have (i) resolved some problems with the Navy in Course XIII-A (Naval Construction and Engineering), (ii) improved mechanisms for administering Course XIII-W (our part of the MIT/WHOI Joint Program), (iii) participated in the teaching of fundamental subjects in Courses II and VI, (iv) undertaken three projects as part of MIT's Project Athena, and (v) expanded our collaboration with the Charles Stark Draper Laboratory (CSDL).

PROGRAMS OF INSTRUCTION

Undergraduate Program

Several sophomore-level subjects, each of which was more or less duplicated elsewhere in the School of Engineering, were dropped in the fall. As a sequel to this action, ocean engineering faculty members taught four sections of 6.003 in the fall term and two sections of 2.01 in the spring term. It is hoped that several purposes may be served in this way:

- (a) For some years, we have assumed that a good way to attract undergraduates to ocean engineering is to offer outstanding second-year subjects in fundamental areas. As a recruiting effort, this has failed, and so now we are trying an alternative, namely, not to offer our own fundamental subjects in the second year but instead to provide good teachers for similar subjects in other departments. Of course, we do not know yet whether this will be successful as a recruiting process, but it will enable our faculty to retain and perhaps even expand the level of their contacts with MIT's sophomores.
- (b) We help to relieve the teaching overload in some other departments.
- (c) We eliminate some redundancy in subject offerings and allow our own faculty to devote more effort to teaching subjects that are unique to ocean engineering.

A new sophomore subject will be introduced this fall, a computer-aided-design course on topics that are specific to ocean engineering. The new subject will then permit the reorganization of 13.40, the Department's primary design subject for undergraduates.

Naval Construction and Engineering (Course XIII-A)

Last year, the Navy unilaterally decided to send its officers to MIT for only two years instead of three. This year, that decision was modified: The Navy agreed to send at least ten officers per year for the three-year program, and we agreed to make a two-year program available as well. The latter, leading to a master's degree, requires no new subjects. We are comfortable with this compromise: It ensures the continuation of the longstanding program leading to the engineer's degree, and it answers multiple needs of the Navy. Thus we have continued our 83-year tradition of providing programs responsive to the Navy without a need for a contract.

A new subject was introduced primarily for Course XIII-A students, "Structural Response to Impulsive Loading," taught by Professor Tomasz Wierzbicki.

Each year the Department organizes a special series of short summer courses for XIII-A students. This program provides instruction on special subjects that are not generally appropriate for regular MIT subjects. Enrollment is limited to USN officers, employees of the Navy, and contractor personnel who are approved for attendance by the Navy. This year we conducted these courses at the Charles Stark Draper Laboratory. One new course was added, on submarine control; it was taught by Dr. Damon Cummings, a lecturer in the Department and a regular CSDL staff member.

Ocean Systems Management Program (Course XIII-B)

In 1983, the Department decided on several curriculum changes in Course XIII-B, and this year the first of these was put in place: A new subject was offered this spring that provides students in the SM program with an opportunity to combine their engineering and management skills in the solution of a real-world problem. The specific problem that the students investigated this spring was the disposal of sewage sludge from Boston disposal plants. At the end of the term, the class made a three-hour presentation of their results. Representatives from the Environmental Protection Agency, the Metropolitan District Commission, and the Massachusetts Department of Environmental Affairs attended the presentation and commented on the students' work; their reaction was highly favorable. Next year the project course will be required of all SM students in the Program. In addition, there will be new requirements on the distribution of subjects taken.

Joint MIT/WHOI Program (Course XIII-W)

The Joint Program is an important part of the Ocean Engineering Department's graduate program. Several courses in our curriculum are taught either entirely or partially by WHOI staff. The Arctic acoustics project of the Department is a joint enterprise with WHOI, involving faculty, students, and staff of both organizations. Our students are also working with the WHOI staff on problems of remotely operated vehicles, an area in which WHOI is particularly renowned.

This year the Department faculty modified its procedures for the doctoral qualifying examinations in order to encourage students' participation in the Joint Program. In addition, WHOI staff started taking major roles in the administration of the examinations.

PROJECT ATHENA

The Department is a vigorous participant in the Institute's **Project Athena**. Four Ocean Engineering Department proposals have been funded and are under way:

- (1) Development of a new sophomore-level subject in computer-aided design, under the direction of Professor Justin E. Kerwin.
- (2) Development of equipment and software to provide interfaces between instructional laboratories and the **Project Athena** system (this is an Institute-wide undertaking led by Professor Jerome H. Milgram).
- (3) Adaptation of the computer-assisted teaching methods in 2.01 to the **Project Athena** system and their extension to 13.10J, directed by Assistant Professor Dale G. Karr.
- (4) Enhancement of 13.021 using **Project Athena**, by Assistant Professor Dick K. Yue.

RESEARCH

The use of the oceans for the disposal of waste materials was taken for granted for decades. Now the United States prohibits most such practices, but land disposal presents major difficulties too: There are some who maintain that the land is the more fragile environment. And so research is accelerating on how and to what extent the oceans can be used for the disposal of sewage, industrial wastes, and radioactive wastes. It is important to conduct such research also to provide guidance on handling accidental spills in the ocean. The Ocean Engineering Department is prominently involved in such research on several fronts: (i) use of incinerator ships for disposal of chemical wastes (Associate Professor Henry S. Marcus), (ii) subseabed disposal of high-level nuclear wastes (also Professor Marcus), (iii) disposal of sewage sludge (Associate Professor Judith T. Kildow), (iv) clean-up of spilled oil and hazardous substances (Associate Professor Harilaos N. Psarftis and Professor J. D. Nyhart).

Early in the year, the Sohio Foundation announced the award of a grant of approximately \$2 million to MIT for the Ocean and Civil Engineering Departments to conduct a five-year program of research on

offshore structures with special emphasis on Arctic problems. The OE part of this program has concentrated on analyzing the failure modes of ice and predicting the interactions between an ice sheet and a platform structure. Professor Tomasz Wierzbicki and Associate Professor Paul C. Xirouchakis are conducting this investigation. Recently, Associate Professor J. Kim Vandiver started another project under the Sohio grant, investigating the dynamics of deep-water structures excited by waves and ice.

Professors Ira Dyer and Arthur B. Baggeroer and Associate Professor Peter N. Mikhalevsky have made another research expedition to the Arctic Ocean, this time as part of the Marginal Ice Zone Experiment (MIZEX). The "marginal ice zone" refers to that part of the Arctic Ocean that alternately freezes and thaws with the seasons; what happens in this region is believed to have major effects on the weather of the northern hemisphere, and it has great importance for defense and the nation's energy supply. The MIT team is concentrating on acoustics problems, including transmission through the nonhomogeneous water of the Arctic and through the upper (ice and/or free surface) and lower (seabottom) boundaries.

The MIT Sea Grant Program and companies in the offshore industry have organized a consortium to support research of broad concern to the industry. The first two major projects have now started, one on the dynamics of marine risers and one on the analysis and design of deep-water moored systems. The project directors are, respectively, Professor Chryssostomos Chryssostomidis and Associate Professor Michael S. Triantafyllou.

FACULTY

Professor Arthur B. Baggeroer was appointed MIT Chairman of the MIT/WHOI Joint Program Committee.

Professor David V. Burke, Jr., Capt, USN, has retired from the Navy and thus from MIT. He will join the staff of the Charles Stark Draper Laboratory in the summer.

Professor Ernst G. Frankel has been on leave this year, serving as Advisor on Ports, Shipping, and Aviation to the World Bank.

Captain Clarke Graham, USN, has been appointed Professor of Ocean Engineering and Head of Course XIII-A, effective 1 July 1984. Capt. Graham has been Adjunct Professor of Naval Architecture since 1977.

Dr. Dale G. Karr joined the faculty on 1 September 1983 as Assistant Professor of Ocean Engineering.

Dr. Peter N. Mikhalevsky joined the faculty on 15 January 1984 as Associate Professor of Ocean Engineering. The Acoustical Society of America announced this spring that Dr. Mikhalevsky is the winner of the ASA's Biennial Award, its highest honor for a young researcher.

Associate Professor Terrence L. Tinkel, Cdr, USN, has retired from the Navy and from MIT.

Associate Professor Robert J. Van Houten has resigned effective the end of this year.

Associate Professor J. Kim Vandiver has been named Director of the Experimental Study Group in the School of Science.

Lieutenant Commander W. David Whiddon, USN, has been appointed Associate Professor of Ocean Engineering and Academic Officer of Course XIII-A, effective 1 July 1984.

Dr. Tomasz Wierzbicki was appointed Professor of Applied Mechanics, effective 1 July 1983. He had been Visiting Professor in the Department since 1981.

Assistant Professor Dick K. Yue has been named Henry L. Doherty Professor of Ocean Utilization for two years starting 1 July 1984.

FACILITY CHANGES

The three project rooms used by students in Course XIII-A were completely renovated. Two of the rooms were subdivided into units for three or four students each. In all of the rooms, improved lighting and sound-absorbent materials were installed.

The Ship Model Shop was eliminated. The space was divided in two, one for a new welding laboratory and the other for student offices.

ROBERT BRUCE WALLACE ACADEMIC PRIZE

The fourth Robert Bruce Wallace Academic Prize, for the 1984-85 academic year, will be awarded to Mr. Kenneth Weems, Class of 1985. This prize was endowed by Albert H. and Marion W. Chatfield in memory of Mrs. Chatfield's father, Robert Bruce Wallace, Class of 1898, an alumnus of the Department and former President of the American Ship Building Company. The Prize is awarded to a student for demonstration of outstanding potential for success in ocean engineering, without regard to the student's financial need. The amount of the award covers tuition and modest living expenses for one academic year.

PUBLICATIONS

In the fall, the Department published Vol.1, No. 1 of the **Ocean Engineering Bulletin**, which is intended primarily as a means of communicating with alumni. The second issue was sent out in the spring. This is planned as a semi-annual publication.

An attractive brochure was produced early in the year, describing the opportunities in the field of ocean engineering and telling how MIT prepares young people for careers in the field.

T. FRANCIS OGILVIE

Artificial Intelligence Laboratory

The primary goal of the Artificial Intelligence Laboratory is to understand how computers can be made to exhibit intelligence. Two corollary goals are to make computers more useful and to understand certain aspects of human intelligence. Current research includes work on computer robotics and vision, expert systems, learning and common-sense reasoning, natural language understanding, and computer architecture.

Professor Patrick H. Winston works on the problem of learning from precedents. Professor Robert C. Berwick studies learning in the context of natural language syntax acquisition. Professor Marvin Minsky works on general theories of intelligence and knowledge representation. Dr. J. Michael Brady, Professor Berthold K. P. Horn, Professor Tomaso Poggio, and Professor Shimon Ullman head efforts in computer vision. Professor John M. Hollerbach, Professor Tomás Lozano-Pérez, Professor Warren Seering, Dr. J. Kenneth Salisbury, and their staff work on other aspects of Robotics. Professor Thomas F. Knight and Professor Gerald J. Sussman work on the problems of integrated circuit design. Professor Knight also explores the development of the Cross-Omega Connection Machine, a special-purpose machine for concurrently manipulating knowledge stored in semantic nets. Professor Randall Davis and Dr. Howard E. Shrobe work on expert systems that use functional and physical models. Dr. Charles Rich and Dr. Richard C. Waters explore the creation of intelligent programming environments. Professor Carl E. Hewitt, Dr. Gerald R. Barber, and their staff study distributed problem-solving and parallel computation.

The Laboratory's 155 members include 13 faculty members, 10 academic staff, 55 research and support staff, and 75 graduate students active in research activities funded by the Defense Advanced Research Projects Agency, System Development Foundation, Office of Naval Research, Air Force Office of Sponsored Research, National Science Foundation, Atari, Digital Equipment Corporation, International Business Machines, Martin Marietta, Bendix, and NL Industries, Inc.

ROBOTICS

Professor Lozano-Pérez's interests include the development of algorithms for space planning in Robotics. Professor Lozano-Pérez and Bruce R. Donald extended previous work on motion planning and collision avoidance for robots with six degrees of motion freedom. Mr. Donald developed and tested an algorithm for planning collision-free motions of complex polyhedral objects among obstacles. This motion planning system is the first program able to plan motions involving the three rotational degrees of freedom of a moving object, as well as the three translational degrees of freedom.

Professor Lozano-Pérez and Michael Erdmann, in conjunction with Professor Matthew T. Mason of Carnegie-Mellon University and Dr. Russell H. Taylor of IBM, developed a method for automatically planning compliant motions for robots to perform mechanical assembly. Joseph L. Jones and Patrick A. O'Donnell implemented a compliant motion capability for one of the Laboratory's commercial manipulators, which allows the planned compliant motions to be tested. Work on planning compliant motions, together with that on obstacle avoidance, is part of a continuing effort to achieve the automatic synthesis of robot programs from high-level task specifications.

Professor Lozano-Pérez and Dr. W. Eric L. Grimson have been developing a system capable of recognizing objects using polyhedral models of known objects and three-dimensional information about the position and surface orientation of a few points. Their system determines which of a set of known objects is being sensed and what the object's orientation must be. This system can recognize objects based on data obtained from stereo vision, laser ranging, or tactile sensing. Michael Drumheller extended the system to determine the position of a mobile robot in a known environment using data from an ultrasonic range sensor.

Professor Hollerbach's research involves the development of efficient algorithms for kinematics, dynamics, and trajectory planning in Robotics. The determination of the minimal time path between two points, given actuator constraints, has been a long-standing problem in manipulator trajectory planning. Gideon Sahar and Professor Hollerbach developed a solution that involves graph search, whose nodes are obtained by a tessellation of joint-space positions and velocities and whose arcs are the minimum movement times between adjacent nodes. The

minimum movement times are obtained by application of a general time-scaling formulation of manipulator dynamics developed by Professor Hollerbach.

Professor Hollerbach feels that future manipulators will be redundant, with seven or more degrees of freedom. These manipulators will have an increased ability to avoid obstacles, and their designs will eliminate the problem of internal singularities. Professor Hollerbach examined possible configurations for seven degrees-of-freedom rotary manipulators and proposed a design based on a balanced consideration of internal singularities, improved workspace, and mechanical feasibility. With Ki Choon Suh, Professor Hollerbach developed a control algorithm for redundant arms that resolves the redundancy by minimizing the torque loading at the weaker joints. The method involves the use of generalized inverses for accelerations, rather than the common formulation of generalized inverses for velocities, and the substitution of these accelerations into the inverse dynamics.

Many control algorithms developed in robotics research laboratories remain untested because current industrial robots are not useful in research-oriented situations. For example, current industrial robots are unable to control torques because of controller design and gearing-related problems, because they are slow, and because they have low payload capability. After designing and constructing the appropriate electronic interfaces, Professor Hollerbach and Mr. Suh installed a working version of the direct-drive arm developed by Professor Haruhiko Asada of the Mechanical Engineering Department. Because the gearless design of the Asada arm reduces friction and eliminates backlash, this arm provides a unique testbed for various control algorithms.

Advanced control algorithms in Robotics must adapt to changing conditions. For example, when picking up a load, the control algorithm must first identify the characteristics of the new load. Working with a wrist force-sensor on a PUMA robot, Christopher G. Atkeson, Chae Hun An, and Professor Hollerbach are investigating the problem of identifying new load characteristics using the Newton-Euler equations as the basis for relating force readings to velocities and accelerations derived from joint angle readings. They are using system-identification techniques to derive load mass, center of gravity, and moments of inertia.

Professor Hollerbach continued to collaborate with Professor Steven Jacobsen and Professor John Wood of the University of Utah on the design and control of a four-fingered, tendon-driven hand with built-in sensors. To control the hand, David M. Siegel, Sundar Narasimhan, and Professor Hollerbach are designing and constructing a multiprocessor system based on the Motorola 68000 and the multibus, where each finger and its eight tendons are controlled by one microprocessor. The sensory input to each microprocessor consists of four joint angles, tendon forces, and tactile/force arrays based on fiber optics. There is an overall finger-coordination microprocessor. A VAX 11/750 handles higher-level planning and control.

Ignacio H. Garabieta, Mr. Siegel, and Professor Hollerbach are designing large-array tactile sensors based on capacitance sensors. The arrays are defined by conductive strips screened onto thin rubber sheets, and a special electronic circuit detects capacitance change due to decreased distance between conductive strips from pressure deformation. Because of their thermal conductivity differences, temperature sensing is an efficient way to distinguish materials. Seeking a way to combine temperature sensing with tactile sensing, Mr. Siegel investigated resistance or capacitance changes with temperature as a way of combining temperature sensing with tactile sensing. Nathaniel I. Durlach of the Research Laboratory of Electronics and Professor Hollerbach are conducting a series of psychophysical studies on human haptic perception.

Ronald Fearing and Professor Hollerbach theoretically analyzed the extraction of features from a soft tactile sensor. A continuum mechanics modelling of pressure-sensitive elements embedded in an elastic medium indicates the feasibility of extracting force angle and magnitude and of basic shape discrimination between edges and planes. Fingerprints were conjectured to serve as stress concentrators. Mr. Fearing also examined grip stability for two-fingered grasping of planar objects without feedback or knowledge of exact object position or shape. Extending research done by Professor Mason, Mr. Fearing showed how geometry and friction can interact to yield a stable grasp; simple forms of object reorientation such as pencil twirling can be accomplished using the results.

Professor Hollerbach and Mr. Atkeson have analyzed planar two-link arm trajectories to investigate the question of whether human movements are planned in external Cartesian space or in joint space. Joint-interpolated trajectories were shown to be well described by a class of polar coordinate curves, the n -leaved rose, which is inherently curved and readily distinguishable from Cartesian straight-line trajectories. The literature in support of joint-space planning claims that joint-rate ratios can be constant despite evident straight-line trajectories. However, near the boundaries of the workspace to which these results apply all trajectories can be shown to approach the same joint-

rate ratio, so that these results are shown to be artifacts of kinematics. Professor Hollerbach and Mr. Atkeson continue their analysis of Selspot data to determine why trajectories in certain parts of the workspace are curved rather than straight.

Dr. Salisbury's research concerns the design and control of articulated hands. Dr. Salisbury plans to increase the dexterity and adaptability of robots by understanding the basic mechanics of manipulation with multiple degrees-of-freedom end effectors. He implemented several experimental control systems for coordinating the tendons and fingers of the Stanford/JPL hand, which he designed. High-quality position, force, and stiffness control has been achieved.

A second area of Dr. Salisbury's investigation centers on the design of sensors for augmenting articulated hand manipulation. Prototypes of several robust strain-gauge sensor systems have been built and tested by David L. Brock. One sensor is planar and will be used as a palm surface. A second sensor, spherical in shape, is being miniaturized for use as fingertips. Both sensors can determine accurately the location and exterior shape of contacts as well as their orientation. The sensors have the advantage of using a minimum number of sensing elements. Software for identifying and modelling the complex finger system dynamics, developed by Stephen L. Chiu, is being used to improve the performance of the hand. One result of this will be better positioning accuracy and better stiffness control.

Dr. Salisbury is making significant progress toward the development of a LISP-based user environment for effecting and interpreting motions of the hand. This environment, in conjunction with the fingertip sensors, will enable Dr. Salisbury to implement the object recognition algorithms developed by Professor Lozano-Pérez and Dr. Grimson as well as other grasp and task-related functions. Dr. Salisbury, with assistance from Mr. Brock and Mr. Chiu, is developing a three degree-of-freedom wrist and forearm to interface the Stanford/JPL hand to the direct drive Asada arm, to address the issues of hand/arm coordination.

Professor Warren Seering and his students concentrate their efforts on developing methods for utilizing advanced computational capability to enhance the performance of robots. One project involves the design of a controller network which will optimally process input from sensors for use in robot control. A second project involves the creation of models of robot dynamic performance including resonant phenomena and design of control algorithms which will interact with such models in real time to maximize system performance.

Professor Seering's students are also involved with the design of alternatives to conventional manipulators. They have designed an air-powered robot and manipulators of two, three, and four degrees-of-freedom as well as a very precise six-axis system. Several students are working on design of cooperating sets of robots.

Professor Horn and his staff work in the area of computer vision, studying the appropriate representation of objects. The extended Gaussian image provides a new way of encoding the shape of an object. For example, the extended Gaussian image of a closed surface has been shown to have interesting mathematical properties: it is unique, and its center of mass has to be at the origin of the unit sphere. The surface normal information used to construct an orientation histogram, the discrete approximation of the extended Gaussian image, may be obtained from multiple images obtained using different lighting conditions, a method called photometric stereo. It depends on solutions of the image irradiance equation, given multiple constraints. In practice, the solution is encoded in a lookup table.

Similar information is obtained from a laser scanning system designed by Dr. Philippe Brou, who has investigated the appropriate representation of rotations to make the search for the correct attitude efficient. Rotations, like displacement, have three degrees-of-freedom, but there is no obviously best method for representing it. Of the eight or so well-known approaches, only one method, that using unit quaternions, leads to a metric on the space of rotations. The problem of even rotation sampling then becomes one of placing points evenly on a unit sphere in four-dimensional space. For efficient generation of these points, the subgroup and co-set structure of the group of rotations must be explored. Dr. Brou is improving the accuracy of the laser scanning system with the addition of computer-controlled mirror deflectors, eliminating the use of the XY table. The CAD system used to represent objects for the vision algorithms has been expanded to include surfaces of revolution and generalized cylinders. Research to generate CAD models directly from laser data continues.

In another area, Shahriar Negahdaripour is exploring the use of moving images for determining the motion of an observer as well as the shapes of surfaces in the environment. Previous work by Dr. Brian G. Schunck and Dr. Anna Bruss accomplished this by exploiting the optical flow, an intermediate representation of the changes taking

place in the image. Professor Horn and Mr. Negahdaripour are developing mathematical techniques to bypass this intermediate step.

Dr. Brady and his staff continue to develop a new shape representation called smoothed local symmetries. Haruo Asada and Dr. Brady implemented a fast algorithm that first locates significant features on the shape's boundary using a process analogous to edge finding, then fits an approximation to the boundary, from which the smoothed local symmetries are computed. Scott S. Heide and Dr. Brady developed an algorithm to find symbolic descriptions of the smoothed local symmetries of a shape and to classify the symmetries for matching against models to perform recognition. Using local-symmetry descriptions, Steven C. Bagley implemented a model-based system for recognizing articulated two-dimensional parts that may be occluded or damaged.

The shapes of objects, particularly tools and parts used in assembly tasks, are related to their uses. Jonathan H. Connell is developing an interface between the smoothed local symmetry representation and the semantic network representation implemented by Professor Winston and his colleagues. David J. Braunegg is developing an algorithm that uses the shape representation to infer disassembly sequences.

Dr. Brady, Alan L. Yuille and Jean Ponce developed algorithms that compute symbolic descriptions of three-dimensional surfaces computed from range data supplied by a system developed by Dr. Brou. The algorithms adapt the program developed by Dr. Brady and Mr. Asada to characterize surface intersections. Dr. Brady and Dr. Yuille proved a theorem relating the surface representation to a volumetric representation advocated by the late Professor David C. Marr.

Dr. Brady and Professor Richard P. Paul of Purdue University co-chaired the First International Symposium of Robotics Research, hosted by the Artificial Intelligence Laboratory and organized by Karen A. Prendergast. Fifty of the world's leading researchers in computer vision and robotics participated in the week-long symposium.

Professor Poggio, Professor Ullman, and their associates are developing a theory of computational vision intended to shed light on both biological and machine vision. The theoretical understanding of vision and machine application can benefit from the study of human vision because biological visual systems provide the best-known examples of efficient visual processors. Problems studied include edge detection, spatio-temporal interpolations, stereo, motion, surface reconstruction, multigrid algorithms, computation of spatial properties, intelligent signal processing and biophysics of computational systems.

Professor Poggio and Professor Vincent Torre of the University of Genoa analyzed theoretically the problem of edge detection. Dr. Yuille is continuing the work by studying and exploiting the properties of multiresolution representation of the image. The associated techniques promise to provide a much-needed bridge between raw sensory signals and symbols.

Professor Poggio is developing a new theoretical framework that promises to unify several results in the analysis of early vision problems and to indicate how to approach other problems in early vision. The approach is based on the recognition that most problems in early vision are mathematically ill-posed problems and can be solved by exploiting the rigorous regularization methods developed by mathematicians in recent years.

The approach provides a formal justification for the use of variational principles of a specific type to solve early vision problems. Professor Poggio, Professor Torre, Dr. Yuille, and Harry L. Voorhees are applying regularization analysis to several problems in early vision such as stereo matching, structure-from-motion, and edge detection.

Unconventional analog computational machines for solving variational problems of this type are also being explored by Dr. Christof Koch and Professor Poggio. This work is closely connected to the area of biophysics of computational systems, a new theoretical approach aimed to understand the computational mechanisms used by nervous systems. The work being carried out by Professor Poggio, Dr. Koch, and others has already shown that single neurons are likely to be very highly parallel devices performing hundreds of independent analog operations on their inputs.

The problem of stereo vision continues to be an important focus of research. Dr. H. Keith Nishihara investigated the implications of noise and other practical performance considerations for stereo matching. He developed a real-time stereo matcher for robotic applications using special hardware designed by him and by Noble G. Larson. Michael H. Kass and Professor Poggio are developing a new matching scheme for solving the correspondence problem of stereo

and motion. Dr. Yuille and Professor Poggio are exploring constraints on the stereo matching from the perspective geometry of the imaging process and are implementing their results in a new stereo vision system.

The measurement of the optical flow—the field of velocities in the image—is another important visual task. Dr. Ellen C. Hildreth developed and analyzed a method for computing the velocity field along contours in the image from the projection of arbitrary three-dimensional surfaces moving freely in space and deforming over time. Dr. Hildreth also explored the problem of detecting discontinuities in the optical flow. This is a critical operation for separating figure from ground and for segmenting the changing image into separate objects.

The entire Computer Vision group is working closely with the Cross-Omega Connection Machine group in the exciting project of exploiting the new parallel architecture of the Cross-Omega Connection Machine to perform sophisticated image interpretation in real time.

LANGUAGE AND LEARNING

During the past year, Professor Berwick implemented and tested a program that can acquire the meanings of new words as a network of causal relationships in a small database of story plots. Preliminary work is in progress on linking the word-learning program to the existing syntax-learning program.

New representational formats for grammars were investigated so that previously difficult constructions using conjunctions like *and* can be easily handled. This analysis does not use conventional syntactic trees, but rather relies on set representations. This new representation may solve many of the remaining computationally difficult problems in the syntactic analysis of natural language.

During the past year, Professor Berwick, with Amy Weinberg, published *The Grammatical Basis of Linguistic Performance*, MIT Press, Cambridge, MA, 1984.

Professor Winston's theory of reasoning by analogy consists of the following parts: an English-understanding module, developed by Boris Katz, that converts prepared text into relations in a semantic network; a cause-dominated matcher that finds the best possible correspondences according to the causal framework determined by the situations themselves; an analogizing module that reaches conclusions about a given situation by using a remembered precedent; and a rule builder that constructs if-then rules. Professor Winston extended the theory to the problem of learning what things look like from functional definitions, prior knowledge, and particular examples.

Another dimension of the work involves a learning program, under development by Richard J. Doyle, that constructs behavioral descriptions of simple physical systems. Given a structural description, some background knowledge, and a list of actions which can be performed, the program, via examples, analogies, and experiments, identifies quantities in the system, associates them with physical objects, and identifies causal relations between quantities using such heuristics as temporal adjacency and physical connectedness. The learned description is then used to predict the behavior of the physical system.

During the past year, Professor Winston published three books: *Artificial Intelligence*, second edition, Addison-Wesley Publishing Company, Reading, MA, 1984; *LISP*, second edition, with Berthold K. P. Horn, Addison-Wesley Publishing Co., Reading, MA, 1984; and *The AI Business: The Commercial Uses of Artificial Intelligence*, with Karen A. Prendergast, MIT Press, Cambridge, MA, 1984.

COMMON-SENSE REASONING

Kenneth D. Forbus' work concerns common-sense reasoning about the physical world. He developed Qualitative Process theory to model how changes occur in physical systems. Many important physical phenomena, such as heating, boiling, moving, and breaking, can be represented as processes. The theory includes a qualitative representation of quantities, called the Quantity Space, that allows many useful conclusions to be drawn without detailed numerical information. Qualitative Process theory provides techniques for reasoning about when processes occur, what changes they cause, and how the processes themselves change. During the past year, Mr. Forbus constructed a program that uses Qualitative Process theory to make predictions about the possible behaviors of physical systems. He tested this program on simple models of fluids and motion, and is currently developing more

sophisticated models for these two domains. The goal is to develop models that can be used for reasoning about complex engineered systems, such as power plants.

David A. McAllester produced a reasoning utility package that is now in use in Mr. Forbus' project, in Dr. Rich and Dr. Waters' Programmer's Apprentice Project, and in several other projects at MIT and elsewhere. The package has programs for doing simple deductions, recording justifications, tracking down assumptions, and performing modifications as premises are changed. Mr. McAllester is working on theoretical issues concerning the ontologies used by mathematicians and engineers with a view toward building still more effective reasoning packages.

John Batali is developing a computational theory of practical reasoning. An important observation guiding the research is that the problem of determining the right thing to do is itself a situation for which an appropriate action must be found. A theory of practical reasoning therefore must account for the actions taken to solve a problem as well as the actions taken to determine how to solve the problem. A single representation for programs, situations, plans, histories, and the process of deliberation is under development. This representation will be used to describe the goals and abilities of a rational agent and the progress of such an agent as it constructs and executes plans.

An important way that Mr. Batali's system will determine its actions will be by comparing its current situation with previous problem situations and attempting to find a solution similar to one that worked before. The system will also have the ability to compile common problem solving strategies into programs that can be executed without further deliberation. In fact, most of the time the system will be executing pre-compiled code fragments. Only when the situation is especially difficult or novel will the system have to carefully deliberate about its actions.

Kenneth W. Haase is working on computer systems which demonstrate expertise in multiple domains. These systems, called eclectic problem solvers, use a variety of methodologies and representations to function in different domains. Unlike most systems, which typically are limited to a single approach in a single domain, the eclectic problem solver moves from approach to approach and domain to domain as it comes across new problems or new situations. The development of an eclectic problem solver draws on the large body of existing reasoning technology and tries to build a unified framework for describing and implementing these proven techniques and methodologies in a single program.

INTELLIGENT APPRENTICES

Professor Davis' work is focused in two main areas: model-based expert systems and the application of Artificial Intelligence to signal processing.

Professor Davis, Dr. Shrobe, and their associates are building an expert system that uses knowledge about structure, function, and causality to diagnose faults in digital electronic hardware. Previous expert systems have typically been built from large collections of empirical associations. This work relies instead on a detailed model of the structure and function of the device under test, allowing it to reason about how the device works, and how it fails, in a manner similar to an experienced engineer.

Building and using such a model represents an important advance in the art of expert systems construction, since it provides the system with a more fundamental understanding of the device than is possible using the traditional approach. While the current work is aimed at computer diagnosis because of its familiarity and the significance of the problem, the larger concern is that of reasoning about devices in general, understanding how they work and how they fail.

The work has explored multiple uses of descriptions of structure and behavior. These descriptions are used for candidate generation (determining which components of a circuit can account for observed malfunction), test generation (designing tests to distinguish between candidates), and diagnostic generation (designing a comprehensive collection of tests that verify correct device operation), on a collection of faults ranging from simple stick-ats to bridges and assembly errors.

A second component of Professor Davis' expert systems work is a project with Reid G. Simmons on reasoning about geologic processes. This was inspired by earlier, traditional expert system work on a program for analyzing

measurements taken on oil wells. The current effort is aimed at developing a program that understands and is capable of reasoning about geologic processes responsible for formations and deposits.

Professor Davis also collaborates with Professor Alan V. Oppenheim in exploring connections between Artificial Intelligence and digital signal processing, in the belief that techniques developed in both areas can be modified and combined to produce improved signal interpretation and signal enhancement systems. Two current foci are pitch detection and signal enhancement.

Dr. Rich and Dr. Waters study how expert programmers analyze, synthesize, modify, explain, verify, and document programs. A long-term goal of this research is to develop tools that automate the programming process. Recognizing that total automation is not close, they are developing a system, the Programmer's Apprentice, which acts as an intelligent assistant to an expert programmer. The Programmer's Apprentice will begin by automating the more routine, straightforward parts of the programming task, leaving more of the programmer's attention free to concentrate on the difficult decisions.

Over the past year, Dr. Waters implemented a major new scenario using the Knowledge-Based Editor in Emacs (KBEmacs) to demonstrate the feasibility of the Programmer's Apprentice concept applied to the area of program editing. This scenario is a significant step forward in several respects. First, the programs constructed in this scenario are significantly larger and more complex than those in earlier scenarios (50 to 100 lines long as opposed to 10 lines long). Also in this scenario, the Knowledge-Based Editor has been closely integrated with the Emacs-type program editor in the Laboratory's LISP Machine programming environment. As a result of this integration, the programmer can intermix ordinary text and parse-tree editing commands with knowledge-based editing commands, using whichever is more convenient at a given point. Finally, this scenario includes programs written both in LISP and ADA, demonstrating the programming-language independence of the basic Programmer's Apprentice technology.

Dr. Rich began implementation of the new reasoning system, called Cake, which will form the basis of the next phase of development of the Programmer's Apprentice. This new reasoning system builds on earlier work by Mr. McAllester and other Laboratory members on general-purpose logical inference methods. Specifically, the Cake system uses Mr. McAllester's implementation of algorithms for incremental congruence closure, unit propositional resolution, and belief maintenance. To these facilities, Dr. Rich has first added a layer of special-purpose decision procedures for common algebraic properties of functions and relations. On top of this, he is implementing a third layer of procedures operating on a flowchart-like representation of program structures, called the Plan Calculus, specially developed for the Programmer's Apprentice.

In addition to this implementation work, Dr. Rich, Dr. Waters, and their graduate students began or completed studies on a number of related theoretical topics including: new methods of program specification and documentation, formalizing reusable software components, automated knowledge acquisition (of program requirements and of program implementation knowledge), computer-aided programming instruction, efficient compilation of programs operating on sequences of data, flexible display in a structure editor, and an efficient algorithm for parsing flow graphs.

EXPERT SYSTEMS FOR ELECTRONIC DESIGN

Professor Gerald J. Sussman and his associates have made considerable progress in their research into techniques and tools for very large scale integrated circuit (VLSI) design.

In one project, Gerald L. Roylance is working on a compiler for circuits. A circuit compiler is similar to a programming language compiler except that instead of compiling an abstract language to a concrete machine language, it compiles an abstract circuit design to a concrete one consisting of resistors, capacitors, and transistors. For example, an analog circuit design might use an abstract amplifier; the compiler might transform that amplifier into a transistor cascade circuit. In order to do this transformation, the circuit compiler must understand how the parts of the original circuit specification interact to constrain each other. These constraints are found by constraint propagation, a well-established technique. While analog circuit design is the domain of the Roylance compiler effort, the ideas about building circuits also apply to VLSI design, digital logic design, and other engineering domains such as numerical programming.

In another effort, Daniel Weise designed and is implementing a system for the verification of VLSI designs. The system accepts a schematic of a circuit and specification of the circuit's intended functional and temporal behaviors. It then either reports a successful match between actual and specified behaviors or informs the designer why the match failed. This system is the first to model transistors and busses realistically.

A special-purpose silicon compiler, developed by Philip E. Agre, has been important to the development of the SCHEME chip, a VLSI device for running SCHEME, a dialect of the LISP programming language. Given a small program definition, Mr. Agre's compiler produces code specifying the layout of a SCHEME-compatible chip to implement that function. The compiler uses traditional techniques and some novel heuristic methods to reason about the tradeoffs involved in writing highly parallel microcode.

Jonathan D. Taft constructed a prototype SCHEME chip evaluation system. It uses a small 36 bit backplane to provide memory support for a computer system centered around a SCHEME chip. It also includes extensive diagnostic testing hardware and a front-end interface to a host computer, currently a LISP Machine. This system has been used to diagnose problems with fabricated SCHEME chips and to run them in an initial cold environment.

Andrew A. Berlin completed the design of a silicon chip which performs a two-dimensional Gaussian convolution using a successive averaging technique. His design is in fabrication.

Finally, in the analog domain, Dr. Andrew L. Ressler completed work on an expert program that designs operational amplifiers. Dr. Ressler's program works from a set of specifications similar to specifications found on operational amplifier data sheets. From these specifications, it designs an operational amplifier using a circuit grammar and a collection of rules. The circuit grammar describes a space of reasonable operational amplifier topologies, and the collection of rules describes how to expand the top level objects in the grammar consistently with the specifications.

MUSIC COGNITION GROUP

Professor Minsky's Music Cognition Group investigates the cognitive foundations of musical behavior using the methods of Artificial Intelligence. The general objective is to extract and represent expert knowledge about music by building computational models of the cognitive processes involved in composing, performing, and listening. Currently, the group's activities are concentrated in two areas: the automated composition of music in well-understood historical styles and the analysis of improvised keyboard music. These efforts provide a focus for research in musical learning, problem solving, reasoning, and knowledge representation.

John Amuedo developed a new algorithm for separating superimposed quasi-periodic signals. The method fits a model of almost-harmonically-related sinusoids to the set of peaks found in the short-time magnitude spectrum of an acoustic signal. Each peak is allowed to assert a number of hypotheses about possible sources to which it may be related. The hypotheses from different peaks are combined in such a way that hypotheses common to several peaks are reinforced. The method produces estimates of the number of sources present in each frame of signal, the periodicity of each source, and the energy of signal components believed to be related to the same source. Estimates from nearby frames are combined to synthesize a filter which can track, enhance, or remove a desired source or signal component. The algorithm has been used to separate as many as four almost-periodic signals in the presence of additive noise.

David A. Levitt models musical expertise in several styles of jazz piano. His goal is to show how left-hand patterns and melodic elaborations are learned from increasingly complex examples. In an early project, Mr. Levitt's IMPROVISOR program assembled musicians' commonsense structural descriptions of a tune and used them to construct original improvisations that satisfy jazz harmony and other constraints. He is currently working on ways to incorporate diverse stylistic knowledge into a growing expert system for assisting composition and analysis.

David M. J. Saslav is developing a program that generates a *basso continuo* style accompaniment from the harmonic analysis of a supplied chord progression. A correct *basso continuo* accompaniment must satisfy a number of rules governing voice-leading and doubling, as well as constraints pertaining to the contour, range, and texture of each

part. One of the objectives of this work is to discover rule forms and derivation strategies which can generate musical examples satisfying a number of concurrent subgoals. Mr. Saslav also developed a parser for the Pistonian harmonic notation, which is being used to compile a database of harmonic progressions.

Henry Minsky demonstrated an algorithm for following the score of a keyboard performance while the performance is in progress. The player annotates a graphical record of a past performance, indicating how instruments are to be assigned to parts of the score. The player then performs the piece on a keyboard attached to a computer, while the program supplies the orchestration. The program matches the stream of events coming from the keyboard against the annotated score to determine how individual notes will be assigned to instruments of a computer-controlled synthesizer. The algorithm enables a performer to control a number of synthetic instruments from the same keyboard input device.

Christopher M. Fry is developing a language for representing the score generation process as a network of phrase processing elements. These objects generate, modify, and combine score fragments represented as musical event streams. The elements share a common communications protocol, so musical transformations can be described and combined in flexible ways. The language is being used to test new methods of score generation utilizing object-oriented programming techniques.

INTELLIGENT SUPERCOMPUTING

The Cross-Omega Connection Machine is a computer that performs fast, parallel searches through networks, a fundamental, rate-limiting step in many problem-solving programs. Led by Professor Knight, work on this machine is a major effort.

During the past year a prototype machine was designed and a packaging scheme was selected, implementation of prototype hardware begun. Because the design requires parts to be duplicated in great numbers, yield, testing, packaging, and reliability are receiving careful attention. The large scale of the project forces the development of new methodologies and design tools.

Alan Bawden utilized applicable parts of conventional compiler technology to implement a prototype language for programming massively parallel machines such as the Cross-Omega Connection Machine. The resulting language is still simple, but serves as a convenient basis for extension languages that support higher-level models of the Connection Memory Machine.

Initial experiments with this language revealed common Cross-Omega Connection Memory Machine programming practices and principles that will help to design future languages. Mr. Bawden is working on a successor to this prototype language whose compiler will have a better understanding of synchronization techniques so as to relieve the programmer of some of the burden of dealing with synchronization himself.

Another approach to creating parallel systems is that of Professor Hewitt and his associates. They have developed ACTOR theory, a rigorous abstract theory of parallel systems, that provides a foundation for the construction and analysis of highly parallel problem-solving systems and the APIARY architecture for parallel artificial intelligence systems. In the past year, Jonathan B. Amsterdam developed and implemented improved algorithms for migration and load balancing. Thomas J. Reinhardt upgraded the ACT3 systems-level parallel programming language, a language system that provides a unified basis for both description and action, to incorporate capabilities needed for parallel processing. Mr. Reinhardt also designed a compiler for ACT3 in order to bring the language up to the point where it can support parallel Artificial Intelligence applications.

Elijah Millgram and Chun Ka Mui completed the design and preliminary implementation of a debugging system for the APIARY. Their work was extended by Carl R. Manning and Mark McEntree in delimiting and reverting transactions. Peter de Jong reworked the SCRIPTER system to increase its efficiency and robustness. Making use of a natural language system developed by Mr. Katz, Mr. de Jong developed a preliminary version of a natural language interface for our parallel description system. Mr. de Jong developed some exciting new ideas for synergistically combining architectural ideas of the scientific community metaphor and cognitive science models.

Henry Lieberman designed and partially implemented a new interactive stepper for LISP. James Cerrato extended the design to apply for parallelism so that it can be used for ACT3.

PATRICK HENRY WINSTON

Center for Advanced Engineering Study

The rapid pace of technological advance and accelerated international competition have increased general interest in continuing education for engineers. The Center attempts to serve the needs of practicing engineers in four different ways:

- . The Advanced Study Program--under which engineers in professional practice, teaching or technical management come to the Center for a semester or a year of individualized study.
- . The Video Course Program--which through over 1000 videotaped lectures brings technical information to approximately 50,000 technical people each year.
- . The Conference and Seminar Program--which develops short courses, workshops, and seminars for practicing engineers to study subjects intensively for short periods of time.
- . Through integrated offerings of the Center in which all three portions of the Center participate by focussing their efforts on a particular problem of interest to industry.

Advanced Study Program

This is an on-campus program that enables engineers and scientists to work in depth in technological areas of their choice. The program serves technical managers who wish to understand developments that bear directly on their problems, men and women who seek competence in depth at technological frontiers, and those who desire to strengthen their technological base. This year there were 64 Fellows from 17 countries. The Advanced Study Program (ASP) is directed by Dr. Paul E. Brown.

Fellows of the program are affiliated with the Center for one or more terms. They may develop courses of study to meet their individual needs or may participate in specialized programs. Included in ASP are several specialized programs such as Air Transportation, Systems Reliability and Risk Analysis, Quality and Productivity, Communications Technology and Policy, and Design and Manufacturing Automation and Control, as well as the Visiting Engineer Program. The Visiting Engineer Program is similar to ASP except that the emphasis is on participation as colleagues in research with faculty members.

The programs coincide with the normal academic terms and year. Special weekly seminars are planned and conducted during the fall and spring terms especially for Fellows of ASP and participants in the Visiting Engineer Program. Each term several special subjects of broad interdisciplinary interest are also offered within the Center for participants in the programs.

Grades are recorded for all MIT subjects taken for credit. A certificate is awarded following satisfactory completion of a Program. Fellows also may apply for admission to the MIT Graduate School.

Video Course Program

Introduction to VLSI Design by Professor Jonathan Allen; a revision of Artificial Intelligence by Professors Davis, Horn, and Winston; Advanced Tribology by Professor Ernest Rabinowicz; and Action Plans for Implementing Quality and Productivity by Professor Myron Tribus were all published and received immediate and enthusiastic acceptance by American industry, reaching thousands of new learners.

The further development of vertical, video-based curriculums in all engineering disciplines is well underway. Completion is scheduled for fiscal 1989. The existing library of 1000 videotapes will be increased to 1500. We expect to be reaching over 100 thousand learners at a distance annually by the end of the decade. The Video Course Program is under the direction of Richard J. Noyes.

Conference and Seminars Program

The Conference and Seminar Office was established in 1977 to provide professional and logistical support for the growing number of technical continuing education conferences, seminars, and noncredit short courses at MIT. While the majority of programs offered through the Seminar Office originate in the College of Engineering, the Seminar Office is prepared to handle continuing education programs from any area of science and technology and is designed to manage these programs on and off campus -- in the United States and throughout the world. The Seminar Office has received the approval of both the Engineering Council and the Academic Council as a recognized office of continuing education at MIT.

The Conference and Seminar Office manages every aspect of the program from concept through post-meeting evaluation. This includes program development, marketing, logistics and financial management. This professional attention has resulted in a yearly increase in programs with a substantial rise expected in 1985. People from more than 48 states and 34 countries have participated in the continuing education offerings from the Seminar Office.

The heavy demand for continuing education offerings has resulted in a growing number of programs at MIT. Some of the 1983-84 programs included: "Finite Element Theory and Practice" sponsored by the Department of Mechanical Engineering; "Thermal-Hydraulic Design and Safety for Light Water Reactors" sponsored by the Department of Nuclear Engineering; "The Special Studies Program in Transportation", a series of meetings sponsored by the Center for Transportation Studies; "Managing Systems of People and Machines for Quality and Productivity" sponsored by the Center for Advanced Engineering Study; and "Methods for Nonlinear Finite Element Analysis" sponsored by the Department of Mechanical Engineering. The Conference and Seminars Program is directed by Christine Simonsen.

Integrated Offerings by the Center

For the last two years the Center has focussed its efforts on helping industry to increase quality and productivity in domestic and international commerce. This work has involved all aspects of the Center and has required the Director and Associate Director to develop programs which cut across the Center.

The tapes of W. Edwards Deming have been augmented by new tapes on statistical methods, case histories, and how to institute activities and manage according to "Deming's Way".

Several Conferences and Seminars have been held in different parts of the country, in which the Director and associate Director, Dr. Deming and representatives of industry made presentations and led discussions of Quality and Productivity improvement.

The Advanced Study Program developed a special program on quality and productivity and solicited nominees from American industry.

A subject, "Managing Systems of People and Machines for Quality and Productivity" was introduced (with joint sponsorship from Mechanical Engineering). The subject will be repeated in 1984 with participation by a member of the Sloan School of Management.

A group of representatives from industry and academia was assembled to initiate a new national activity, The American Quality and Productivity Institute (AQPI). AQPI maintains a network of interested quality and productivity experts via the MIT Multics system. Linkages with the American Society for Quality Control, the American Statistical Association and other professional groups, as well as "user groups" in Lawrence, MA, in Long Beach, CA, in Philadelphia, PA and in other geographic regions are being developed.

Small invitational meetings are planned to develop ideas for new programs that would help industry to increase quality and productivity.

Although AQPI contributes to the strength of MIT's program, today and in the near future, by bringing to the Center many people from industry who would not otherwise come, in the long term it is planned that AQPI will become an independent organization and the Center will move on to other topics around which to mobilize the resources of the Center and the institute.

MYRON TRIBUS

Center for Policy Alternatives

The Center for Policy Alternatives (CPA) is dedicated to both research and education in science and technology policy. Professor Nicholas A. Ashford serves as Director of the Center. Since its founding in 1972, CPA has been presenting alternative courses of action to government, industry, labor, and educational institutions that are addressing complex socio-technical problems. CPA has been concerned with both industrial innovation -- the way new technology is developed and introduced -- and with technology's effects on society.

CPA's objectives are to identify and study important emerging social issues in which science, technology and engineering play a significant role, to assess the consequences of established institutional policies and develop alternatives available to decision makers, and to provide faculty, research staff, and students with research and training opportunities in policy formulation and analysis. The Center especially welcomes the participation of faculty, students, and staff from other departments, centers, and laboratories in joint research efforts. This year CPA has formalized a group of affiliated faculty who are working with the Center to develop research areas of mutual interests.

CPA faculty and staff are active participants in the Technology and Policy Program (TPP) in the School of Engineering. Last year the Center took major steps to strengthen its association with the TPP program by the initiation of an informal seminar series jointly sponsored by CPA and TPP, the provision of research space and supervision of a substantial number of TPP students at CPA and the commitment of research funds to support research assistance sufficiently in advance of their entrance in order to attract them to the program.

The CPA approach to policy analysis is multidisciplinary, involving specialists from a wide variety of backgrounds, including science, engineering, law, economics, political science, and philosophy. Research at the Center often requires the development of new research methodologies that both encompass and extend traditional methods. Legal analysis is an important dimension of the Center's work, and law and technology courses at MIT have been developed and are taught by Center faculty and staff.

Many CPA studies are international in scope and use a comparative approach, or focus on the experience of a single foreign country, often with the collaboration of foreign research centers or universities. CPA research reports and publications are distributed to leaders in government, industry, labor, education, public interest groups, and to other research centers throughout the world.

During the past year CPA continued its specialization in technology and industrial policy; telecommunications and information policy; regulation and technological change; environment, health, and safety regulation; and issues related to technology, labor, and the consumer.

RESEARCH

Technology & Industrial Policy in the U.S.

Dr. Nancy Dorfman continued an NSF-sponsored study of the contributions to innovation of small enterprises in high-technology electronics industries. The focus of the study is on the external conditions, the size and age of successful firms. The project builds a basis for formulating a theory that will predict the conditions under which small firms will turn out to be the main innovators in an industry.

Professor Marvin Sirbu began a research project on the determinants of computer and communications standards. This research project will develop and test a theory which explains the process by which compatibility and variety-reduction standards are invented, developed, promulgated, adopted, and enforced. Decisions by individual firms to support standards will be treated as a problem in technology development and market strategy. The goal is to account for when and why standards are adopted and to understand the relationship between standards and the structure of information markets.

Dr. Christopher T. Hill completed his project for the National Science Foundation with a report entitled New Indicators of Industrial Innovation. The study assessed the feasibility of the collection and analysis of data for producing new science and technology indicators that could enhance the nation's capability to monitor the rate and direction of technological innovation and change. The results of the survey via a questionnaire to 103 firms affirmed the possibility of designing a variety of new indicators of industrial innovation and the feasibility of collecting the data needed to construct such indicators by surveying industrial firms.

Mr. Robert T. Lund concluded his remanufacturing study with a state-of-the-art review for the World Bank. The report discusses remanufacturing in the United States, the economics of remanufacturing, what constitutes a favorable environment for remanufacturing, selection criteria for products for remanufacturing, preliminary findings from studies related to other countries and benefits of remanufacturing in the United States and in other countries.

Technology & Industrial Policy in Other Countries

The declining competitiveness of many industrial sectors in Sweden, other industrialized countries of Europe and in the United States is a subject of intense public and governmental concern in these countries. The Salen Foundation of Sweden funded a CPA study under the supervision of Dr. K. N. Rao that developed indicators of mature industries in Sweden. The level of maturity of Swedish industry was compared with other OECD countries on a sectoral basis in order to assess its vulnerability to competition in the decades ahead.

Professor Nicholas Ashford participated in three major international workshops on technological innovation and is developing research proposals to undertake cross national comparisons of innovation policies. Professor Ashford was invited by Prime Minister Andreas Papandreu of Greece to attend a workshop last summer in Athens on The Challenge for Democratic Economic Planning. He also delivered an invited paper describing the Center's work in Portugal at the OECD workshop in Dubrovnik on Technological Innovation Policy in Less Industrialized Member Countries. Most recently, he attended a meeting on Innovation Policy and Management in London which focused on new technologies.

Telecommunications and Information Policy

Dr. Curtiss Priest has been developing and directing a Policy Research Information System (PRIS). The system includes 1) the use of micro-computers by research staff to access external information and compose reports; 2) the use of government and commercial information databases, i.e., the National Library of Medicine Elhill system and Lockheed's Dialog system; 3) the development of an in-house, IBM 3033-based, bibliographic management system (FOCUS) to facilitate data entry, analysis, and production of tables and charts for reports. This has been used to establish 11 project-level citation databases, and the software package has been licensed by MIT to Brown University, Cheeseborough-Ponds, the Insurance Company of North America, and others.

Dr. Priest and Dr. Dale B. Hattis have been evaluating the development and use of information databases for EPA policy and scientific research for the Environmental Protection Agency.

Dr. Priest and Professor Caroline Whitbeck have been examining the effects of new information and communications technology on values. Their study addresses how standards of association can be maintained or improved when the form of communication undergoes rapid technological change, how the restructuring of information flow can achieve human welfare goals; and what new rights, obligations, and responsibilities will result from the adoption of new information technology. Current focus is on values critical to the design of computer information technologies in medicine.

Regulation & Technological Change

The NSF-sponsored study of innovation in the pharmaceutical industry is continuing and is an in-depth analysis of three therapeutic areas to reveal associations between specific kinds of regulatory and non-regulatory stimulus conditions, drug development process types, and innovative progress. A data base has been compiled for the period 1950-1981 to analyze trends in drug innovation. Examining three therapeutic classes of drugs to isolate the changing patterns of drug innovations which are attributable to regulatory influences after 1962, Dr. Hattis, project manager, Dr. Ashford, principal investigator, and the research team have found that there are fewer new drugs appearing, but they are of greater therapeutic value than those appearing prior to 1962.

Professor Ashford and George Heaton, Esq. completed a review of the empirical evidence for the effects of regulation on technological change in the chemical and pharmaceutical industries. The review was published in the Duke University Journal of Law and Contemporary Problems and is entitled "Regulation and Technological Innovation in the Chemical Industry."

Environmental, Health and Safety Regulation

Professor Ashford, Charles C. Caldart, Esq., and C. William Ryan, a TPP student, completed an extensive study of the way in which three federal agencies, EPA, OSHA, and the Consumer Product Safety Commission addressed the issue of formaldehyde's carcinogenicity. The work was published in both the Harvard Environmental Law Review and in Science magazine and influenced the reversal of regulatory policy in EPA and a court action against OSHA, requiring reconsideration of its regulatory policy.

Dr. Hattis, with Professor Robert Goble of Clark University, conducted a study comparing the actual impacts of the OSHA lead standard regulation with those anticipated at the time of its promulgation in 1978. Their study shows that both air lead and blood lead levels have come down significantly, consistent with OSHA's predictions. However in none of the major lead industries is there yet compliance with the long term mandated air lead level.

The OECD has sponsored a study of the review of the state-of-the-art in methodologies for assessing the economic impact of chemical regulation. The report will focus on research undertaken in the United States and will be used by OECD in conjunction with a parallel European investigation, to identify methodological research needs in the future. Dr. Priest and Professor Ashford are responsible for the investigation.

The second year of the cooperative grant agreement with the Environmental Protection Agency concluded with three reports outlining the commercial uses of new and existing chemicals within selected chemical structural categories, based on surveys of recent trade and patent literature. The principal aim is to provide background information for the development of Significant New Use Rules (SNUR's) and other potential action on pending Pre-Manufacturing Notices (PMN's). The three reports covered aromatic amines and their important azo and diazonium derivatives, epoxides, and hydrazine derivatives.

The last decade gave rise to a considerable diversity of government legislation designed to control safety and health hazards. These laws incorporate various value judgments about the acceptability of risk. Professor Ashford has continued a study, Criteria for the Design of Coherent Sets of Social Controls for Health and Safety Hazards, to elucidate the underlying values and ethical principles reflected in the current health, safety and environmental legislation and in administrative and judicial actions implementing that legislation. Dr. W. Curtiss Priest is the project manager.

The U.S. Mineral Management Service (MMS) in Virginia undertook research on the Management of Environmental and Safety Risks of Offshore Development. Dr. Christopher Hill completed a study for them based in part on an examination of the uses of risk analysis for offshore technologies by firms, government agencies, and consultants in the U.S., Norway, and the United Kingdom. It includes both a review of available reports and documentation and interviews overseas. The inquiry is being combined with an analysis of the functions of MMS to define the potential contributions of risk analysis. The project was carried out in close cooperation with the Technology Assessment and Research Program of MMS under a contract from Sandia National Laboratory in New Mexico.

Technology, Labor, and the Consumer

The Office of Technology Assessment of the U.S. Congress has been focusing much attention on policy issues concerning the relationship between technological change and employment. CPA completed one study in this area for OTA in September 1983 and is currently engaged in another.

The earlier study, Retraining Displaced Adult Workers for Jobs in the 1980s and 1990s: A Review of Past Programs, Current Proposals, and Future Needs, was conducted by Dr. John A. Hansen, Dr. Andrew Martin and James Maxwell. It analyzed evidence on the gap between the skills of those currently in the workforce and the pattern of skill needs being generated by rapidly changing technology. The extent to which the gap can be narrowed by public policy designed to provide or support retraining was evaluated in the light of experience abroad as well as in the U.S. The study concluded that appropriately designed retraining programs can contribute significantly to narrowing the skills gap, that government has an essential role in assuring an adequate supply of

retraining, and that experience points to substantial possibilities for improving the effectiveness of retraining programs.

The second study, Technology and the American Economic Transition: Public Health and Safety, is being conducted by Dr. Martin. As part of a large project organized by OTA, it is aimed at charting the entire range of economic activities involved in the definition and implementation of governmental regulation in the areas of health, safety and the environment, including the suppliers as well as users of goods and services required to comply with regulation. Relationships between patterns and trends in investment and employment in these activities and changes in health, safety and environmental policy are being analyzed in order to understand the mechanisms by which policy affects the activities and provide a basis for anticipating the possible consequences of alternative future patterns of policy.

Professor Ashford and Charles C. Caldart, Esq. completed a two-year study of human monitoring in the workplace which investigated the scientific and legal problems related to tests performed on human subjects in the work environment for the purposes of determining health status and toxic uptake. This work has just been published in the Harvard Environmental Law Review and has been accepted for publication by the Johns Hopkins University Press.

Mr. Robert T. Lund completed his study for the Environmental Scanning Association with a report entitled, Connected Machines, Disconnected Jobs. The report outlines the various forms of advanced manufacturing technology likely to have a major influence on the factory of the next ten years. After outlining the general effects on the firm and the labor force, the report gives several strategic alternatives for dealing with the various consequences for the workforce from technological change in the next decade.

EDUCATIONAL ACTIVITIES

Students perform a major role in CPA research and are involved in most projects undertaken by CPA. Many of the MIT graduate students who work at CPA are Masters candidates in TPP. Professor Ashford and Professor Sirbu serve on the TPP Faculty Steering Committee, and Professor Sirbu has served as the Academic Coordinator for the Program. Professor Whitbeck has been asked by Professor Richard de Neufville, Director of TPP, to contribute as well. CPA has as its first educational priority to establish a stronger coupling with TPP. The Center has increased its role in guiding the Program, provided space for approximately half of the TPP students, initiated a joint seminar between the CPA and TPP students, and for the first time committed funds to the support of research assistants sufficiently in advance of their entrance in order to attract them to the Program. CPA will continue these activities, as well as the supervision of theses and assistance to the TPP graduates in securing policy-related employment.

CPA is one of several centers at MIT which contributes to the collaborative effort of the Research Program in Communications Policy. Graduate students develop their own interdisciplinary course of study through the Program in Technology and Policy, or through other Departments including Electrical Engineering and Computer Science, Economics, the Sloan School of Management, and the School of Architecture and Planning. Professor Sirbu teaches a joint EECS-Political Science course 6.933J Telecommunications Technology and Policy. CPA now houses four research assistants and one Ph.D. candidate in Communications Policy and provides an Institute focus for students in this area.

INFORMATION DISSEMINATION

CPA Bibliographic Management System (BMS), a computer-based storage and retrieval system designed by Dr. Priest and based on the FOCUS data-base management system, is now in its fourth major version. It contains 14 substantive bibliographies; innovation, toxic substances, regulation, benefits, values, transportation, trade secrets, medical, reindustrialization, chemicals, lead, and well-being. Interests in this powerful research tool, which organizes and searches bibliographic material and generates bibliographies, continues to grow within CPA and the larger MIT community, as well as outside of the Institute. BMS is now being used by MIT's Technology Adaptation Program and by the Aga Khan Program for Islamic Architecture. BMS software is available from MIT.

Under the direction of Professor Whitbeck, the CPA-TPP informal Seminar Series was begun in the fall. Presentations thus far have been "Division of Labor and Distribution of Tacit Knowledge in the Automation of Small Batch Machining" presented by Bryn Jones; "Knowledge Representations for Casual Reasoning" presented by Benjamin J. Kuipers; "The Political Meaning of Medical Ideas" presented by Deborah Stone; "Accident Prevention and Regulation" presented by Dr. Leon Robertson;

"The Emergence of Micro Electronics" presented by Jost Halfmann; "Paradigmatic Bias in Policy Analysis: The Limits of Microeconomics" presented by Professor Steven Kelman; "Commercialization of Academic Research, Is Biotechnology Any Different?" present by Professor Charles Weiner; "A History of Innovation in Computers and Semiconductors: The Role of New Companies" presented by Nancy S. Dorfman.

PUBLIC SERVICE

During the past year, members of CPA continued to serve on public or professional advisory committees and to testify before Congress on public policy issues. In addition, several staff members served as advisors and consultants to private firms, labor organizations, and public interest groups.

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FACULTY, STAFF, AND STUDENTS

Faculty and Staff Changes

Professor Ashford was granted tenure in the School of Engineering.

Janet Bleckley joined CPA as the Production Manager/Document Coordinator in January and is responsible for publications, reports and proposal preparation.

Professor Sirbu, who has been with the Center since 1972, was named to the Kokusai Denshin Denwa Career Development Professorship in Communications and Technology in the Sloan School of Management. The objectives of the chair are to promote teaching and research in the area of communications and technology and to further cultural and intellectual exchange between Japan and the United States.

John A. Hansen, George R. Heaton, Robert T. Lund and K. N. Rao left the Center to work at Boston University.

Visiting Research Staff

Professor Cristiano Antonelli, at the University of Calabria in Italy, has been a Rockefeller Fellow at CPA. He has developed papers on the diffusion of modems and data communications and the impact of telecommunications on multinational corporations and international trade.

Dr. Marco Diani, Attache de Recherche, Centre d'Etudes Sociologiques, and part-time researcher at the Istituto di Psicologia del CNR, Rome, is working on an international comparison of the impact of new technologies in both new and older industries and participating in preparation of a joint proposal for a study of office automation in the French Administration.

Dr. Stephanie Bird came to CPA as a joint appointment with the Science, Technology, and Society Program, from a Mellon Foundation fellowship. Her research at CPA, which will last over several years, will focus on the ethical aspects of premenstrual syndrome.

Mr. David Allen, a member of the MIT research program on communications policy, is the project director of a videotex database survey. The survey is compiling descriptions of original databases in Boston-area universities and cultural organizations. The project will analyze databases in this sector to evaluate their potential for general business and home use.

Professor William White from the University of Illinois spent his sabbatical at the Center while writing on issues of health economics and labor economics.

Per Lunde Jensen came from Roskilde University of Denmark to spend a month researching industrial innovation in Scandinavia.

NICHOLAS A. ASHFORD

Center for Transportation Studies

The Center for Transportation Studies (CTS), was founded in 1973 to stimulate and coordinate transportation research and education at MIT, and to develop working relationships with the transportation profession. Since its beginning, CTS has conducted nearly \$15 million of research involving all transportation modes and covering a diversity of economic and geographic settings. The Masters Program in Transportation, established in 1979, has graduated 74 students, and our continuing education programs attract over 100 mid-career professionals each year.

CTS has working relationships with nearly 60 faculty members from 13 departments within the Institute. On-going review and direction is provided by the CTS Executive Committee which included the following members for 1983/84: Professor Ann Friedlaender (Head, Department of Economics), Professor Ralph Gakenheimer (Urban Studies and Planning), Professor Thomas Magnanti (Head, Management Sciences Group, Sloan School of Management), Professor Amedeo Odoni (Chairman, Standing Faculty Committee for the Transportation Masters Program; Aeronautics and Astronautics), Professor Nigel Wilson (Head, Transportation Systems Division, Civil Engineering), and Professor David Wormley (Head, Department of Mechanical Engineering).

EDUCATION

After four years experience with the Master of Science in Transportation Program, the requirements were changed in response to feedback from students and faculty. The required number of core courses has been cut in half, while the required specialization courses have been doubled from two to four. This change, while making room for the concurrent increase in specialization requirements, also serves to standardize the core curriculum. In the past, when students were given a choice of three out of five designated core courses, it was not possible to assume a common base of knowledge among all the participants in the program, because not all of them chose the same courses. Now there are only two core courses -- Applied Microeconomics and Transportation Systems Analysis -- both of which are required for every participant in the program.

The Special Studies Program in Transportation offers practicing professionals the opportunity to remain abreast of new developments in their field and to acquire new techniques specific to their needs. Begun as a one-week course in the summer of 1969, the program has evolved into a package of several subjects offered over a three-week period each year. Subjects are offered both simultaneously and sequentially, and the participants are encouraged to tailor their curricula to their individual needs. The Special Studies Program typically draws 100 professionals from around the world.

In the Summer of 1983, in conjunction with the Center for Advanced Engineering Study, the Center offered six separate but coordinated courses:

- Transportation Systems Management and Analysis
- Microcomputers in Transportation
- Forecasting Transportation Demand
- Railroad Operations Planning and Management
- Public Transportation Service and Operations Planning
- Logistics Analysis for Carriers and Shippers

The Executive Program in Transportation is a joint effort of the Center for Transportation Studies and MIT's Sloan School of Management. It is a series of short courses intended for senior executives in all carrier modes, for those with responsibility for the logistics and distribution functions of industrial firms, and for the management personnel of those suppliers, manufacturers and financial institutions which support the transportation sector. The program is one of several executive programs at MIT, including the Sloan Fellows Program and the Sloan School's Senior Executive Program, as well as the Special Studies Program in Transportation and the Summer Program in Air Transportation. This May, a one-week intensive course was offered on Strategic Management in Transportation, taught by Thomas Magnanti, Head, and Arnaldo Hax, Professor of Management Science at the Sloan School of Management, George Kocur, Assistant Professor of Civil Engineering and Henry Marcus, Associate Professor of Marine Systems.

RESEARCH

CTS continues to have an active research program involving all modes of transportation with specific emphasis on developing a research program in freight transportation and the private sector. An important accomplishment in this regard is the designation of MIT as an Affiliated Laboratory of the Association of American Railroads (AAR).

The AAR Affiliated Rail Program builds upon and expands existing research and education activities which have been going on at MIT for the past ten years -- through the MIT Research Program in Railroad Operations and Economics and the Vehicle Dynamics Laboratory -- providing a framework for what has become, through these two ongoing programs, a productive long-term relationship with the railroad industry.

Initially set up for five years, the program receives three kinds of funding. General funds cover salaries, fellowships, and seed research, and are used for communications such as newsletters, conferences, faculty visits, and continuing education programs for mid-career professionals. Core funding fosters general research into areas of particular importance to the industry -- such as metallurgy, engineering, and economics and systems, the three designated areas for 1983. At MIT, the core research is being conducted in the area of economics and systems, focussing specifically on possible productivity improvements to be made through automation and robotics. Along with the general and core funding, the AAR provides project funding for specific research efforts which may or may not be related to the core research. Two such projects are currently underway at MIT, and it is intended that in the future further efforts will also be undertaken in technological areas such as metallurgy and materials behavior.

The Director of the AAR Affiliated Rail Program is Professor David Wormley, previous Director of the Vehicle Dynamics Laboratory, current Head of MIT's Mechanical Engineering Department, and a member of the Center's Executive Committee. Assisting Professor Wormley as Program Manager is Principal Research Associate Carl Martland, Head of the MIT Research Program in Railroad Operations and Economics.

TRANSPORTATION COMPUTATION LABORATORY

The recent mushrooming of microcomputer development has created enormous opportunities for improving productivity in transportation operations, planning, and management. Because of that, the establishment of a Laboratory for Transportation Computation has been a major priority of the Center -- to provide low-cost facilities for the entire transportation community at MIT and to serve as a focal point for teaching and research involving computer use. This year, with seed funding from the UPS Foundation Endowment (and with supplemental support from Texas Instruments and the MIT Civil Engineering Department) the beginnings of such a laboratory have come into being, offering four different levels of computation:

For simple graphics and planning models, five Apple II eight-bit computers are networked to a common hard disk data storage facility. For more complicated work, two larger, 16-bit IBM personal computers are available, one of which is equipped with a 32-bit co-processor that permits it to run the Xenix operating system with three users. For most of the computation done in connection with course work and research, a cluster of six terminals and a high-speed printer are connected to a Digital VAX 11/780. And for very large optimization and statistical problems, two terminals can be used to connect to MIT's largest IBM mainframe computer.

The Laboratory for Transportation Computation has already begun to fulfill much of its intended role. A new course entitled Computer Algorithms in Transportation has been introduced, and many of the students used the laboratory's microcomputers for their class projects. Other courses have also begun to make use of the laboratory, and some student thesis work has relied on it as well. In addition, the equipment has made it possible for the Center to offer continuing education courses in Microcomputers in Transportation, and a one-week course in computers for senior executives in the Maine Department of Transportation.

In the coming year, several courses in the academic program -- such as Transportation Demand and Activity Analysis and Transportation Networks Equilibrium Analysis -- will be able to expand their computation by using the Laboratory.

In the next phase of development, the lab's capabilities will be increased in interactive graphics. Given the complexity of most transportation problems, the ability to display results in comprehensible graphic form will be an important element of future transportation software. The Transportation Computation Laboratory is supervised by Professor George Kocur, a member of the Transportation Systems Division of the Civil Engineering Department.

DANIEL ROOS

Innovation Center

Student interest in technological innovation and entrepreneurship remains at a high level, with approximately 100 students participating in classroom, laboratory, and other activities. Entrepreneurial activity nationwide, and indeed worldwide, is growing at a rapid pace. This move toward smaller, more flexible business entities is a major trend within large corporations, and internal venturing is becoming a focus for new activity within these companies. Innovation Center is beginning to see the career directions of students affected by this trend.

While not yet becoming a large program, the Industry/Innovation Center Cooperative Program has been successful in providing framework for experiential education in technological innovation. Emphasis within the program is on product creation and development, and new products are created in response to the market needs of member companies. During the past year, two new industrial sponsors have begun to support work at the Innovation Center.

A new graduate subject on the topic of product development, called "The Idea/Product Transformation", was offered for the first time this past spring. The innovation methodology development work of the Center is presently concerned with the product development process. Significant increases in innovation productivity can be made through improvements in the development of new products. This important segment of the innovation process is typically very expensive and often not done very effectively, making it an important area for methodology research for the Center.

DAVID G. JANSSON

Laboratory for Computer Science

The MIT Laboratory for Computer Science (LCS) is an interdepartmental laboratory whose principal goal is research in computer science and engineering.

Founded in 1963 as Project MAC (for Multiple Access Computer and Machine Aided Cognition) the Laboratory developed the Compatible Time-Sharing System (CTSS), one of the first time-shared systems of the world, and Multics -- an improved time-shared system that introduced several new concepts. These two major developments stimulated research activities in the application of on-line computing to such diverse disciplines as engineering, architecture, mathematics, biology, medicine, library science, and management. Since that time, the Laboratory's objectives expanded, leading to research across a broad front of activities.

The first such area entitled Knowledge Based Systems involves making programs more intelligent by capturing, representing, and using knowledge which is specific to the problem domain. Examples are the use of expert medical knowledge for assistance in diagnosis carried out by the Clinical Decision Making Group; and the use of solid-state circuit design knowledge for an expert VLSI (very large scale integration) design systems by the VLSI Design Project.

Research in the second and largest area entitled Machines, Languages, and Systems strives to discover and understand computing systems at both the hardware and software levels that open new application areas and/or effect sizable improvements in their ease of utilization and cost effectiveness. New research in this area includes the architecture of very large multiprocessor machines (which tackle a single task, e.g., speech understanding or weather analysis) by the Computation Structures, Functional Languages and Architectures, and Real Time Systems Research Groups. Continuing research includes the analysis and synthesis of languages and operating systems for use in large geographically distributed systems by the Programming Methodology and Real Time Systems Groups. Extended networks for such distributed environments are studied by the Computer Systems and Communications Group, while distributed file servers are pursued by the Distributed Computer Systems Group. Finally a key application, involving the tailoring of news and other community information to individual needs, is pursued by the Imaginative Systems Group.

The Laboratory's third principal area of research entitled Theory involves exploration and development of theoretical foundations in computer science. For example, the Theory of Computation Group strives to understand ultimate limits in space and time associated with various classes of algorithms; the semantics of programming languages from both analytical and synthetic viewpoints; the logic of programs; and the links between mathematics and the privacy/authentication of computer-to-computer messages. Other examples of work in this area involve the study of distributed systems by the Theory of Distributed Systems Research Group, and routing algorithms for VLSI circuits.

The fourth area of research entitled Computers and People entails societal as well as technical aspects of the interrelationships between people and machines. Examples include the use of computers in the educational process by the Educational Computing Group; the use of interconnected computers for planning; as well as the societal impact of computers carried out by the Societal Implications Research Group.

During 1983-84, the Laboratory embarked on the ambitious effort of constructing Project Tanglewood, an emulation facility consisting of 64 interconnected large computers, whose purpose is to analyze the behavior of larger (up to several thousand machines) multiprocessor systems. This facility, funded by the newly formed Strategic Computing Program of the Defense Advanced Research Projects Agency, will enable our experimenters to try out ideas before committing their proposed architectures to silicon circuits. Another related development during this period has been the continuing development of the MULTILISP multiprocessor language by Professor Robert H. Halstead of the Real Time Systems Group. A multiprocessor applications workshop sponsored by members of the Laboratory was held in Spring 1984 to establish the amount of parallelism that can be expected in a variety of applications.

Another growth activity during 1983-84 has been the newly established Educational Computing Group, which is now headed by Dr. Andrea diSessa and includes Professors Harold Abelson, Seymour Papert, and Dr. Sylvia Weir. This group, which in the last 12 years developed the widely used language Logo, is currently focusing its efforts on the development of Boxer, a successor to Logo that encompasses new concepts in the computer and cognitive sciences and in educational innovation.

During this reporting period we have also made substantial progress in distributed systems research. The NuBus architecture that we developed was successfully transferred to industry (Texas Instruments) and we took delivery of 30 Texas Instruments Nu Machines supplied to us in exchange for our contributions. These and other related machines (single-user Vaxes and Lisp Machines) are being interconnected into

prototype interconnected systems within the Laboratory thereby forming an experimental basis for the study of distributed systems. During the Spring of 1984, key researchers in distributed systems presented their results to some 400 attendees in an ILP-sponsored conference.

During 1983-84, the Laboratory formed two new entities -- the Distributed Computer Systems Research Group and the VLSI Design Project. The first entity, headed by Senior Research Scientist Dr. David D. Clark is concerned with the architecture of distributed systems and in particular with file servers and communication protocols. The second entity, headed by Professors Charles E. Leiserson and Richard Zippel, is intended to coalesce and focus the various VLSI design activities within LCS. A key research activity of the VLSI Design Project is the study and development of an expert VLSI design system, Schema, which will be used as a common basis for all MIT VLSI design research.

Other events in 1983-84 were the arrival of three IBM engineers who will help us construct the Laboratory's emulation facility; and the launching of the Laboratory's bimonthly newsletter -- The Gateway.

In 1984, the Laboratory issued the LCS Achievement Award to Professor Joel Moses for his pioneering work on MACSYMA; and the one-time LCS Founder's Award to the founder of LCS (then Project MAC) Professor Robert M. Fano. Professor Fano will be retired effective July 1984, but will remain a part time member of the Laboratory. Other departures included Professor Christos Papadimitriou (to Stanford University) and Professor Michael Hammer (to his own company).

Arrivals during the same period were Assistant Professor Shafi Goldwasser, Silvio Micali, Ramesh Patil, Christopher Terman, and Research Associates William Ackerman and Benjamin Kuipers. Our Laboratory consisted of 340 members -- 53 faculty and academic research staff, 30 visitors and visiting faculty, 57 professional and support staff, 110 graduate and 90 undergraduate students - - all organized into 16 research groups. Laboratory research during 1983-84 was funded by 16 governmental and industrial organizations, of which the Defense Advanced Research Projects Agency of the Department of Defense provided over half of the total research funds.

Technical results of our research in 1983-84 were disseminated through publications in technical literature, through Technical Reports (TR299-TR317), and through Technical Memoranda (TM238-TM262).

MICHAEL L. DERTOUZOS

Laboratory for Electromagnetic and Electronic Systems

On July 1, 1983 the Laboratory for Electromagnetic and Electronic Systems (LEES) was formed by the combination of three previously existing laboratories. The Electric Power Systems Engineering Laboratory (EPSEL), The High Voltage Research Laboratory (HVRL), and the Continuum Electromechanics Laboratory (CEL). LEES has assumed the research mandates of the original three laboratories and has expanded its research interests into areas in which the overlap of talent and interest allows for the development of new research directions.

During 1983/84 the laboratory was made up of 17 faculty members, seven professional research staff members and approximately 60 graduate and undergraduate students. LEES facilities are located in buildings 10, 38, 7, N9 and N10.

The largest single research project in the Laboratory continues to be the design and construction of a 10-MVA superconducting generator using advanced and previously untested concepts. Power electronics research continues to grow, reflecting advances in semiconductor device technology and new application areas. Energy conversion at a power level in excess of 50W and a frequency of 10MHz was achieved using new power MOSFETs. The MIT Power Electronics Collegium completed its second year with a membership of 11 companies. Two Collegium workshops were held during the year.

Research in high voltage continued with significant advances in analysis of space charge effects and dielectrics. Research continued in properties of insulators. A major new research area was developed and funding secured from a consortium of electric utilities for the development of monitoring methods for electrical transformers. Industry funding also supports a major new research activity in development of Zinc Oxide materials (with Materials Sciences) for application to the utility industry.

In the area of Continuum Electromechanics, work was completed in development of an AC electrostatic precipitator. Work underway covers diverse activities in analysis of gas flows and in paint spraying.

New research finding was developed in energy systems analysis through the Integrated Energy Systems program funded by an international consortium. This effort looks to define new, tightly integrated systems for energy delivery and to identify opportunities and funding for basic engineering research in these areas.

Two additional areas for future research initiatives by the laboratory are currently under development. These are: space power systems, and integrated (intelligent) machines and motors.

THOMAS H. LEE

Laboratory for Information and Decision Systems

The Laboratory for Information and Decision Systems (LIDS) is an interdepartmental research laboratory of the Massachusetts Institute of Technology. Its staff includes faculty members, full-time research scientists, postdoctoral fellows, graduate research assistants, and support personnel. Undergraduate students participate in the research program of the laboratory through the Undergraduate Research Opportunities Program (UROP). Every year several research scientists from various parts of the world visit the laboratory to participate in its research program.

The fundamental research goal of the laboratory is to advance the field of systems, communication and control. In doing this it explicitly recognizes the interdependence of these fields and the fundamental role that computers and computation play in this research. The laboratory is conducting basic theoretical studies in communication and control and is committed to advancing the state of knowledge of technologically important areas. For example, Flexible Manufacturing Systems is currently an important research area in the laboratory.

As an interdepartmental laboratory, LIDS reports to the Dean of the School of Engineering, Professor Gerald L. Wilson. The Director of the laboratory is Sanjoy K. Mitter, Professor of Electrical Engineering. Robert G. Gallager, Professor of Electrical Engineering, is the Associate Director. The Assistant Director is Stanley B. Gershwin, Principal Research Scientist.

Thirteen faculty members and eight research staff members are presently associated with the laboratory. In addition, approximately sixty graduate students conduct research in LIDS. Currently, the laboratory provides thirty-five research assistantships to graduate students. A number of undergraduate students also participate in research and thesis activities.

Financial support for research in the laboratory is provided by Defense Advanced Research Projects Agency, Army Research Office, Office of Naval Research, Air Force Office of Scientific Research, National Aeronautics and Space Administration, National Science Foundation, National Institute of Health, IBM Corporation, Dupont Corporation, General Electric Company, and Data General Corporation.

CURRENT RESEARCH

The current research activities of the laboratory cover a wide range of theoretical and applied areas in systems, communications, and control. These areas include:

Data Communication Networks

Research in Communication Science and Systems ranges from basic information theoretic studies of networks and communication channels to the architectural design of network protocols. The major objective of this work is to develop the scientific base needed to design data communication networks that are efficient, robust, and architecturally clean. Both wide area and local area networks and both point-to-point and broadcast communication channels are of concern. Some of the topics in this area are routing, flow control, diverse traffic mixes, the communication complexity and delay of distributed algorithm protocols, multiaccess contention resolution, failure recovery and topological design. Professors Dimitri Bertsekas, Robert Gallager, Pierre Humblet, and Robert Kennedy are conducting this research.

Fiber Optic Local Communication Networks

The goal of this newly initiated program is to identify and resolve the fundamental issues pertaining to the design of local communication networks that utilize very broad band optical fiber technology to realize an integrated system that can provide all necessary communication services in a campus environment. Theoretical, experimental and design activities will contribute to the work.

Particular emphasis will be placed upon taking full advantage of the unique capabilities of single mode fiber technology. For example, the use of fiber couplers to increase the number of users that can be accommodated without repeaters will be investigated. Another effort will explore the use of tunable optical filters and heterodyne detection to achieve dynamic frequency concurrency. Professors Robert Kennedy and Pierre Humblet are conducting the research.

Estimation, Statistical Signal Processing, and Inverse Problems

A variety of stochastic estimation, analysis, and signal processing problems are being studied by Professors Bernard C. Levy, Sanjoy K. Mitter, George C. Verghese, and Alan S. Willsky and their students. Theoretical studies are conducted in the areas of estimation algorithms for spatially distributed random processes, nonlinear filtering, relationships among filtering problems in scattering theory, and the analysis of large-scale systems subject to a variety of very rare events. Complementing this theoretical research are more applied projects, including the design of algorithms for detecting and compensating for sensor or actuator failures, and the development of model-based signal processing algorithms. The specific signal processing problems include the diagnosis of arrhythmias in electrocardiograms, the detection of objects or anomalies given tomographic measurements such as those made using X-rays or ultrasound in medical and industrial nondestructive testing applications, and the analysis and inversion of spatially-distributed geophysical data.

Deterministic and Stochastic Nonlinear Dynamical Systems

The theory of nonlinear systems, both deterministic and stochastic, has developed rapidly during the last ten years. There is increasing interest in deterministic nonlinear control and various problems of adaptive control which lead to problems of nonlinear control. In the context of stochastic dynamical systems, problems of the qualitative behaviors of such systems under different time-scales are of great interest. Recent work on nonlinear filtering has shown their relationship to infinite-dimensional, bilinear systems, and there is increasing interest in the understanding of the qualitative behavior of nonlinear filters for large and small time-intervals. Various investigations in this area are being conducted by Professors Athans, Mitter, Verghese, Willsky and their students.

Multivariable and Adaptive Control

Systematic design of multiple-input-multiple-output systems, using a unified time-domain and frequency-domain framework, is an extremely active research area in the laboratory. Various theoretical and applied studies are being carried out by Professors Michael Athans, H. Austin Spang III, Gunter Stein, Bernard Levy, and Dr. Lena Valavani and their students. Theoretical research deals with issues of robustness, aggregation, and adaptive control. Recent application-oriented studies include the control of VTOL aircraft, submarine control systems, control system designs, and issues of integrated flight control.

Theory and Algorithms for Optimization

This project focuses on analytical and computational methods for solving broad classes of optimization problems arising in engineering and operations research, as well as for applications in communication networks, control theory, power systems, computer-aided manufacturing and other areas. Currently, in addition to traditional subjects in nonlinear and dynamic programming, there is an emphasis on solution of large-scale problems involving network flows and differential and difference equation dynamics. The thrust is twofold: first, to find ways to handle the typically huge number of constraints; second, to explore the use of distributed and parallel processing to reduce the computation time needed to solve a problem and to economize on information transfer from remote data collection points to a computation center. This gives rise to fundamental issues involving the synchronization of computation and communication that are as of yet only partially resolved. Professor Dimitra Bertsekas and his students perform this work.

Command, Control, and Communication Systems

The study of military Command, Communication, and Control (C³) systems defines basic research directions in the areas of distributed detection and estimation, distributed data bases, and team decision theory. Professors Michael Athans and Robert R. Tenney, Dr. Alexander H. Levis, and Ms. Elizabeth R. Ducot, together with a large group of graduate students, are developing novel theoretical and algorithmic approaches for this rich class of system-theoretic problems.

Recent advances have been made in the following areas: (a) organization structures based on information-theoretic concepts; (b) mathematical models of distributed decision problems with limited communications; (c) multisensor-multiobject tracking algorithms including sensor scheduling; (d) integration of distributed data base systems within vulnerable communication networks; (e) development of a computer-based testbed in support of analytical research.

Manufacturing Systems

Modeling, analysis, and control of manufacturing systems are studied by Dr. Stanley B. Gershwin, Professor Sanjoy K. Mitter, Dr. Ramakrishna Akella, and their students. The effects of machine failures on routing and scheduling policies are investigated to reduce in-process inventories and the time spent by material in the factory. The architecture of an on-line computer system that will optimally control

the flow of material is being considered. The concept of a transfer, or production, line has been extended to that of an assembly/disassembly network for the purpose of studying the interplay between reliability, speed, buffer size, production rate, and average in-process inventory levels. The FlexMan computer system was developed by Ms. Elizabeth R. Ducot to help transfer our results to industrial users.

Information Transfer and Retrieval

Research on information transfer and retrieval focuses on investigating issues concerning the way computer-based information systems can be engaged more easily and effectively by potential human users. These investigations involve the application of theoretical, analytical, and experimental techniques in areas such as information and computer science and technology, computational linguistics, and psychological human-factor studies.

Three current projects include analytical and experimental investigations of: (1) electronic document-delivery networks applicable to interlibrary resource-sharing; (2) expert computerized intermediary systems to assist end-users in accessing and operating heterogeneous bibliographic databases and retrieval systems; and (3) intelligent terminals with microprocessor and telecommunications hardware and software that enable automatic connection and log-in to remote computers. Staff members directing these three efforts are, respectively, Professor J. Francis Reintjes, Mr. Richard S. Marcus, and Mr. John E. Ward.

System Reliability and Risk Management

Research on risk assessment and management is carried out in many MIT departments and laboratories. In LIDS there is interest in describing the reliability of complex systems in terms of what is known about the reliability of their components. Professor Alvin Drake has supervised research on the development of models and algorithms for studying the manner in which uncertainties about component reliabilities are reflected in uncertainty about system reliability. The primary area of application has been to low probability, high consequence risks in nuclear reactor safety. Professor Drake also is concerned with probability assessment, particularly the quantification of expert judgement.

Honors

Professor Robert G. Gallager gave the prestigious Shannon Lecture at the International Information Theory Conference held in St. Jovite, Canada, September 26-30, 1983.

SANJOY K. MITTER

Laboratory for Manufacturing and Productivity

The long range goal of the Laboratory for Manufacturing and Productivity (LMP) is to establish the disciplinary basis for the manufacturing field. This goal is being achieved by laying the rational and axiomatic foundation for decision making, development of concepts for intelligent machines and efficient processing techniques, innovation of new sensing techniques for automation, and addressing flexible automation tasks with robots and other automatic machines. Our goal is also being achieved by improving the educational program through the development of new academic subjects and involving a large number of UROP students and theses students. Our students are learning to think systematically and creatively through their involvement in conceptual research projects that address real problems of the world.

During the academic year 1983-1984, many important contributions have been made by researchers in the Laboratory. The direct drive robot developed by Professor H. Asada, that can accelerate at 5 g., is now finding commercial applications. His concept for using a momentum of inertia diagram to chart the most stable and low inertia direction has also provided a new concept in robot design. Professor D. Hardt's intelligent sheet metal forming machines provide efficient and elegant solutions to many long-standing industrial problems. In the field of polymer processing, a number of major advances have been made. A new technique of imparting exceptional toughness to molded plastics has been developed. Also, an important step toward making an intelligent injection molding machine was taken with the invention of an advanced version of low thermal inertia molds. Acoustic sensors for on-line measurement of particle dispersion in polymeric streams were developed by Professor Lewis Erwin, and a new concept for measuring the individual thickness of a multi-layer composite sheet was developed by Professor Timothy Gutowski. In the field of tribology, newly designed electric contacts eliminate the need for gold coating in some electronic applications, and a new means of controlling the friction at the sliding interface was developed. These new developments are generating exciting possibilities for industrial sponsors.

During the past year, LMP has undertaken many new research projects under the sponsorship of industrial firms and government agencies. Professor Steven Dubowsky's work on vision for computers, Dr. George Chryssolouris's laser machining, the application of synthesis axioms to plant layout and design of complex industrial machines, the development of a mixalloying process to alter metal processing concepts, the design of composite machine tools, the application of robots in metal fabrication, and the investigation of the tribological problems of magnetic tape recording are some of the newer projects in LMP.

A significant portion of LMP's research is done through cooperative research programs with industry. In addition to the MIT-Industry Polymer Processing Program, there are the Tribology Research Program (Director, Professor Ernest Rabinowicz), the MIT-Industry Flexible Materials Processing Program (Director, Professor Stanley Backer), and the Machine Dynamics Program (Director, Professor Richard Lyon). In recent years, the Tribology Research Program has grown rapidly in part because of its emphasis on tribology of electronic equipment. Cooperative research provides a convenient and effective research vehicle for coherent, long-term basic research that addresses industrial problems in an uninhibited manner.

Several acquisitions of machine tools and computers have been made to accommodate the demands of modern research in the field of manufacturing. State of the art machine tools (e.g, a WOTAN CNC milling center and a DAEWOO CNC lathe) will now provide research opportunities and educational tools. The computers will enable simulation of manufacturing systems, computer-aided design and manufacturing, and facilitate other computational needs.

LMP's rapid growth in terms of personnel and facilities is again creating space problems. Efforts are being made to address this problem.

NAM P. SUH

Materials Processing Center

The Materials Processing Center (MPC), formed within Massachusetts Institute of Technology's (MIT) School of Engineering in 1980, promotes the generation and transfer of scientific information necessary to improve the health of the materials processing field. Founded with a NASA grant to establish a research base in materials processing, the Center has rapidly expanded to a current annual research budget of \$4 million. NASA still provides about 20 percent of the Center's total budget, with 40 percent provided directly by industry, and another 40 percent from other governmental agencies.

INTERDISCIPLINARY, FUNDAMENTAL RESEARCH

Central to the Center's basic philosophy is the control of a material's properties through the control of its microstructure. This control must be based on a fundamental understanding of the basic science of materials processing rather than on a purely empirical view; that is, to understand how and why a process successfully controls microstructure and subsequent properties rather than simply that it works. The Center also strives to increase the number of materials processing students and professionals, expanding the talent base available for industry. This expansion is crucial, since requests from industry for materials research and development engineers and scientists are about three times the number of these professionals graduating.

Center research covers a broad range of materials and activities, with a number of common themes. Foremost is the economical control of structure and properties. In addition, projects have both practical and fundamental significance, with many related to space processing. Many researchers in both ground-based and reduced gravity environment-based studies are increasing their use of mathematical modeling techniques as a research tool. The interdisciplinary nature of many projects requires the involvement of a number of faculty, staff, and students from several different departments, including Chemical Engineering, Materials Science and Engineering, Mechanical Engineering, Electrical Engineering, and Chemistry.

In the past year, the Center created the Metal Matrix Composites Processing Laboratory (with a current level of support of \$242,000/year). This lab has three main goals: to establish the fundamentals of foundry practice for the processing of metal matrix composite components; to predict and control composite properties; and to explore the effects of uniform dispersions of very fine particulates on the tensile and fracture behavior of aluminum alloys. Research focuses primarily on the interface between the metal matrix and the fiber or particulate. We expect this new lab to expand significantly during the coming year.

COLLABORATION WITH INDUSTRY

Due to the rapid rate of scientific and technological innovation, new mechanisms must be developed to facilitate the transfer of scientific information and technology to industry in ways that go beyond the traditional modes of research publication and student graduation. Collaboration with industry is critically important to the university, providing academic programs with the long-term direction necessary to maintain a high degree of relevance to rapidly evolving industrial needs.

Since its inception, the Materials Processing Center has encouraged a close relationship with industry through its Industrial Advisory Board, Industry Collegium, and research consortia. The Board, whose members all come from industry and government, annually reviews the ongoing research programs and policies of the Center, promoting direct interaction with industry. The Collegium, now with 65 worldwide corporate member companies, encourages close contact between industrial representatives and the faculty, staff, and students of the Center through workshops, visits, and tours of the research facilities. The consortia, or multi-client sponsored research concept, was adopted in 1980 to promote collaborative, generic materials processing research. Three such consortia now exist in the Center, the largest of which is the Ceramic Powder Processing Research Consortium (established last year) with its 22 members from industry and government. Research funded by the consortium studies fundamental, generic processing concepts, which each participating company can then adapt to its own proprietary technology. It is through groups such as these that the Center strengthens the link between basic research at the university and innovation in industry.

The Center undertakes educational and advisory roles in addition to its research role. Through the Collegium, the Center sponsors informational workshops, graduate fellowships, and summer scholarships. The major benefits of these workshops, which have been well attended by industrial, university, and government personnel, are the timely dissemination of research results and the ensuing exchanges between

speakers, Center staff, and attending industrial representatives. Workshops held last year dealt with "Recent Advances in Welding and Joining Processing," "Convection Effects in Materials Processing" (which was co-sponsored with NASA), and "Polymer Processing." Workshops planned for next year will cover rapid solidification and materials systems analysis.

The fellowship program, established in 1982, endeavors to attract the very best entering graduate engineering students to materials processing. To date, the Center has offered eleven fellowships to students in the Departments of Materials Science, Mechanical, Electrical, and Chemical Engineering. The many departments involved in this program illustrate the interdisciplinary components of materials processing research and development. Similarly, the summer scholarship program, also begun in 1982, seeks to encourage undergraduate students to pursue an education and career in materials processing at MIT. The Center offers summer scholarships to sophomores and juniors enrolled in chemistry, physics, and mechanical, chemical, and electrical engineering in universities throughout the United States. During the summer, these undergraduates participate in ongoing materials processing research programs before returning to their respective schools in the autumn to complete their undergraduate programs.

Collegium member companies also receive Collegium Reports, which provide timely access to research reports. In addition, the Center encourages representatives from these companies to tour Center facilities, or to send representatives for an extended visit during which they participate in current research projects. These visitors provide excellent opportunities for bilateral information and technology exchange. With Collegium funds, the Center develops new curriculum and texts, aids in the purchase of necessary major equipment, and supports seed research projects. The Center also offers an intensive two-week summer course on Applied Materials Technology for industrial representatives as well as special groups such as NASA's astronauts.

LINKS WITH GOVERNMENT

In addition to its ties with NASA, the Center encourages interactions with other governmental agencies. During the past year, the Center conducted a detailed examination of the possibility of substituting ceramic materials for critical and/or strategic materials. Entitled "Potential of Ceramic Materials to Replace Cobalt, Chromium, Manganese, and Platinum in Critical Applications," the report was commissioned by Congress' Office of Technology Assessment.

Last September, the founding director of the Center, Professor Merton C. Flemings, was asked to give testimony at a hearing of the Subcommittee on Space Science and Applications in the U.S. House of Representatives. Using the Center as a model, Professor Flemings advocated federally supported, focused, basic research within university "Centers of Excellence."

The Materials Processing Center, through its direct interaction with industrial personnel, promotes the technology transfer upon which innovation in materials processing is based. For the past four years, the Center has provided a focus and forum in which academic, industrial, and government personnel can broaden their knowledge while collaboratively developing new scientific and technological skills in materials processing. Through such collaboration and cooperation, American industry can retain and maintain its leadership in basic processing, the keystone of high technology and advanced materials systems.

H. KENT BOWEN

School of Humanities and Social Science

The principal activity of the year was the development of long-range plans for each of the departments and sections and for the School as a whole. In the case of the departments, the process was a fairly straightforward one. Their direction is largely determined by their determination to constantly strengthen their graduate programs to enable them to compete successfully in a highly competitive market. Planning is, therefore something which goes on all the time. In the case of the sections, however, the process was a much more difficult one. Essentially, the sections were being asked for the first time since they became autonomous to work out a coherent statement of objectives. This involved them in looking at the past as well as thinking about the future, and assembling much-needed statistics. Because the whole process is so new it will need more than a year to work out priorities in some of the sections, but a very good beginning has been made.

One thing that emerged clearly from the planning discussions was that the sections of the Humanities department are seriously underfunded. If they are to function effectively and to recruit strong faculty, more money will have to be found. Fortunately, there are signs that major foundations are at last becoming aware that the Humanities have been badly neglected in the United States in recent years, so that foundation help is no longer almost out of the question as it has been for many years.

It was heartening that one of the first major external grants in connection with Project Athena has been made to a team in the Humanities for work in computer-aided foreign language learning. This is one of those areas in which there is a happy conjunction of interest on the part of MIT students, ESG, and faculty members in Artificial Intelligence and Foreign Languages and Literatures. The key member of the team is Dr. Janet Murray who is a research associate in the School. It is my hope that a similar team can be put together to explore the possibilities in computer-aided instruction in writing.

As I leave the deanship, I want to thank all those who have worked with me over the past eleven years and more, and welcome my successor, Professor Friedlaender. She will find that there are still plenty of challenges awaiting her.

HAROLD J. HANHAM

TABLE I
Enrollment in Humanities, Arts and Social Science Subjects:
1983-84*

| Field | Elective Subjects | | Distribution Subjects | | Totals | |
|------------------------------------|-------------------|------------------|-----------------------|------------------|------------------|------------------|
| | £ of Subjects | £ of Students | £ of Subjects | £ of Students | £ of Subjects | £ of Students |
| Anthropology/ Archaeology | 12 | 79 | 5 | 86 | 17 | 165 |
| Drama & Dance | 4 | 50 | 0 | 0 | 4 | 50 |
| Economics | 15 | 1279 | 1 | 26 | 16 | 1305 |
| Foreign Languages & Literatures | 34 | 1178 | 24 | 624 | 58 | 1802 |
| History | 26 | 239 | 13 | 420 | 39 | 659 |
| History of Art & Architecture | 1 | 48 | 3 | 151 | 4 | 199 |
| Interdisciplinary | 4 | 10 | 1 | 19 | 5 | 29 |
| Linguistics | 1 | 19 | 1 | 112 | 2 | 131 |
| Literature | 23 | 490 | 13 | 687 | 38 | 1177 |
| Music | 15 | 442 | 6 | 392 | 32 | 834 |
| Philosophy | 15 | 250 | 8 | 532 | 23 | 782 |
| Political Science | 28 | 325 | 9 | 358 | 37 | 683 |
| Psychology | 13 | 501 | 0 | 0 | 13 | 501 |
| Science, Technology & Society | 21 | 202 | 10 | 207 | 31 | 409 |
| Urban Studies | 3 | 20 | 5 | 115 | 8 | 135 |
| Visual Arts & Design | 15 | 309 | 2 | 81 | 17 | 390 |
| Western Tradition | 0 | 0 | 6 | 271 | 6 | 271 |
| Writing | 21 | 635 | 4 | 311 | 25 | 946 |
| TOTALS | 251 | 6076 | 111 | 4392 | 362 | 10,468 |

*In previous President's Reports, separate tables were given for Elective subjects and Distribution subjects which satisfied the undergraduate Requirement in the Humanities, Arts, and Social Sciences, using figures from the Registrar's 5th week count. This year the grade/subject distribution report (which shows the final tally for each class) was used instead and information about Elective and Distribution subjects has been included in a single table. The numbers shown are for undergraduate subjects which normally satisfy the HASS Requirement; they do not include subjects allowed towards the Requirement only upon petition.

TABLE II: CONCENTRATIONS IN ALL FIELDS OF HUMANITIES,
ARTS, AND SOCIAL SCIENCES *
JUNE 1984

| Fields Of Concentrations | Class of 1987 | Class of 1986 | Class of 1985 | Class of 1984 ** | Totals in Fields |
|---------------------------------------|------------------|------------------|------------------|---------------------|---------------------|
| American Studies | (0) 0 | (5) 1 | (3) 0 | (6) 5 | (14) 6 |
| Ancient and Medieval Studies | (0) 0 | (3) 0 | (1) 0 | (6) 6 | (10) 6 |
| Anthropology/Archaeology | (0) 0 | (3) 0 | (4) 2 | (17) 16 | (24) 18 |
| Drama | (0) 0 | (4) 0 | (9) 1 | (14) 13 | (27) 14 |
| Economics | (3) 0 | (84) 6 | (98) 36 | (285) 285 | (470) 327 |
| Film and Media Studies | (0) 0 | (3) 0 | (11) 0 | (12) 6 | (26) 6 |
| Foreign Languages and Literatures *** | (7) 1 | (115) 24 | (92) 28 | (242) 185 | (456) 238 |
| History | (1) 0 | (16) 4 | (40) 12 | (70) 60 | (127) 76 |
| History of Art and Architecture | (0) 0 | (2) 0 | (1) 0 | (5) 3 | (8) 3 |
| Labor in Industrial Society | (0) 0 | (0) 0 | (0) 0 | (0) 0 | (0) 0 |
| Latin American Studies | (0) 0 | (0) 0 | (0) 0 | (0) 0 | (0) 0 |
| Linguistics | (0) 0 | (2) 0 | (1) 0 | (12) 12 | (15) 12 |
| Literature | (0) 0 | (26) 2 | (29) 6 | (66) 64 | (121) 72 |
| Music | (1) 0 | (20) 1 | (27) 7 | (98) 98 | (146) 106 |
| Philosophy | (1) 0 | (7) 1 | (18) 4 | (42) 40 | (68) 45 |
| Political Science | (0) 0 | (7) 1 | (36) 10 | (61) 50 | (104) 61 |
| Psychology | (0) 0 | (13) 2 | (25) 8 | (53) 52 | (91) 62 |
| Russian Studies | (0) 0 | (2) 0 | (0) 0 | (2) 2 | (4) 2 |
| STS | (0) 0 | (5) 0 | (10) 2 | (30) 21 | (45) 23 |
| Special | (0) 0 | (6) 0 | (9) 4 | (43) 39 | (58) 43 |
| Traditions and Texts | (0) 0 | (0) 0 | (0) 0 | (4) 4 | (4) 4 |
| Urban Studies and Planning | (0) 0 | (1) 0 | (8) 2 | (7) 7 | (16) 9 |
| Visual Arts and Design | (0) 0 | (7) 1 | (15) 2 | (27) 24 | (49) 27 |
| Women's Studies | (0) 0 | (2) 0 | (2) 0 | (4) 3 | (8) 3 |
| Writing | (0) 0 | (22) 1 | (32) 2 | (54) 52 | (108) 55 |
| TOTALS | (13) 1 | (355) 44 | (471) 126 | (1160) 1047 | (1999) 1218 |

* The parenthetical figure is the number of proposed concentrations in the given class and field; the figure to its right is the number of these concentrations that have been completed.

** Substantial discrepancies between numbers of proposed and completed concentrations for seniors result from 1) switching concentrations without cancelling the first one; and 2) failure to have completion certified, usually because of a change in date of graduation.

*** Figures for subfields of Foreign Languages and Literatures:

| | | | | | |
|------------------|-------|--------|---------|---------|----------|
| French | (1) 0 | (35) 8 | (36) 12 | (82) 70 | (154) 90 |
| German | (3) 1 | (37) 7 | (11) 4 | (65) 49 | (116) 61 |
| Russian | (1) 0 | (7) 2 | (13) 3 | (14) 11 | (35) 16 |
| Spanish | (1) 0 | (24) 5 | (19) 6 | (41) 30 | (85) 41 |
| World Literature | (0) 0 | (2) 1 | (2) 1 | (8) 6 | (12) 8 |
| Other Languages | (1) 0 | (10) 1 | (11) 2 | (32) 19 | (54) 22 |

TABLE III

Undergraduate Majors in the School of Humanities and Social Science*

| Year | Economics | Humanities** | Philosophy | Political Science | Psychology*** | TOTAL |
|---------|-----------|--------------|------------|----------------------|---------------|-------|
| 1973-74 | 55 | 67 | 10 | 30 | -- | 162 |
| 1974-75 | 63 | 48 | 1 | 14 | -- | 126 |
| 1975-76 | 67 | 41 | 3 | 24 | -- | 135 |
| 1976-77 | 67 | 31 | 7 | 25 | -- | 130 |
| 1977-78 | 52 | 34 | 7 | 21 | -- | 114 |
| 1978-79 | 48 | 38 | 5 | 30 | -- | 121 |
| 1979-80 | 44 | 37 | 9 | 36 | -- | 126 |
| 1980-81 | 50 | 40 | 11 | 30 | -- | 131 |
| 1981-82 | 51 | 49 | 9 | 32 | -- | 141 |
| 1982-83 | 48 | 37 | 7 | 28 | 11 | 131 |
| 1983-84 | 48 | 24 | 3 | 22 | 20 | 117 |

* As registered in the second term of academic year 1973-74 to 1983-84. Data taken from the Registrar's fifth-week report.

** These figures do not include double majors who registered first in a course other than Humanities.

*** Undergraduate degree in Cognitive Science, instituted in 1982-83.

TABLE IV

Graduate Students in the School of Humanities and Social Science+

| Year | Economics | Linguistics & Philosophy | Political Science | Psychology | TOTAL |
|---------|-----------|--------------------------|----------------------|------------|-------|
| 1973-74 | 114 | 54 | 96 | 25 | 289 |
| 1974-75 | 114 | 53 | 95 | 25 | 287 |
| 1975-76 | 120 | 49 | 89 | 27 | 285 |
| 1976-77 | 114 | 46 | 91 | 29 | 280 |
| 1977-78 | 123 | 45 | 102 | 24 | 294 |
| 1978-79 | 121 | 48 | 96 | 28 | 293 |
| 1979-80 | 138 | 63 | 143 | 36 | 380 |
| 1980-81 | 126 | 66 | 121 | 32 | 345 |
| 1981-82 | 111 | 55 | 142 | 26 | 334 |
| 1982-83 | 136 | 51 | 163 | 27 | 377 |
| 1983-84 | 113 | 52 | 99 | 25 | 289 |

+ As registered in the second term of academic year 1973-74 to 1983-84 (including special graduate students). Data taken from the Registrar's fifth-week report.

Humanities Undergraduate Office

In its second year the Humanities Undergraduate Office continued to provide most of the services enumerated in the 1982-83 annual report. It also assumed several new responsibilities and was relieved of one, the management of Humanities films. The Office's two-element structure still works well, with the Humanities, Arts, and Social Sciences Information Center involved in administering the Institute Requirement, the Course XXI Office coordinating major programs in ten fields.

With the transfer of the film operation, the Humanities Undergraduate Office was able usefully to consolidate both space and staff. As of March 1984 the office occupies 14N-405, 407, and 409. This unified block of rooms has helped to bring about better intra-office communication. During the Spring term senior secretaries Jacqueline Bausch and Alexandra Tyszka left to do other things. Replacing them as full-time Administrative Assistant is Shawn Finnegan. Ruth Spear remains Coordinator, Travis Merritt Director.

HUMANITIES, ARTS, AND SOCIAL SCIENCES INFORMATION CENTER

During this year it has become increasingly apparent that the functions of the Center extend well beyond the dissemination of useful information to students. A great deal of work, this year, has gone into the development of processes which make the Humanities, Arts, and Social Sciences (HASS) Requirement run more smoothly and better realize its potential as an educational instrument. The office also generates information and statistics useful to MIT's faculty and administration, and contributes to making the strength and variety of the HASS program better known outside the Institute. Among the more noteworthy developments:

--Publication and distribution to all undergraduates of three issues (for Fall 1983, Spring 1984, and Fall 1984) of the MIT Student's Guide to the Humanities, Arts, and Social Sciences. After some experimentation with content and format, the Guide has settled into its basic semester-by-semester business of 1) explaining fully the terms and procedures of the Institute Requirement and, 2) listing in a single location all of the subjects available in HASS, with descriptions of those being taught in the semester upcoming and especially detailed information on Humanities Distribution (HUM-D) subjects. Each upperclass student receives a copy of the Guide with pre-registration material in December and May, each entering freshman in September. Indications are that the tabloid is being used extensively and that it enlightens somewhat the process of subject selection.

--Working out, in consultation with the chairman of the Faculty and the Registrar, a set of Revised Procedures for Fulfilling the Humanities, Arts, and Social Sciences Concentration Requirement, and coordinating the application of these procedures in all HASS fields. The objectives of these changes, in line with the adjustments to the HASS requirement voted by the faculty in May 1983, include the following:

- 1) early involvement of student in the planning of a concentration, with the proposal approved before the end of the Sophomore year;
- 2) getting the student's Faculty Advisor involved and informed;
- 3) keeping the Concentration Field Advisor in touch with changes as they occur;
- 4) certifying actual completion of the requirement;
- 5) having numbers and identity of Concentrators recorded in a single, centrally accessible location for each Field.

All of these objectives seem, at the close of the new system's first year, to have been met in some measure. The best of it is that every senior graduating in June 1984 certifiably completed the Concentration program that had been proposed. As for prompting students to propose a Concentration program before the end of Sophomore year, there was progress. Roughly a third of the Class of 1986 (355 students) had filled out a proposal form by the end of this academic year. While this is a big improvement over the previous year's sophomore total of 140, it is by no means good enough. Our hope is that, through increased publicity and faculty cooperation, we may move much closer to full compliance in 1984-85.

There is also room for improvement in the involvement of Faculty Advisors, in the extent of contact between Concentration Field Advisors and Concentrators, and in getting students more genuinely to regard the Concentration as an intellectual "home," part of their academic identity.

In any case, the new system makes it possible for the first time to compile complete (and educationally instructive) statistics showing patterns in the various populations of Concentrators.

--Developing for the Dean of Humanities and Social Science a set of procedures for introducing new HUM-D subjects, altering the HUM-D status of existing subjects, proposing new fields for Distribution or Concentration, or altering specific requirements in a field of Concentration. These new procedures were made necessary by the adjustments to the HASS Requirement voted in May 1983, which abolished the Committee on the HASS Requirement and turned the functions of that committee over to the Dean of the School and the faculties in the individual disciplines. During this first year these changes have not brought the flood of new HUM-D subjects that some had predicted, although the total number of HUM-D's did jump from 156 to a new high of 165.

An extension of these procedures was also worked out, in collaboration with the Committee on the MIT-Wellesley exchange, to cover the obtaining of MIT HUM-D status for Wellesley College subjects.

--Preparing for publication and distribution a new eight-panel flyer, Liberal Education at MIT. Although this brochure is a production of the School of Humanities and Social Science, and aims to make more widely known the strength and variety of the Institute's programs in HASS, it was thought most effective to place this message in the context of the distinctively balanced liberal education which is available to undergraduates here. Approximately 40,000 of the flyers are being mailed by the Admissions Office to high schools and to the best qualified high school students in the nation, in the hope of exciting interest among those who might otherwise not consider MIT because of its "narrow tech" image.

--Compiling a five-year set of enrollment statistics showing population trends for subjects in all HASS fields, including both fifth-week and term's-end figures.

In addition, the Center continued to provide substantially those ongoing services enumerated in the 1982-83 Annual Report.

COURSE XXI

The Course XXI Office continued in 1983-84 to administer full (XXI) and joint (XXI-E, XXI-S) major programs in ten humanistic fields. All in all, it was a year of relative structural stability and of distinguished academic performance by students enrolled in these degree programs.

Students: Numbers and Quality

The combined population of Courses XXI, XXI-E, and XXI-S re-approached its ten-year high, with 71 majors enrolled in May 1984. Most of this year's gain occurred in the full major program (XXI), whose enrollment rose from 21 to 28. The joint major programs showed virtually no change, with 31 in XXI-E and 12 in XXI-S for a total of 43. Enrollments by humanities field remained pretty stable as well, except for a welcome increase (from four to 12) in Foreign Languages and Literatures, whose faculty are obviously doing a good job of attracting students to serious and sustained studies in their disciplines. The persistently small number of Anthropology/Archaeology and History majors continues to be a matter for concern. The Director plans to hold discussions with faculty in these fields next year to explore possible remedies.

The most remarkable population change since June 1983 is a sharp up-swing in the number and percentage of our students who are double or triple majors. There are 39 (including three triples) of these now, as opposed to 22 a year ago. For many years roughly a quarter to a third of our majors have been double degree candidates, so we are accustomed to the phenomenon, but this year's leap to well over half is hard to account for, apart from the standard explanation that, in the interest of future employment, students are ever more reluctant to leave MIT without an engineering or science degree.

The improved academic performance of our majors, mentioned in a couple of recent annual reports, also seems to have reached a new high. At the close of the 1984 Spring semester, only 14 of 71 (19%) majors had cumulative averages below 4.0. This may be compared with the situation only three years ago, when 24 of 66 (37%) were below 4.0. For the first time in the Director's memory the end of term brought no actions by the CAP on Course XXI students.

It is tempting to link the general improvement in measurable academic performance with the increasing number of double degree candidates, but any such correlation will have to await a complete assessment of all the data covering the past several years.

Degrees, Honors, and Post-Graduation Plans in 1983-1984

One student received the S.B. in February (in XXI-S) and 15 in June (two in XXI, seven in XXI-E, six in XXI-S), a total of 16 for the academic year.

Course XXI students once again earned a variety of honors, awards, and prizes. Shawn O'Donnell '84, a Russian Studies and Electrical Engineering major, was elected to Phi Beta Kappa. William L. Stewart Awards for substantial contributions to the quality of student life at MIT were won by Tina Bahadori '84 (French and Chemical Engineering), Will Doherty '85 (Writing and Computer Science), and Sabrina Lewis '84 (Music and Chemical Engineering). Stella Hetelekidis, a graduating senior in Literature and Biology, received the Laya B. Wiesner Award for outstanding service to MIT by an undergraduate woman. Jay Slagle '85 (STS and Physics) won the McDermott Playwriting Prize in the competition's first year. An Eloranta Fellowship for summer writing went to Mihai Manoliu '84. John McCrea '84 received honorable mention in the Boit writing competition.

Some of the graduating seniors are heading directly for the workplace; their employers include COMSAT Laboratories, the US Air Force, and Nippon Electric Corporation. Others will pursue advanced degrees at Yale in Chemical Engineering, Yale in Political Science, Oxford in Classics, the University of Wisconsin in Astrophysics, Claremont in International Relations, the New England Conservatory of Music, and the New York College of Medicine.

TRAVIS MERRITT

Department of Economics

The dominant problem facing the Economics Department continues to be graduate fellowship support, caused by uncertainties associated with the National Science Foundation (NSF) Fellowship program. This year the number of NSF Fellowships awarded to incoming graduate students in economics was lower than usual, while the number of fellows that chose to attend MIT dropped significantly. The reasons for this decline in enrollments are difficult to understand, but are partly due to aggressive recruiting and generous supplements awarded by competing institutions - particularly Stanford and Princeton. In an effort to obtain more funds for fellowship support, the Department has undertaken a fund-raising campaign. In addition, it has established an Economics Forum to encourage corporate support of the Department and its graduate students.

In spite of the ongoing difficulties associated with funding graduate students in recent years, the Department's Ph.D. program remains attractive to the best students. Gratifying evidence came this year, when MIT's Economics Department was the only one to receive three dissertation fellowship awards (the maximum permissible) under the Sloan Foundation's new fellowship program in Economics. In addition, the Department's graduate students continue to be highly attractive to other major Departments in the job market.

This summer will mark the completion of the renovations to the Economics Department, which will enable the faculty and graduate students to have office space in the second and third floors of the Sloan Building. This will mark the first time in several years that the faculty and students have not been dispersed and/or disrupted by space constraints and renovations. The change in the quality of life afforded by the renovations is notable.

The faculty continue to be highly productive and to publish research in a diverse number of areas. Within the general area of macroeconomics and economic policy, major faculty research was conducted in the following areas: price behavior and economic fluctuations (Professors Olivier Blanchard and Stanley Fischer); taxation and firm behavior (Professors Franco Modigliani and James M. Poterba); profit sharing, inflation, and unemployment (Professor Martin L. Weitzman); search equilibrium and unemployment (Professor Peter A. Diamond); the foundations of macroeconomics (Professor Robert M. Solow); the international debt problem (Professors Rudiger Dornbusch and Richard S. Eckaus); and industrial policy and trade restrictions (Professor Paul R. Krugman). Microeconomics has attracted the following research topics: the current state of economics (Professor Lester Thurow); retirement and savings behavior (Professors Diamond and Jerry A. Hausman); cogeneration and the supply of electricity (Professor Paul L. Joskow); housing markets (Professors Poterba and Daniel L. McFadden); labor markets and organization (Professor Michael J. Piore); regulation and anti-trust policy in the electric power industry (Professor Joskow); the computer industry (Professor Franklin M. Fisher); health economics (Professors Peter Temin and Jeffrey E. Harris); market behavior with many sellers (Professor Eric S. Maskin); and market behavior of commodity futures exchanges (Professor Garth Saloner).

The faculty have received a number of honors this year. Professor Piore received a MacArthur Award, Professor Diamond was elected to the National Academy of Science, and Professor Thurow was elected to the American Academy of Arts and Sciences. Professor McFadden served as First Vice President of the Econometric Society and is its President-Elect for the coming year. Professor Charles P. Kindleberger is President-Elect of the American Economic Association. Professor Modigliani continued as Vice President of the International Economic Association and was elected its Honorary President. Professor Diamond continued on the Council of the Econometric Society, while Professor Ann F. Friedlaender continued as a member on the Executive Committee of the American Economic Association. Professor Thurow received the Champion Award for the best economic writing, and Professor Fischer received the best teacher award from the Graduate Economics Association. Professor Solow gave the first Annual Hicks lecture at Oxford, while Professor Fisher was an Erkinde Fellow at the University of Canterbury in New Zealand.

Several personnel changes in the faculty occurred during the past year. The following faculty were away for the entire academic year: Professor Henry S. Farber, as a Fellow at the Center for Advanced Study in the Behavioral Sciences at Stanford; Professor Timothy J. Kehoe, as a Fellow at Churchill College in Cambridge, England; Professor Jerome Rothenberg, at the Center for Real Estate & Urban Economics at the University of California, Berkeley. Those on leave for a semester were Professor Solow, as a Fellow at Churchill College, Cambridge in the spring term; and Professors Dornbusch and Hausman, on sabbatical at MIT in the fall and spring term respectively. To cover these leaves, the Department had a number of distinguished visitors: Professors Mervyn King of the University of Birmingham and Elhanan Helpman of Jerusalem University were at MIT for the entire year; Professors Ben S. Bernanke of the Stanford Business School and Lars P. Hansen of the University of Chicago were here for the fall term. Professor Robert Wilson of the Stanford Business School gave a very successful set of lectures on the state of research in

oligopoly theory during the Independent Activities Period. One new appointment has been made for the coming year: Jean Tirole of the Center for Teaching and Research in Socioeconomic Analysis in France will join the Department as an Associate Professor. Professor Dornbusch has been appointed Ford International Professor of Economics.

Professor Evsey D. Domar retired this year after a long and distinguished career as an economic theorist and historian. Besides his great distinction in his fields of research, he has been Director of Placement for more than two decades and a stimulating and devoted teacher. We will miss his contributions to the Department.

ANN F. FRIEDLAENDER

Department of Humanities

Anthropology/Archaeology Program

This past year has been one in which a great deal of the Anthropology/Archaeology Program's work has been carried out away from MIT. Of the A/A Program's eight members, four were on leave during all or part of 1983-84, and especially in the Spring Semester, our offices and labs seemed somewhat bare. Next year, although three out of four of this year's stay-at-homes will go on leave for at least a semester, most of the Program's faculty will be in residence. In addition, the program will have a full-year Visiting Assistant Professor, Jonathan Wylie; a Visiting Research Scientist, William Durham; and a Research Associate, Frank Dubinskas.

One of the high points of the year came in February, when the Program was delighted and proud to learn that Professor Heather Lechtman had been named a MacArthur Prize Fellow, with a term of five years. In March, the Center for Materials Research in Archaeology and Ethnology (CMRAE), which is closely associated with the Program, received a grant from Asarco Inc. and its affiliated companies to establish a two-year fellowship. Professor Suzanne De Atley's research next year will be supported by an Old Dominion grant, James Howe's by fellowships from the National Endowment for the Humanities and the Woodrow Wilson Center.

At home or away, all A/A faculty members are pursuing active research programs. Among publications this year, perhaps most noteworthy were Professor Jean Jackson's The Fish People: Linguistic Exogamy and Tukanoan Identity in Northwest Amazonia and Professor Martin Diskin's Trouble in Our Backyard: Central America and the United States in the Eighties. Professor Diskin, who spent 1983-84 at the U.S.-Mexican Center in San Diego, was in great demand for his expertise on the Central American crisis, testifying before Congress and giving numerous invited talks.

The Center for Materials Research in Archaeology and Ehtnology had a highly productive year. In addition to the grant from Asarco Inc. mentioned above, it was notable for another successful CMRAE Summer Institute advanced intensive course, given in June, this year devoted to ceramic technology and taught by Professor De Atley; and for the addition of a new member, Dr. Frederick Wiseman. Dr. Wiseman, appointed as Principal Research Scientist in the CMRAE, is also a lecturer in the A/A Program.

The A/A Program expended considerable energy this year in designing a continuing series of scholarly activities, focused on the cultural interpretation of material objects. This topic, of increasing importance in several fields, inspires a great deal of enthusiasm in the Program, in part because it engages the interest and expertise of both archaeologists and cultural anthropologists. 1984-85 will be devoted to a faculty seminar and to planning for colloquia, conferences, and publications in the following years.

After a three-year term as Program Head, James Howe is stepping down in favor of Professor Arthur Steinberg.

JAMES HOWE

Foreign Languages and Literatures Section

Though morale is high among faculty and staff in Foreign Languages and Literatures (FLL), several problems are of special concern. Enrollments continue to rise, without sufficient assurance of funds to staff our classes adequately. Space limitations remain inadequate; especially vexing is the needed expansion of the Language Laboratory, which will soon be housing microcomputers. Although progress has been made in reducing part-time staffing, the proper balance between professorial appointments and non-faculty (lecturer) appointments is still an issue to be resolved. FLL's strength requires that the number of professorial slots be maintained, if not increased.

Replacement searches conducted this year will bring us two new talented individuals in the fall: Joseph Brami, Assistant Professor of French, whose field is literary theory and modern poetry; and Robert di Donato, Lecturer in German, who is a specialist in foreign language pedagogy.

The curriculum was enhanced this year by a revision of our advanced subjects in French conversation and composition (taught by Lecturer Gilberte Furstenberg); and by the addition of two new subjects, 21.301 The Occult, Mysticism, Religious Heresy, and Literature (taught by Professor Robert Jones) and 21.314 Tolstoy: An Approach to Biography and Creativity (taught by Professor Krystyna Pomorska). The annual and sometimes biennial rotation of upper-level literature subjects has proved to be a successful way of offering students--especially concentrators and majors--maximum choice of subject selection. New subjects designed for next year include 21.293 History of the Spanish Language, 21.299 New Women's Voices, and 21.310 Masterpieces of the Hispanic Tradition.

FLL began this year to work closely with the Experimental Study Group on a joint venture within Project Athena to produce computer-based software for foreign language instruction. Dr. Janet Murray is serving as Principal Investigator of this project, which aims to bring artificial intelligence programming techniques and the latest research in communication theory to bear directly on second language pedagogy. Work is under way for several language-independent prototypes.

The study of foreign languages, literatures, and cultures is perceived by government and industry as a high priority for the 1980s. In this context, a consortium of the Ivy League, MIT, Stanford, and the University of Chicago is being established to work jointly on revising and upgrading instruction in these fields nationwide. FLL participated in several working sessions this year aimed at launching this consortium.

The faculty and staff of FLL continue to be actively engaged in research and publication. The following are indicative of the kinds of scholarly work colleagues are producing. Professor Manuel Delgado's book on political drama in the Siglo de oro, La tiranía en el teatro de Guillén de Castro, has been published in Spain by Editorial Puvill. Professor David Dollemayer's co-authored textbook, Neue Horizonte, appeared from D.C. Heath, and is already in use by colleges nationwide. Professor Robert Jones' book on the dramatist H.-R. Lenormand went to press with Twayne Publishers. Women Writers in Translation: An Annotated Bibliography (Garland Press) was co-edited by Professors Isabelle de Courtivron and Margery Resnick. Professor Pomorska's book (with Roman Jakobson), Dialogues (MIT Press) was published in Russian and Japanese versions. Professor Suzanne Flynn's essay on "Differences Between First and Second Language Acquisition" appeared as a chapter in Acquisition of Symbolic Skills (Plenum Press, London). Lecturer Kathy J. Irving contributed to the journal Theory Into Practice. Senior Lecturer Claire Kramsch's essay "Interactions langagières dans la classe de langue" appeared in Etudes de Linguistique Appliquée. Professor Pomorska's article on Mayakovsky and poetics was published in the American Journal of Semiotics. Professor Edward Turk's essay on the pedagogy of seventeenth-century French poetic texts appeared in Modern Language Studies.

Members of FLL were highly visible at scholarly conferences at home and abroad this year. At the annual convention of our profession's most important organization, the Modern Language Association, Professor Kathryn Crecelius spoke on George Sand's novel Valentine, Professor Michael Geisler delivered a paper on Heinrich Heine, and Senior Lecturer Claire Kramsch spoke on foreign language pedagogy. Professors Julia Alissandratos, Catherine Chvany, and Krystyna Pomorska each addressed the International Congress of Slavists in Kiev, Russia. Professor David Dollemayer read a paper at the Third Annual Döblin Colloquium. Professors de Courtivron and Turk and Lecturer Gilberte Furstenberg presented papers at the American Association of Teachers of French convention in Lille, France. Professor James Harris spoke at the Col.loqui Internacional de Lingüística Teòrica i Llengües Romàniques in Sitges, Spain. Professor Chvany addressed the Annual Conference of the Neo-Formalist Circle in Oxford, England.

Extra-curricular events continue to enhance the quality of our undergraduate mission and our individual intellectual pursuits. Among the invited speakers this year were Professor Annette Insdorf (Yale) on Film and the Holocaust; Professor Edward Ahearn (Brown) on Blake, Baudelaire, and Marx; Dr. Joan Rubin (American Academy of Arts and Sciences) on foreign language learning strategies; and William Sussman on the Spanish Civil War. With the cooperation of neighboring institutions, FLL sponsored the performance of Marivaux's La Double Inconstance by members of the French Conservatoire, and hosted, at MIT, a day-long program on interactive and satellite video for language learning.

Finally, we are pleased to note honors which accrued to faculty this year: the National Endowment for the Humanities provided a grant to Professor Delgado for travel to Spain for his research on Biblical drama; Cornell University nominated Professor Flynn's dissertation for the annual prize awarded by the journal Language Learning; Professor Edith Waldstein was elected President of the Massachusetts chapter of the American Association of Teachers of German; and Professor de Courtivron received a fellowship from the Marion and Jasper Whiting Foundation to pursue her research on the Simone de Beauvoir-Violette Leduc correspondence.

EDWARD BARON TURK

History Section

During the year 1983-84 members of the History Section decided that they would henceforth be known as the History Faculty. The older name, advocates of the change argued, became confusing once the demise of the Department of Humanities made it unclear of what larger unit the historians constituted a "section." Also, the new name requires less explanation to foreign colleagues.

The year also saw several dramatic changes in personnel. Professor Thomas Henry Donald Mahoney retired after having been on the Institute faculty since 1945. A specialist on the eighteenth-century politician and writer Edmund Burke, Professor Mahoney taught subjects in European history and American-Asian relations. At present, however, the Faculty's teaching needs are most pressing in American history. Many subjects in that field have been taught over the past years by persons on temporary, fill-in appointments. The History Faculty therefore held a major national search for American historians to take Professor Mahoney's place and also to replace Professor Alan Brinkley, who left his assistant professorship at MIT to accept a position in the Harvard History Department. Two hundred and thirteen applications were received, and four persons were interviewed. In the end, the positions were offered to two Yalies. Michael McGerr will join the History Faculty as an assistant professor in the fall term. He is a specialist on American political history who traces the decline in voting between the nineteenth and twentieth centuries to a dramatic change in political culture, one from the "spectacular," partisan-oriented politics of the post-Civil War era to the candidate-oriented "advertised politics" of our own time. Sarah Deutsch, who is now completing her doctorate in New Haven, will join the Faculty in January. She is an American social historian whose research is on the Chicano population of Colorado and New Mexico from 1900 to 1935. The arrival of McGerr and Deutsch will add considerable stability to the teaching of American History at MIT.

During the year 1983-84 Professor Philip Khoury was on leave, supported by a post-doctoral fellowship from the Social Science Research Council and an Old Dominion fellowship. He also served as a post-doctoral fellow at Harvard's Center for Middle Eastern Studies. Professor Khoury was awarded the Class of 1922 Career Development Professorship at MIT, which he will hold from 1984 to 1986, and an Andrew W. Mellon fellowship for 1984-85 by the Aspen Institute for Humanistic Studies. The only other assistant professor currently on the History Faculty, Professor Peter Perdue, held the same Mellon fellowship from the Aspen Institute last year. He, too, was on leave from the History Faculty in 1983-84. The recipient of a grant from the Committee on Scholarly Communication with the People's Republic of China, he expected to begin work at the China Number One Historical Archives in Beijing last September. Unfortunately, permission for him to enter the PRC and use the Archives was denied in late summer. Thanks in part to the urgings of the Provost, Francis Low, the PRC finally granted Professor Perdue access to its holdings, and he arrived there early in 1984.

Senior faculty members also had some success in obtaining grants. Professor Robert MacMaster received an IREX grant to continue his research on Tolstol in the Soviet Union, which he hopes to visit next spring. Professor Robert Fogelson was awarded a grant from the Graham Foundation to help him pursue a study of the social and architectural history of American armories. Professor Peter Smith will serve as a Fulbright Senior Lecturer in Mexico during the summer of 1984. And Professor Robert Rotberg continues to be supported in part by a grant awarded by the Research Division of the National Endowment of the Humanities, to sustain work on a biography of Cecil Rhodes.

Several books were published or completed by Faculty members. Professor Khoury's Urban Notables and Arab Nationalism; The Politics of Damascus, 1860-1920 was published by Cambridge University Press in the fall of 1983. Modern Latin America, by Professors Peter H. Smith of MIT and Thomas E. Skidmore of the University of Wisconsin, Madison, appeared in the spring. Professor Bruce Mazlish's The Meaning of Karl Marx is scheduled for publication by Oxford University Press in August 1984, and Professor Robert Fogelson's Pensions: The Hidden Cost of Public Safety will be brought out by Columbia University Press in September. Professor Pauline Maier completed work on an American history textbook for eighth grade that commanded her attention over the past two years. The book will be published by D.C. Heath and Company in 1985 or 1986. Other major projects now nearing completion include Professor Arthur Kaledin's study of Alexander DeTocqueville and Professor William Watson's study of Ernest Hemingway, John Dos Passos, and Joris Ivens in the Spanish Civil War. Members of the History Faculty also published or completed a number of scholarly articles over the past year. Among them was Professor MacMaster's "Tsarism Right Side Up in Tolstol's Polikushka," in American Contributions to the Ninth International Congress of Slavists (Kiev, 1983), Professor Harold Reiche's "Ancient Myths of Decline and End" in The End of Mankind in Western Imagination (New York, 1984), and several articles on Africa by Professor Rotberg.

Members of the History Faculty serve on the editorial boards of several scholarly journals, including the Journal of Interdisciplinary History (which is edited in Building 14 by Professor Rotberg), Reviews in American History, the American Historical Review, Political Psychology, The Psycho-History Review, and Family History; and they have given lectures or papers at a large number of occasions held outside the Institute. Professor Peter Smith also organized a conference on "Statistics, Epistemology, and History" which was held, with the support of the Sloan Foundation, at MIT last fall. It should be noted, too, that Professor Rotberg remains a member of the Executive Council of the American Historical Association (AHA). Professor Maier is now a member and will next year be chair of the AHA's Nominating Committee.

The History Faculty sponsored a particularly successful series of lectures in the spring of 1984 on "Power, Politics, and Public Places: Monumental Design in History." Speakers included Professor Robert Fogelson, Professor of Urban Studies and History at MIT, Julia Trilling, a lecturer in the Department of Urban Studies, and Professor Thomas N. Brown of the University of Massachusetts, Boston. The History Faculty also helped sponsor a lecture in memory of Malcolm H. Kerr, President of the American University of Beirut. That lecture, which Professor Khoury arranged, was given by Charles Issawi, Bayard Dodge Professor of Near Eastern Studies at Princeton, on February 23.

Professor David Ralston, who taught at the University of Singapore during 1983-84, will return to MIT in 1984-85, as will Professors Khoury and Perdue. In the spring of 1985, three members of the Faculty will be on sabbatical leave---Professors MacMaster, Reiche, and Kaledin.

In conclusion, it should be noted that a change has occurred that can be at most suggested in any brief summary of the History Faculty's current activities. The professional strength of the Faculty has taken a dramatic upward turn. In each of the last four national searches conducted by the History Faculty, it was able to hire the top candidate(s). The future of any institution is best predicted by the strength of its most junior members, and History Faculty's junior members are an especially promising group. Among the senior faculty, too, publications and other professional activities have increased. Members of the History Faculty are able to contribute more richly to other programs within the Institute than was the case in many past years, and should, in general, enhance MIT's reputation for excellence in areas beyond science and engineering. The challenge for the future will be less to "turn things around" than to sustain and build upon the progress already made.

PAULINE MAIER

Literature Section

Of the three most pressing problems confronting the Literature Faculty, two are chronic and concern the needs of adequate staffing and of research support for faculty currently at hand. Those familiar with sources of external research funding in the humanities will know that the likelihood of successful grant applications is about 7.9% for all fields of study and 1.5% in literature. At the same time, internal sources of funding are practically non-existent, and the bulk of research expenses as well as a considerable portion of research times must go unremunerated. As for staffing: The Literature Faculty offers a three-tiered curriculum, whose aim is to explore the possibilities of literature as an expression of mankind's basic narrative and poetic capacities. The point of the tiering system is in part to ensure that some subjects enroll a significant number of students with one or more subjects in literature behind them, and in part to afford faculty an opportunity to develop their research interests in the classroom, despite the generalized character of the program. Currently, however, the number of sections offered by the faculty is not sufficient to assure a due proportion of first and second level subjects "feeding" students into the third tier, and each year several ad hoc temporary appointments must be made, utilizing funds made available by unpaid faculty leaves. The situation is not satisfactory and is likely to be with us for some time. The third problem concerns the decline of recent years in the number of literature majors by nearly fifty per cent. Although the number of concentrators has remained steady and the number of majors was never large, the latter's presence in the classroom was of perceptible advantage to the former. As majoring in literature has waned, so majoring in writing has waxed. We are uncertain how to address the problems arising from the shift in student interest.

We are pleased to report the resolution of another long-standing problem. The absence of faculty representation in the literature of drama has been filled by the appointment of Professor Theoharis C. Theoharis. Medieval literature, however, continues unrepresented, and Black literature is represented only by a temporary appointment.

On the scholarly front, the faculty continued to maintain a substantial MIT presence in literary studies at the national and international levels, by acting in various editorial and consultational capacities for learned journals (e.g., Classical World, Ancient Philosophy, Transactions of the American Philological Association, Classical Journal, Cinema World, American Quarterly, Radical Teacher) and for several university presses (e.g., Princeton, Illinois, Nebraska, Georgia, Columbia, Wesleyan) and also by offering papers and seminars at diverse meetings and institutions, both in this country and abroad. Of special note were invitations to speak before international conferences on Orwell (at Strasbourg and Ohio State), Literature and Science (at San Francisco), Women's Studies (at Rome), Shakespeare (at the Modern Language Association [MLA] in New York), and American Television (at the Siebert Seminars in Illinois). Mention should also be made of the fact that the Literature Faculty led a special session at the MLA on the problems of teaching in the humanities at predominantly scientific and technical institutions. A creditable number of essays have appeared by members of the faculty on subjects as various as Shakespeare, baseball, bucolic poetry, modernist poetry, Edith Wharton, the practice of literary theory, Plato, and women's studies, in journals such as Renaissance Quarterly, Criticism, Women's Study Quarterly, Arena, American Poetry Review, ESQ, and Twentieth-Century Literature, among others, and six essays have appeared in book format: two by Professor Peter S. Donaldson (on Machievelli and on narcissism in King Lear), one by Professor Irene Taylor (on the figure of the female in eighteenth-century literature), one by Professor David M. Halperin (on Solzhenitsyn), and two by Professor Cynthia Griffin Wolff (on Edith Wharton and on Joan Didion). In addition, Professor Halperin published two lengthy encyclopedia articles. The year also saw the appearance of Professor Stephen J. Tapscott's book on the poetry of William Carlos Williams and Professor William J. Paul's book on the American films of Ernst Lubitsch, a book of poetry by Professor Tapscott, an edition of The House of Mirth edited by Professor Wolff, and a novel, The Snow Ball, by Professor A. R. Gurney, Jr. Members of the faculty also published several poems and translations and two short stories, one of which (by Professor John Hildebidle) was co-recipient of the Katherine Anne Porter Prize in Fiction. Counting the production of a play as a form of publication, we list here the appearance of Professor Gurney's The Golden Age on Broadway. Professor Gurney's previous success, The Dining Room has been produced in translation in several countries abroad, and an adaptation has been taped for future broadcast on national television's American Playhouse series.

This year deserved promotions to the rank of Associate Professor went to Professors Amy Lang and William Paul. In addition, members of the faculty received awards from the American Council of Learned Societies (ACLS), the Massachusetts Council for the Arts, the Annenberg Scholars Program, and the Associated Writing Programs Award for Poetry. We also note the selection of Professor Wolff as future

chairman of the prestigious Hubbell Award Committee. Finally, we take pleasure in the completion of a book-length manuscript by Professor Donaldson on Machiavelli and the mysteries of state and by Professor Lang on the figure of Anne Hutchinson in American literature.

ALVIN C. KIBEL

Music Section

For the Music Section, this year was notable in the coincidence of several important anniversaries and the writing of our first Long-Range Plan. We celebrated in concerts, competition, exhibits and ceremony the One Hundredth Anniversary of the first organized Musical Groups (Glee Club and Symphony Orchestra), the thirty-fifth year since John Corley started the Concert Band and the tenth years of both the MIT Chamber Music Society and the Experimental Music Studio. This festive look to the distant and recent past was useful in clarifying and projecting future goals and directions in Section leadership, instruction and research.

In terms of leadership, our experiment with annual change of the Section chair which began with Professors John Harbison and David Epstein continued this year with Professor Marcus Thompson. He created a three-person chair committee consisting of the present, former and next officers in order to improve communication and assure greater continuity. The experiment which continues for three more years is intended to offer each of us a wider perspective on our needs and provide more flexibility and options to the nearly twenty-five year term that shaped the Section at its inception. We received a considerable boost to our efforts with the help of a new Administrative Assistant, Nancy Cavanagh, through whom faculty decisions concerning the Musical Groups (such as budget supervision, use of practice spaces) as well as the usual academic matters are implemented. Her presence over the next several years will also enhance continuity. Professor Thompson reaffirmed the Section's commitment to affirmative action goals and process through appointment of a four-person committee consisting of Professors John Buttrick, Jeanne Bamberger, Jane Coppock and Marcus Thompson.

In terms of instruction there were several new developments. With the creation of a new subject, 21.659 Advanced Music Performance, ten instrumental students who are members of the Musical Groups became the first to study privately for credit with master teachers at New England Conservatory and MIT under direct supervision of the faculty. Financed in part by contributions to the Section by Ragnar Naess, Rudolf Gruber and through a special arrangement with New England Conservatory, this subject is expected to help maintain and increase the high level of performance in the Musical Groups. Faculty approval of an equivalent in vocal study and a generous grant from the Council for the Arts at MIT will allow this option to expand in the coming year. These developments come at a time when the already underfunded Musical Groups will sustain budget cuts ranging from 5% to 15% after two years of no increases. In the coming years we will need to restore these losses and encourage through a thoughtful redistribution of funds even greater activity of those groups whose overall programs meet Section goals of developing individual professionalism and musicianship. Projected shortages have a chilling effect on future plans for touring, editing of recordings, the purchase of music and repair of instruments.

In addition, the faculty has approved new subjects in Non-Western Music to complement two subjects already offered in Western Music and Film Music to join new offerings elsewhere in Film and Media studies. Overall enrollments were 425 in the fall and 379 in the spring. These figures do not include the large numbers who participate in the Musical Groups without credit.

This was also a year in which plans for pursuing advanced research within MIT in Music Cognition and Theoretical Studies gained momentum in the seeking of grants, setting of timetables and strategies and in the recognition of new ways in which research efforts by Professors Epstein and Bamberger can profit by a closer association with the Experimental Music Studio. Professor Barry Vercoe, Director of the Experimental Music Studio, informs us of the expansion of graduate offerings beyond the present Master of Music and Technology degree to the Doctorate of Music and Technology (in cooperation with the School of Architecture) to begin this fall with the Studio's move to the new Arts and Media Technology building and the arrival of two graduate students.

The faculty and teaching staff remain active in concertizing, recording, editing, advising, lecturing, research and publication. Professor Stephen Erdely and his wife Beatrice recorded works for violin and piano by Dohnanyi, Weiner, Bartok, Kodaly for Pantheon Music International; three of pianist Professor Buttrick's recordings of Beethoven Sonatas, Brahms Intermezzi and Schubert Songs with Soprano Elisabeth Speiser were released in Europe; Professor Thompson recorded works by Mendelssohn and Beethoven for Spectrum Records with pianist Barry Snyder at Eastman School of Music. The John Oliver Chorale will soon be heard on Northeastern Records as will Lecturer Melissa Howe in the String Quartet #2 by Thomas Oboe Lee.

In performance Professor Epstein appeared as guest conductor with the New Philharmonic Orchestra of Paris and in Alice Tully Hall in New York with The New Orchestra of Boston which he founded and which will also be performing this summer at the Mozarteum in Salzburg, Austria. Professor Buttrick toured Switzerland and Germany as recitalist and was soloist in the Reger Piano Concerto with orchestra in Winterthur.

Professor Thompson returned to festivals in Alaska and Seattle and for the first time was guest with the Manhattan String Quartet at Music Mountain. He also appeared at the Cape and Islands Chamber Music Festival where he premiered Sonata for Viola and Piano with composer/pianist Anthony Newman. The work was commissioned by the Council for the Arts at MIT and later performed on recitals at Kresge Auditorium and Carnegie Recital Hall. Senior Lecturer John Oliver's Tanglewood Festival Chorus was heard throughout the Boston Symphony Orchestra season in works by Debussy, Durufle, and Franck; in a rarely heard complete version of Mahler's Das klagende Lied, which was repeated at Carnegie Hall, and in the World Premiere of Tippett's The Mask of Time. The John Oliver Chorale performed the Britten War Requiem at Symphony Hall under Mr. Oliver's direction. Lecturer Mark Harvey appeared in jazz performances throughout New England and here at MIT as leader of AARDVARK and as a member of RIBS. Lecturer Martin Marks improvised music for silent films at the Harvard Film Archive.

Professor Harbison's Symphony #1, commissioned to commemorate the Boston Symphony Orchestra Centennial, received its World Premiere at Symphony Hall. Professor Epstein's Lament of Job, The Seasons, Vent-ures were played at Florida State University. His Night Voices was played by the Denver Symphony Orchestra. Senior Lecturer, Edward Cohen's String Quartet #1 was premiered in Kresge Auditorium by the Atlantic String Quartet.

Professor Bamberger lectured at three universities in Israel; Professor Epstein at universities in Florida, Montreal, Indiana, Ohio, Cincinnati College Conservatory and at Von Karajan Symposium in Salzburg. Professor Erdely spoke at the New Jersey State Museum and at Indiana University. Professor Thompson joined the Viola Faculty at New England Conservatory.

Professor Lowell Lindgren began his term as review editor of the Journal of the American Musicological Society by reviewing Robert S. Freeman's Opera without Drama: Currents in Italian Opera, 1675-1725. He also served on two planning committees for Boston celebrations of the tercentenaries of Bach, Handel and D. Scarlatti. Professor Thompson was appointed to the Board of Directors of the American Viola Society, to the Solo-Recitalist review panel of the National Endowment for the Arts and re-elected to the Board of Directors of Chamber Music America. Professor Bamberger served as consultant to the BBC for a series on Development and Giftedness. Professor Buttrick spoke at Governor Dukakis' Seminar on life in a high-tech society; Professor Epstein served on visiting committees at Brandeis University and Mt. Holyoke College.

Lecturer Claudia Von Canon's book The Inheritance (Houghton-Mifflin, 1983) was placed on a list of "Sixty Notables" by The American Librarians' Association; Martin Marks' article, "The Well-Furnished Film: Satie's Score for Entr'acte." was published by Canadian University Music Review; Professor Bamberger's article "Perception and Representation" was accepted by Psychomusicology and her chapter "Developments of Musically Gifted Children" in the book New Conceptions of Giftedness, Ed. R. Sternberg is in press. Professor Epstein's String Quartet was published by Carl Fischer, Inc.

Research into how Hungarian identity is maintained through the use of folklore is continuing with Professor Erdely as a member of a team of six investigators on a grant to Indiana University from the National Endowment for the Humanities. Professor Lindgren resumes his research abroad this June on the Marion and Jasper Whiting Foundation Fellowship. Lecturer Howe completed research and writing leading to the doctorate in music and psychology and was awarded the degree by Boston University.

Professors Coppock and Harbison were on leave for the full year, she to write, he to complete the second of two years as Exxon-Rockefeller Composer-in-Residence for the Pittsburgh Symphony Orchestra. During his tenure he developed and led the Music Here and Now series. He returns to us as Class of 1949 Professor of Music. Professor Bamberger was Visiting Professor at the University of Tel Aviv for half the year; she returns to us as Section chair. Professor Lindgren was Visiting Associate Professor of Musicology at Eastman School of Music for the first semester; he returned to us as tenured Associate Professor of Music in the second semester. Professor Barry Vercoe was on half-leave for the second semester during which time he made major breakthroughs in his research at l'Institut du Recherche et Coordination Acoustique/Musique in Paris to integrate computer sound into real-time ensemble performance. He returns to us by continuing his summer seminars for composers from which much music is created and performed.

In this festive year there is much to appreciate about our students. Among the highlights, the Jazz Bands under the direction of Herb Pomeroy and Everett Longstreth were once again winners of national awards at annual competitions. The Concert Band, under the direction of John Corley for the last thirty-five years, presented a very moving tribute to him in its performance of works written for the band and in one case by a band member to an audience which included many former members. The MIT Symphony Orchestra, under the direction of Professor Epstein presented the keynote concert in celebration of the one hundredth anniversary of all the Musical Groups. Graduate student Barbara Hughey, who was soloist in the Brahms Violin Concerto received a standing ovation led by President Paul Gray. Graduate student Douglas Carlson became the second recipient of the Hsu Prize for composition for a fanfare in celebration of the one hundredth anniversary. Patrick Yacono, along with members of the Chamber Players, Melissa Howe, Research Associate Stephen Umans and alumna Stephannie Wingfield gave a moving performance of Olivier Messiaen's Quartet for the End of Time; John Oliver recovered quickly from surgery for appendicitis to lead a triumphant performance by the MIT Choral Society of Mendelssohn's Elijah. The concert was attended by the

Music Section's first Director of Music Professor Emeritus Klaus Liepmann and his wife. Fifteen present and former winners of the Ragnar Naess Award appeared in two end-of-year recitals for a joyous Ragnar and Margaret Naess who later increased their fund by \$5,000. The MIT Symphony Orchestra and the MIT Concert Band were co-recipients of the Jerome and Laya Wiesner Award. All told nearly seventy-five concerts and lectures by students, faculty, staff and visitors were ably produced for the Section by Concert Coordinator Clarise Snyder.

The Section expresses its gratitude to Dean Harold J. Hanham for his encouragement and enthusiastic assistance throughout his tenure. There is sadness at the news of several departures: Professor Timothy Aarset, Director of the Early Music Society to another institution (hereafter we will share instruction and facilities with The Collegium Musicum at Wellesley College); Gordon Hallberg, Director of the Brass Ensemble (who also leaves the Boston Symphony Orchestra) to enter another profession; Lee Callander, secretary, to another position; Linda Solow, Music Librarian for twelve years, who although not officially a member of our Section has always been close to our hearts. She leaves to marry Steven B. Blotner. We wish them well.

MARCUS AURELIUS THOMPSON

Writing Program

Now slightly over a decade old, the MIT Writing Program has been experiencing unprecedented growth in demand for its educational services. This growth is expressed in calls for increased (1) expository, creative, and technical writing instruction in conventional writing subjects, (2) inter-departmental (co-op) instruction in undergraduate and graduate programs in the School of Engineering, (3) consultation and special subject offerings for students satisfying the new Institute Writing Requirement, (4) drop-in writing center consultation for members of the MIT community, (5) counselling and career development for MIT writing majors preparing for professional careers in technical communication, and (6) planning and coordination for popular visiting artists series. The Summer Session short-course in Communicating Technical Information has been inundated with applicants from industry, as far away as Hong Kong; new demands are being placed on the Writing Program to provide leadership in Project Athena writing-related research; and still more requests are being made by the ILP and the Summer Session for professional writing seminars offered to MIT alumni.

Faculty development and program design therefore continue to be major objects of consolidation in the MIT Writing Program. These two priorities are vital to keeping the Program abreast of the burgeoning interests in writing at MIT. Although the growing interest in writing has been gratifying to witness, the planning and administrative demands placed on the Program's small faculty have been great. Consequently, efforts to hire replacements for departing faculty are currently taking precedence, and a long-term staffing program is being developed. The Program is staffed largely by visitors and part-time lecturers, an arrangement that requires careful maintenance. To date, the Program has been able to meet the growing interests by means of cleverly-designed low-budget programs funded variously by the Offices of the Dean of Engineering, the Dean of Humanities, and the Provost, but, like many other Institute departments, the Writing Program was required to take a budget cut in excess of 6 percent this year.

This year, members of the Writing Program made special efforts to review and strengthen basic subjects in the three main areas of the Program--(1) Exposition and Rhetoric, (2) Creative Writing, and (3) Science and Technical Writing. This curriculum review was made in order to define more clearly what content applies to the Program's beginning, intermediate, and advanced subjects. It is especially important to fine-tune the main Writing Program curriculum, in order to understand just how to meet the diverse needs of students who enroll in Program subjects for reasons as different as those of passing the Institute Writing Requirement, studying the art of short story writing, and learning how to write professional science and engineering documents. As before, the 1983-84 review reaffirmed the Program's policy of integrating the three different writing areas within the program. Most members teach in at least two of these areas, and our diverse faculty collaborate fully in teaching writing at MIT.

Student enrollments in the Writing Program (Total = 910) grew by about 100 this past year, largely as the result of the new Institute Writing Requirement. The numbers of writing concentrators also grew by about 35% from 65 last year to 89 this year. In addition, the Program continues to have the largest number of Course XXI majors, mainly because students are increasingly seeking employment in the growing field of technical communication as professional science and technical writers. Student enrollments in the Program continue to divide about equally, among Exposition and Rhetoric, Creative Writing, and Science and Technical Writing.

Program development in the Writing Program continues to be vigorously interdepartmental. In 1983-84, the Coop Writing Programs, jointly sponsored with the School of Engineering, continued to develop at both undergraduate and graduate levels. Undergraduate Coop reaches more than 800 MIT students annually. The Graduate Cooperative Writing Program, which tests and instructs graduate engineering students in writing, expanded this year to the Department of Chemical Engineering with a very successful first year. Seven out of 8 engineering departments now participate. In an effort to gain some perspective on Departmental support of the graduate cooperative programs in writing, the Dean of Engineering asked the Writing Program to secure its own funding from respective engineering departments. Although this measure required that the Writing Program plan and carry out an internal funding campaign, all departments voted funds to continue the Programs. Graduate Cooperative Writing Programs in the Sloan School of Management (Prof. JoAnne Yates) and the Department of Urban Studies and Planning (Dr. Louise Dunlap) were transferred from the Writing Program to their respective departments this year, in order to conserve Writing Program resources and to encourage these very successful programs to develop new relationships with their constituents.

The Writing Requirement passed by the faculty in the Spring of 1982 still poses some planning and budget unknowns for the Writing Program. Although the impact of an additional 100 students or so in the past academic year (1983-84) was by no means severe, well over 100 freshmen have not satisfied the requirement as of June, 1984. It is not clear whether they will elect to do so by taking writing subjects this coming fall. And it is still too soon to determine just what the student patterns will be. Members of the Writing Program continued this past year to help the Committee on the Writing Requirement meet with department representatives throughout the Institute to develop undergraduate cooperative writing instruction, so that students will have additional options for meeting the second stage of the Writing Requirement. In the second stage, students must demonstrate competency in writing professional prose within their chosen majors in science or applied science.

The Writing Program's Writing and Communication Center continued to develop this past year, with the aid of the ESL group of the Foreign Language and Literature section and with funding from the office of the Provost. Conceived in 1981, the Writing Center has grown quickly in the course of two years and a half, with student use of its facilities almost doubling again this past year. Run by Dr. Steven Strang, the Writing Center offers both drop-in consulting services for students, staff, and faculty, and a popular series of noontime seminars on writing. The first two years and a half of operation have shown the Writing Center to be a popular resource for the MIT community. The center also plays an important role in helping students meet the Writing Requirement. Support for this program has been given by the Provost's office, the Dean of Humanities and Social Science, and the Writing Program itself; long-term funding still needs to be found for this program.

The Readings Committee of the Writing Program (R. Becker, F. Howe, M. Richardson) prepared one of the most widely-acclaimed reading series ever offered at the Institute. The series, called Women, Writing, and Society, drew more than 2,000 people from throughout the state. Featuring Gwendolyn Brooks, Margaret Atwood, and Grace Paley, as well as a panel of black writers consisting of Ann Petry, Dorothy Sterling, and Dorothy West, the series was widely reviewed in the local media. Next year, the committee will sponsor a series of readings and discussions by noted science-fiction authors.

Faculty research and writing are conducted in many areas and published in a variety of forms too numerous to detail: research on science and the media, (Professor Rae Goodell); biography of Rosa Luxemburg (Professor Elzbieta Chodakowska); a novel set in post-war Germany (Ilona Karmel); textbook on research writing and research on industrial in-house writing practices and education (Professor James Paradis); study of the idea of Zionism (Professor Bernard Avishai); changing status of animals in nineteenth century England (Professor Harriet Ritvo); a collection of essays on technical writing and research on a drill and instruction computer program to help writers (Professor David Dobrin); biography of sculptor Mary Edmonia Lewis (Professor Marilyn Richardson); collection of short stories about women (Professor Robin Becker); textbook on modern writing style and study of Iris Murdoch (Dr. Steven Strang); textbook on writing about computer technology (Dr. Charles Sides).

The faculty have received a number of honors this year. Professor Elzbieta Chodakowska was appointed to the Thomas Melloy Chair in Rhetoric at MIT. Professor Kenneth Manning was nominated for a Pulitzer prize for his biography of E.E. Just; Professor Harriet Ritvo received a Visiting Fellowship to the Yale Center for British Art; Professor Marilyn Richardson was appointed Fellow, W.E.B. DuBois Center for Afro-American Research at Harvard University; Professor Robin Becker received a residency grant from the Helene Wurlitzer Foundation; Professor Bernard Avishai was appointed a Faculty Associate at the Harvard Center for Middle Eastern Studies; Professor Joe Haldeman was nominated for the Nebula Award in Science Fiction; Professor Rae Goodell was the keynote speaker of the Council of Biology Editors annual meeting; lecturer Charles Sides received the National Distinguished Technical Communication Award of the Society for Technical Communication for his work on syntax and style.

There were several changes in faculty and personnel in the Writing Program this past year. Professor Kenneth Manning has taken a joint appointment as associate professor in the Writing Program. Prof. Barbara Gastel left the Writing Program to continue her stay as visiting Professor of medicine and communication at the Beijing Medical College, and Professor Ellen Chu resigned from the Program to take a post as the Editor of Bioscience magazine. The distinguished short story author and poet, Arturo Vivante, will be visiting Professor of Writing in the Program next year; Peter Gwynne, editor of Technology Review, will teach science writing in the Program next year.

JAMES PARADIS

Department of Linguistics and Philosophy

In last year's Report to the President it was noted that one of the Department's major problems was in securing financial support for graduate students and that attempts were being made to find assistance from federal and private sources. The Department has been moderately successful in these attempts and the picture for the coming year is brighter. Nonetheless, efforts to seek additional forms of support must continue in order to place the graduate students support program on a firm basis for the foreseeable future.

This year has also been the year of the Visiting Committee. Under the new chairmanship of Mr. Edward Thompson, the Committee met during the Fall. Its report has not yet been made generally available. However, students and faculty found the visit useful and informative and observations made during the course of the visit and subsequent conversations with the chairman have been helpful in planning future directions and changes for the Department.

Research: Linguistics

In linguistics research was carried forward in four major areas; namely, syntax, semantics, morphology and phonology. The major effort in syntax continues to be the development of Government and Binding Theory. In semantics research into the nature and formal properties of logical form dominates attention, in morphology and phonology there is intensive work being done on the so-called lexical phonology hypothesis. Work in the relationship between phonology and phonetics is also underway.

Research: Philosophy

In philosophy research activity included work in the field of logic, in Rousseau's theory of justice and democratic order, in ethics and in questions concerning time, causation and the historical character of scientific knowledge, to name a few.

Publications

As usual, faculty members in both sections were busy presenting papers and taking part in colloquia around the country and the world. More than sixty articles and reviews and three books have been published by the faculty during the past year. The books are: On Democracy by Professor Joshua Cohen with Joel Rogers (Penguin); The Fateful Triangle: the U.S., Israel and the Palestinians by Institute Professor Noam Chomsky (South End Press) and CV Phonology: A Generative Theory of the Syllable by Professor Samuel Jay Keyser with G.N. Clements (MIT Press).

Honors

Several honors were bestowed upon faculty members during the year.

Professor Ned Block has received a Guggenheim fellowship for next year and will spend the year at the Center for the Study of Language and Information at Stanford University. His article, "Mental Pictures and Cognitive Science," which appeared in The Philosophical Review, XCII, No. 4, 1983, was selected by The Philosopher's Annual as one of the ten best articles to appear in English in the field of philosophy last year. (This article was included in the Occasional Paper Series of the Center for Cognitive Science as Occasional Paper No. 22.)

Professor Chomsky has been named one of the recipients of the Distinguished Scientific Contribution Award of the American Psychological Association. The award was made in part because of important contributions to the field of cognitive psychology. He also received the honorary degree of D.H.L. from the University of Pennsylvania.

Professor Cohen was co-recipient of the Harold E. Edgerton Faculty Achievement Award given to outstanding non-tenured faculty.

Professor Judith W. DeCew has been awarded a Fellowship for 1984-85 from the American Council of Learned Societies.

In recognition of his outstanding contributions to the study of linguistics, Institute Professor Morris Halle was honored by the publication of a festschrift, Language Sound Structure (MIT Press). This collection of essays on phonology was contributed by many of his former students and his teacher, the late

Roman Jakobson, Institute Professor Emeritus, on the occasion of Professor Halle's sixtieth birthday. This is the second festschrift that Professor Halle has been honored with, the first having been presented on the occasion of his fiftieth birthday by an earlier generation of his students.

Professor Thomas S. Kuhn became the first Laurance S. Rockefeller Professor of Philosophy, thanks to the endowment of a chair given by Mr. Rockefeller. Professor Kuhn also received the John Desmond Bernal Award from the Society for Social Studies of Science for "distinguished contributions to the social studies of science".

Educational Activities

This year was the first for the newly instituted Proseminar in Philosophy. Under the direction of Professor Richard Cartwright, the subject is required of all first-year graduate students in philosophy and meets six hours per week.

In May, the department sponsored a four-day Conference on Philosophy and Cognitive Science under a grant from the A. P. Sloan Foundation. The Conference, arranged by Professor James Higginbotham, was held in conjunction with the Society for Philosophy and Psychology, and participants included philosophers, linguists and psychologists from this country and one from Canada.

Personal Computers

One of the more noteworthy departmental activities during the year was the acquisition of personal computers for students, faculty and staff. Six DEC Rainbow personal computers have been made available for student use. These machines, in conjunction with the printing facilities now available in the Center for Cognitive Science, have made it possible, among other things, for students to prepare and print their own theses. Aside from the obvious convenience of this arrangement, there is a considerable financial savings for students since it is no longer necessary for those students making use of this facility to pay for thesis typing. Students have also begun to use these machines heavily for paper preparation in graduate courses and if the trend continues, it may be necessary to purchase two to three additional machines for graduate student use.

Approximately fifteen DEC Rainbows have also been made available to faculty in the department. Although the heaviest usage has been in the area of word processing, members of the department have begun to explore other software applications as well, including ones making use of special graphics programs and various programming languages. Professor Higginbotham, the departmental representative to Project Athena, is currently at work in developing software for possible use in departmental courses.

Six DEC Rainbows have also been made available to departmental staff. These machines are used for letter writing, report preparation and record keeping. They are also used in connection with faculty manuscript preparation since faculty and staff are using the same machines and the same word processing software. While there are still problems involved in integrating these machines into the daily operation of the department after the first year of use, it is already clear that they have become an indispensable part of the department and will have a profound effect on the daily operation of the department in the future.

Sabbaticals

Professor Kenneth Hale spent his sabbatical leave in Belgium and the Netherlands and was Visiting Professor at the Katholieke Hogeschool in Tilburg, the Netherlands.

Professor George Boolos spent the spring semester in Oxford, England, on a fellowship from the National Endowment for the Humanities.

Personnel

We were saddened by the death of recently-retired Professor James F. Thomson in February. In his honor, the James F. Thomson Memorial Lecture was held in May. The speaker was Hilary Putnam, Walter Beverly Pearson Professor of Modern Mathematics and Mathematical Logic, Harvard University, who spoke on topics related to Professor Thomson's research interests.

We regret to announce that Professor Paul Kiparsky has accepted a position at Stanford University.

We are pleased to welcome three new people to the faculty. Professor Luigi Rizzi, who spent this year as Visiting Professor in Linguistics, will become a regular member of the staff, and Professors Donca Steriade and John Carrierio will join linguistics and philosophy respectively.

Department of Political Science

Events have conspired this year to lead the Department into a thorough review of its goals and programs. One stimulus was provided by the Provost's request that each department prepare a long-run plan. Preparation of a draft of this document within the Department, and subsequent discussion of it with the Administration and the Visiting Committee, have proven useful in articulating the Department's distinctive qualities and helping to clarify the choices that must be made for the decade ahead. A far sharper stimulus for reassessing our needs and priorities has been the loss of several valued members of the Department, above all two irreplaceable senior colleagues, Professor Ithiel de Sola Pool who died in March, and Professor William W. Kaufmann who retired in June.

Ithiel Pool's death, after a stubborn battle with cancer, is a particularly painful blow to the Department. A member of the Institute faculty since 1953, Professor Pool led the way in the Department's founding and subsequent development. Combining a spirit of rational inquiry with passion in defending his beliefs, he set intellectual and moral standards for the Department. His innovative scholarship made him a world figure in communications research, and his entrepreneurial talents served to build an interdisciplinary Research Program on Communications Policy involving faculty and students from many parts of the Institute. Professor Pool's last book, Technologies of Freedom, has been acclaimed for brilliantly combining a sophisticated exploration of the potential impact of new communication technologies with a penetrating legal analysis of ways in which First Amendment rights can be preserved. It is a source of great pleasure and pride to his friends and family that this book has recently been named winner of the Gladys Kammerer Award of the American Political Science Association for the best book in 1984 on U.S. domestic policy. Professor Pool was further honored this spring by an Award for Exceptionally Distinguished Achievement from the American Association for Public Opinion Research.

Equally difficult to replace will be Professor Kaufmann, who retired in June after more than two decades of research and teaching at MIT on defense policy issues. Since 1961 he has been the mainstay of the Department's defense and arms control program, arguably the leading training program of its kind in the country. He became legendary as a teacher, not only for his masterful lectures on defense planning and budgetary issues, but for the extraordinary patience and thoughtfulness with which he addressed students seeking personal attention or advice. The wonder was that while devoting great energy to his teaching, he was leading close to a second life in the nation's capital. Professor Kaufmann has served as consultant to no less than four Secretaries of Defense, in both Republican and Democratic administrations, drafting defense posture statements and speeches and winning recognition as the country's most experienced and skilled analyst of the defense budget. In recent years he has continued to pursue these issues as a consultant to the Brookings Institution, a relationship he intends to continue after his retirement. He will continue to do some part-time teaching as well, at the Kennedy School of Government at Harvard, an arrangement that will permit our own students to take advantage of his offerings for some time to come.

Since these two senior figures occupied unique positions in their respective fields, and in the life of the Department as well, the hole left by their absence will be hard indeed to fill. We must, moreover, rebuild in other areas as well. As chance would have it, four gifted junior faculty members left this spring to take up positions elsewhere: Associate Professor Ted Greenwood in defense studies and science policy, Assistant Professor Thomas Ferguson in American politics, Assistant Professor John Freeman in empirical research methods, and Assistant Professor Emma Jackson in urban politics. It is rare for a relatively small department to have so many vacancies to fill at one time, and we intend to take advantage of the opportunity to rethink priorities and review the balance among the Department's subfields. Professor Myron Weiner has been named chair of an expanded Personnel Committee that will coordinate the searches planned for the coming year. One position, in arms control and defense studies, has already been filled by the appointment of Steven E. Miller, who comes to us from the Kennedy School at Harvard where he has edited the journal International Security.

Several changes in faculty status deserve mention. Associate Professor Stephen M. Meyer, who specializes on Soviet and military policies and is a mainstay of our arms control and defense program, has been promoted to tenure. Richard J. Samuels, an expert on Japanese politics and international energy issues, has been promoted to Associate Professor and has simultaneously been named Mitsui Career Development Professor in Contemporary Technology. Also promoted to Associate Professor is Joshua Cohen, who teaches political philosophy in both this Department and the Department of Linguistics and Philosophy. Professor Cohen was further honored this spring by being named co-recipient of the Edgerton Award for outstanding scholarship and teaching by a junior member of the Institute faculty. We are also pleased that Associate Professor Charles F. Sabel, who has been collaborating with this Department from his base in the Program in Science, Technology, and Society, has been promoted to tenure and will, starting next year, join Political Science as his home department. Professor Sabel, recent winner of a MacArthur Prize Fellowship, specializes on the politics and sociology of work and, more broadly, on issues of political economy in industrial societies.

In order to strengthen our graduate curriculum in the core field of political analysis, several new subjects have been introduced. These include a required subject in The Philosophies of Social Science and three elective offerings in the methodologies of research. At the undergraduate level, the decision has been made to give up the Public Policy variant of the Political Science degree, which had not attracted sufficient student interest to merit its continuance. Among the new undergraduate subjects offered this spring was Just Wars, Total Wars and Nuclear Wars, a Humanities Distribution subject taught by Professor Hayward R. Alker, Jr., and Adjunct Professor Edwin Diamond which attracted an unusually large number of students. A comprehensive review of the undergraduate program has begun and will continue next year.

Members of the faculty continue to produce books, articles, and research reports at a pace that astonishes at least their Department Head, given his propensity to make other demands on their time. The lesser works are too numerous and varied to cite, but a listing of the books will illustrate the sort of work being done. Joshua Cohen (with Joel Rogers) has published On Democracy, a book that combines an appraisal of the contemporary American political system with a broader theoretical analysis of capitalist democracy. Edwin Diamond has extended his work on journalism and politics with an MIT Press study entitled The Spot: The Rise of Political Advertising on Television. William Kaufmann's study of The Defense Budget, Fiscal 1985 received more than the usual degree of attention when it appeared this spring during Congressional debates on the military budget. Stephen Meyer's book The Dynamics of Nuclear Proliferation appeared more or less simultaneously with a book-length study on Soviet theater nuclear force planning in the Adelphi Papers series. Richard Samuels' study on The Politics of Regional Policy in Japan was published by the Princeton University Press. Selected for the History Book Club was Modern Latin America, a comprehensive survey of Latin American history and politics written by Professor Peter H. Smith (in collaboration with Thomas Skidmore). Two additional books were completed and accepted for publication: Associate Professor Deborah A. Stone's The Disabled State and Assistant Professor W. Russell Neuman's The Paradox of Mass Politics: Knowledge and Opinion in the American Electorate.

From time to time it is good to take note of positions and honors achieved by faculty members in their professional relationships outside the Institute. Professor Suzanne D. Berger served as Chair of the Fulbright Committee on Western Europe and as a member of the Committee on Studies of the Council on Foreign Relations. Professor Walter Dean Burnham was elected a member of the governing Council of the American Political Association. Professor Nazli Choucri was made a member of the Council on Foreign Relations. Professor Willard R. Johnson was named national co-chairman of the Association of Concerned African Scholars. A Guggenheim Fellowship was awarded to Professor Michael Lipsky. Professor Lucian W. Pye served as Vice Chairman of the National Committee on U.S.-China Relations and on a variety of other organizations concerned with Asian affairs. Professor Eugene B. Skolnikoff is serving as Chairman of the Board of Trustees of the German Marshall Fund. The Task Force on Academic Freedom and Human Rights of the Latin American Studies Association is chaired by Associate Professor Brian H. Smith. Professor Peter H. Smith was appointed Fulbright Senior Lecturer in Mexico and was organizer of a national conference held at MIT on "Statistics, Epistemology, and History." Professor Weiner has been chairing the Joint Committee on South Asia of the SSRC and the ACLS in addition to serving on a number of editorial boards and other professional groups concerned with third world development issues. Other items could be cited, but these illustrate well the range of recent faculty activities.

DONALD L.M. BLACKMER

Department of Psychology

Despite stringencies in the funding of research from federal and other sources, our faculty continues to raise funds at a compounded rate averaging 10 percent per annum. This achievement attests to the talents of our research groups, who demonstrate the necessary quality of performance, level of innovation, and ability to integrate across the spectrum of brain sciences that we represent. Objective recognition comes from a national survey which shows that this department has the highest research support per faculty member of any psychology department in the country. This success, however, has its darker side. As has often been noted, the department is unusual in functioning like a hybrid combining a research laboratory with a more conventional department. With approximately 80 percent of department finances coming from external funding (other than general funds), our viability is dependent upon faculty and staff supporting their own research efforts, and some departmental functions, with successful fundraising activities. To a good extent, the success of these activities has resulted from the presence of a group of investigators approaching the brain and behavior from a variety of perspectives. Not only has this grouping been an unusual one which has promoted training grant and core support, it has also produced a very fruitful cross-fertilization of ideas and techniques among laboratories. These circumstances have made maintenance of the integrity of the department a critical concern. In the interests of keeping the department in the forefront of research we have, by means of appointments and support, deliberately encouraged work in the most innovative aspects of the field. As in the past, the very success of these enterprises generates pressures on them to split off and join other entities within the Institute. Currently, we face such a contingency in connection with the development of the program in neuroscience in the Whitaker College. We applaud the innovative extension of this field into the biological sciences. We are, however, concerned over the co-option of several of our faculty into the Whitaker College in programs that resemble existing ones within this department and could lead to unwanted duplication. Clearly, we must take steps both to delimit the scope of activities in the two administrative entities and to develop new enterprises in order to ensure the continuing viability of both programs.

In accord with the ability of our faculty to win support for their research, their efforts have been recognized by advancements and honors. Professors Carey and Poggio were promoted to full professor and Dr. Corkin was granted tenure. Professors Graybiel, Poggio, Schiller, and Schneider were given joint appointments on the faculty of Whitaker College. Poggio will also serve as Director of the Biological Information Processing Center. Dr. Edward Smith was appointed adjunct professor of cognitive science. The faculty published over 100 items and delivered an equal number of oral papers and colloquia at other universities and conferences. Honors came to Professor Graybiel, made President of the Cajal Club, Dr. Nauta, who received the Ralph W. Gerard Prize of the Society for Neuroscience and the von Helmholtz Award of the Cognitive Neuroscience Institute, Dr. Pinker who received the American Psychological Association's Distinguished Scientific Award for an Early Career Contribution to Psychology and was Annual Nijmegen Lecturer of the Max Planck Institute for Psycholinguistics, Dr. Poggio, who delivered the Second Marr Lectureship at the University of Cambridge, and Dr. Held who received the Doctorate honoris causa from the University of Brussels.

On the educational front, our new undergraduate program in cognitive science attracted an increased number of students (35 percent) of whom majors now number an estimated 31. Our undergraduate course enrollment also increased. We admitted nine new graduate students with excellent credentials to make up a total enrollment of 38. We granted four PhDs.

Our faculty and staff serve the professional community in numerous ways including service on consultative committees, editorial boards, and as reviewers of research grants. Our regular and special colloquia attract members of the community of brain scientists and psychologists throughout the Boston area. We again honored the memory of our founder, Hans-Lukas Teuber, with a symposium entitled "The frontal lobes: Structure and Function" organized by Professors Emilio Bizzi and Suzanne Corkin.

Although the department faces uncertainties of the kind mentioned earlier, its demonstrated strengths and potential give us hope for the future.

RICHARD M. HELD

Program in Science, Technology, and Society

Undergraduate teaching continues to be a main activity of the Program in Science, Technology, and Society (STS). Growth of enrollments continues, but still not as rapidly as might be expected from the favorable student evaluations of the subject offerings and the quality of instruction. Two new courses developed with other departments were offered for the first time this academic year -- STS 400J The Archaeology of Technology, joint with Humanities, and STS 575J The Problems of Advanced Industrial Societies, joint with Political Science.

The Program won the approval of the Committee on Educational Policy for its proposal to offer an Integrated Studies Program (ISP) for a selected group of freshmen, beginning academic year 84-85. Modeled broadly after Concourse, the Program will feature a unified presentation of the basic mathematics and physics courses, a humanities course on topics in the history of science and technology, and a set of seminars in which each Program faculty member will participate on selected aspects of the history of science and technology. These seminars will function as tutorial groups and the respective seminar leaders will act as freshman advisors for the four to six students in each of their groups. An enrollment ceiling of fifty has been set for the course.

STS's cooperative support of graduate students continued. Ten graduate students were supported by fellowships and/or office space. All but one were enrolled in Political Science, and one in Urban Studies and Planning.

RESEARCH AND HONORS

Two members of the faculty published books in the course of the year which received considerable attention. Associate Professor Kenneth Manning's biography of Ernest E. Just, Black Apollo of Science: The Life of Ernest Everett Just, a richly documented study of the career of America's first important black academic scientist, has received wide notice. Associate Professor Sherry Turkle's The Second Self: Computers and the Human Spirit is an ethnographic study of the psychological use made of computers by a variety of kinds of users. Just published, it too is receiving wide favorable notice. Professor Merritt Roe Smith received a Guggenheim Fellowship for the 1983 Fall term and a National Science Foundation Scholarship for the 1984 Spring term. Professor Leo Marx spent the Fall term on leave as a Rockefeller Fellow. Associate Professor Peter Buck had an Old Dominion Fellowship which enabled him to initiate work on the role of the Commonwealth Foundation in the development of hospital-based medical care in small American cities in the 1920s and 1930s.

THE MELLON FELLOWSHIP PROGRAM

The Mellon Fellowship Program is directed at researchers in engineering and science disciplines who wish to spend a year examining the problems of the social interactions of science and technology. Funded five years by the Andrew W. Mellon Foundation, the program was announced in 1982, and there were two fellows under the Program this year -- Dennis Sebian, an engineer working on the history of the Boston water and sewer system, the nation's first urban sewer system, and Mauricio Shojjet, a nuclear engineer from Mexico examining the role and problems of high technology in the Third World.

THE EXXON FELLOWSHIP PROGRAM

The Exxon Fellows this year included Frank Dubinkas, Eric Livingston, and Stephen Woolgar. All were selected with a view of assembling a group who concentrated on the social study of science. The Program provided them with an opportunity for interaction with the scientific and technical community of the Institute to the benefit of their researches. The Fellows and a group of faculty members led by Professors Larry Bucciarelli and Sharon Traweek conducted a year long workshop on the substantive and methodological problems on the ethnographic study of scientific communities. The Exxon Education Foundation funds this fellowship program for scholars in the humanities and social sciences to pursue researches in the history and social interactions of science and technology.

THE VANNEVAR BUSH FELLOWSHIP PROGRAM

Academic year 1983-84 was the first working year of the Vannevar Bush Fellowship Program in the Public Understanding of Science and Technology. The eight experienced science journalists who came under this Program funded by five-year grants from the Sloan and Mellon Foundations were Paula Apsell (WCVB-TV, Boston), Karen Birchard (National Radio News [CBC], Toronto, Canada), Diane Dumanoski (The Boston Globe), Catherine Foster (The Oak Ridger, Oak Ridge, Tennessee), Linda Garmon (Science News, Washington, D.C.), Russ Mitchell (Corvallis Gazette-Times, Corvallis, Oregon), Mitchel Resnick (free lance, San Francisco),

and Richard Saltus, (San Francisco Examiner). Without exception, all found the experience exciting and rewarding and believed that it would make a significant difference to their careers as science journalists. The initial year provided a variety of lessons for all the participants, STS faculty, and the Program leader, Victor McElheny, on the basis of which we expect to provide an even more rewarding year for the next group of fellows. In addition to eight Americans, the group will include a German journalist financed by the Robert Bosch Stiftung Foundation.

VISITING SCHOLARS

In addition, fourteen visiting scholars came to work with the Program faculty and contribute to its seminars and discussions, from the United States and four foreign countries.

PROGRAM IN TECHNOLOGICAL LITERACY

This program, initiated by a grant from the Sloan Foundation and working under the leadership of Professors Margaret MacVicar and Leon Trilling, continued for its second year. MIT has acted as a coordinator and resource institution for the ten liberal arts colleges in New England and Upstate New York areas to develop programs at their own institutions around technological literacy. Next year, visitors from the participating liberal arts colleges will spend all or part of the year at MIT to broaden and deepen their own knowledge for preparation in teaching at their home institutions.

CARL KAYSEN

Center for International Studies

During the past year, the Center for International Studies continued to focus its program on contemporary policy issues, primarily international, that have a strong technological component. Under its director Professor Eugene B. Skolnikoff, the Center sought to provide a setting in which students and faculty from the social sciences and the engineering and scientific departments could interact on public policy matters of common concern.

Arms control and defense policy, especially as affected by new weapons developments, remained a major focus of the Center's program. Professor Jack Ruina, Department of Electrical Engineering and Computer Science, directed the program, which had as its major goal the support of the faculty and graduate students involved in the degree granting program offered by the Department of Political Science. During the year, the Center competed successfully in an international competition sponsored by the Ford Foundation to support research and training in international security issues; the Center's winning proposal will provide three years of support for graduate students.

In addition to the teaching effort at MIT, the Center's program has several other aspects: outreach, research, and communication within the MIT community. In the summer of 1983, with support from the Alfred P. Sloan Foundation, the Center offered a two-week workshop for faculty from four-year liberal arts colleges who are or plan to offer courses on arms control and defense issues. The course sought to provide participants with information on the evolution of arms control and defense policy, weapons characteristics and performance, and a wide spectrum of views on current policy options. The effort was evaluated very positively by participants and sponsor and will be offered again in the summer of 1984. Professor Ruina directed the effort, jointly with Professor Paul Doty from the Center for Science and International Affairs (CSIA) at Harvard University. Also participating were: Professors George Rathjens, MIT Department of Political Science; Ted Greenwood, MIT Department of Political Science; Stephen Meyer, MIT Department of Political Science; and William Kaufmann, MIT Department of Political Science; Dr. Ashton Carter, Postdoctoral Fellow at the MIT Center for International Studies; and from CSIA, Albert Carnesale and Michael Nacht.

Research carried out during the year, in addition to work performed by graduate students, included analysis of Soviet decision-making on weapons development and deployment carried out by Professor Meyer with support from the Ford Foundation and the Advanced Research Projects Agency of the US Department of Defense. Dr. Carter along with Professors Ruina and Rathjens, participated in a joint project with the Brookings Institution to study the potential military uses of space and their implications for arms control. Dr. Carter also explored the technical and policy aspects of the so-called "star wars" initiative; this latter study was funded by the US Congress Office of Technology Assessment. Professor Rathjens began an analysis of the phenomenon known as "nuclear winter"--the potential drastic climate shifts that might follow even limited nuclear exchanges; funding is being sought from the Max and Anna Levinson Foundation.

In addition to funding for specific research and outreach activities noted above, the overall program is supported by the Ford Foundation, the Buffett Foundation, and the MIT endowment fund for International Security and Arms Control. A major effort was undertaken during the year to increase funding levels and provide more long-term funding stability. The new Ford Foundation grant for graduate student support, already mentioned, was one concrete result. At the year's close, word was also received of a major grant from the Carnegie Corporation to support research in the field. Other proposals to Foundations are being reviewed and we are confident that the program has a stable and long-term future.

In addition to faculty, graduate students, and postdoctoral fellows, the program continued to attract visiting scholars. Colonel Carlton Pannell, USAF, spent the year with the program, interacting with faculty and students and carrying out a study of anti-ABM systems. Dr. Judith Reppy, Director of the Peace Studies Program at Cornell University, was also in residence. Dr. Christopher Davis, winner of a Ford Foundation Dual Competency Fellowship, spent the year at the Center working on the impact of defense and weapons decisions on the Soviet economy; Dr. Davis was on leave from the Wharton Econometric Forecasting Associates in London.

The members of the Center's arms control and defense policy program were also active in the extensive search that was conducted during the year to identify new faculty appointments in the field. Dr. Steven Miller was selected as a new Assistant Professor of Political Science; Dr. Miller was previously with the Harvard CSIA and editor of its journal International Security. Two members of the program will be leaving at the end of the year: Professor Kaufmann who initiated the teaching program in the field will be retiring and Professor Greenwood accepted a position at Columbia University where he will be coordinating there the many activities in the defense and international security areas into a more coherent program.

The US/Japan Science and Technology Program continued to grow during the year. Professor Richard Samuels, Department of Political Science, continued to direct the program while on leave as a visiting scholar at the Institute for Energy Economics in Tokyo. During his absence, Professor Eleanor Westney, Sloan School of Management, has served as program co-director, in close collaboration with Professor Skolnikoff. During the year, the Motorola Corporation, the Eastman Kodak Company, and Terradyne Inc. became corporate sponsors of the effort. Six MIT students were placed in internships in Japan, after completing both their technical education and language and other preparation under the program's sponsorship. Student candidates for future internships were chosen, and opportunities identified for them in Japan. Professor Westney also participated actively in discussions in the US Congress and elsewhere on measures to increase the accessibility of Japanese scientific and technological information in the United States. She also participated in a joint MIT-Harvard University study of Japanese management styles. Professors Samuels, Skolnikoff, and Westney were also active during the year in exploring funding for the program with government, industry, and foundation sources.

The Center's program in communications policy suffered a great loss during the year with the death of its founder and director Professor Ithiel Pool of the Department of Political Science. With the foresight that typified his work, however, Professor Pool had devoted a substantial effort to developing resources for a group of young faculty who could continue the work he had begun. Professor Marvin Sirbu, Sloan School of Management, is directing the program, in close collaboration with Professor Russell Neuman, Department of Political Science, and Professor Charles Jonscher, Sloan School of Management. The Program continued to draw participants from the Center for Advanced Engineering Study, the Center for Policy Alternatives, the Laboratory for Computer Science, and the Laboratory for Information and Decision Systems, as well as the Center for International Studies. As in past years, a consortium of sponsors supported the program: American Telephone and Telegraph, International Telephone and Telegraph, International Business Machines, Hughes Aircraft, Alarm Devices Manufacturing Company, Citibank, the Alfred P. Sloan Foundation, the Markle Foundation, and the Times-Mirror Corporation. Also during the past year, the Communications Forum was established in conjunction with the MIT Industrial Liaison Program to increase coordination within MIT and between MIT and corporations in the communications field. Mr. Brian Kahin has joined the Center as coordinator for the Communications Forum.

Several research projects in communications policy continued during the year. Professor Neuman directed the on-going study of the future of the mass audience, attempting to identify the factors that will ultimately limit the demand for information and entertainment in the home. Professor Neuman's work is funded by the Columbia Broadcasting System, Warner Communications, The Washington Post Company, The New York Times, and Time, Inc. The Alfred P. Sloan Foundation provided support for preparation of archival videotapes of the men and women who pioneered the development of the computer. Professor Pool worked on this undertaking with Dr. Richard Solomon of the Center. The Boston Globe sponsored a study directed by Dr. David Allen of the Center evaluating the potential business and home use of videotext. During the year Dr. Pool in collaboration with the Research Institute of Telecommunications and Economics in Japan completed work measuring the flow of information in the United States and Japan. The Markle Foundation and the Japan Society for the Promotion of Science provided the funding.

Other closely-related research efforts in the communications field were conducted under the auspices of other laboratories and centers participating in the MIT program in communications policy. These include the following: Professor Jonscher's study of the economics of information supported by the National Science Foundation (NSF); Professor Sirbu's NSF-sponsored study of the determinants of computer and communications standards; the census of communications flows carried out by Professor Pool with support from the Xerox Corporation; telecommunication needs in rural Egypt funded by the US Agency for International Development and directed by Professor Pool; and a study of alternate Voice of America transmitters by Professor Pool and Dr. Solomon.

Management of health, safety, and environmental risks remained a program focus, bringing together faculty from many parts of the Institute in an active interdisciplinary seminar to discuss research of common interest. During the past year, in addition to the faculty seminars, several small research efforts were underway, each aimed at development of a larger research effort. Professor Steven Tannenbaum and Dr. Laura Green, both of the Department of Nutrition and Food Science, worked on the development of novel diagnostic methods to measure exposure to toxic substances, with special attention to how and by whom such knowledge might be utilized. The use of geological information in assessing risks of such undertakings as siting of dams was studied by Professors Greenwood and Gregory Baecher, Department of Civil Engineering. Community participation in decisions about siting hazardous waste treatment facilities was examined by Professor Lawrence Bacow and Joseph Ferreira, both of the Department of Urban Studies and Planning. Mr. George Heaton of the Center for Policy Alternatives explored how the legal system deals with compensation to individuals for having been put at risk. Engineering economy in the presence of risk, uncertainty, and risk aversion was the subject addressed by Professor Amadeo Odoni, Department of Aeronautics and Astronautics. In the Department of Economics, Professor Jerome Rothenberg sought to develop a model of how groups reach risk-related decisions. These efforts were supported by a grant from the Andrew W. Mellon Foundation. Overall direction of the program was the responsibility of Professors Alvin Drake, Department of Electrical Engineering and Computer Science, and Professor Daniel Metlay, Department of Political Science.

In a separate research project, Professor Metlay studied the strategies different groups adopt in an effort to influence the outcomes of regulatory procedures. Professor Metlay, whose work is supported by the Russell Sage Foundation, seeks to understand why different strategies were adopted and how they affect the regulatory process.

During the year, the Future of the Automobile project, carried out jointly with the Center for Transportation Studies, neared completion. The project was a major multinational effort, involving scholars, industrialists, and governments in the United States, United Kingdom, Germany, Japan, France, and Italy. The major results will appear in a book to be published by the MIT Press, with additional publication of specific articles and technical papers. Funding in the United States was provided by the German Marshall Fund of the United States and the US Department of Transportation. The participants from other countries obtained funding from their own national sources. Professor Alan Altshuler, Department of Political Science, directed the Center's participation in the project.

Work continued during the year on several other topics of long-standing interest. Professor Lucian Pye, Department of Political Science, continued to edit manuscripts resulting from his study of modernization in different Asian societies, work supported by the Rockefeller Brothers Fund. The Joint Seminar on Political Development (JOSPOD) organized its sessions during the year around a general assessment of the political development field, in honor of the seminar's twenty-fifth anniversary. Professor Myron Weiner, Department of Political Science, directed the effort, with funding from the Ford Foundation; JOSPOD is run jointly with the Harvard Center for International Affairs. The Center continued to work closely with Professor Nevin Scrimshaw, Department of Nutrition and Food Science, in the International Food and Nutrition Program, which is closely linked to the United Nations University. Dr. Ann Hollick, formerly of the US Department of State and Johns Hopkins University, spent the year at the Center under the sponsorship of the National Science Foundation studying foreign policy planning in scientific and technological areas. The Center also served as MIT liaison for the joint Harvard-MIT Women in International Development Group.

In addition to these programs, the Center explored new areas for development. During the past year, these included issues related to development, the economy, and energy in Latin America; scientific and technical policy and China; technology transfer; international energy policy; migration; and various perspectives on the Middle East. For the Center, work in developing programs in these areas involved mainly Professor Skolnikoff.

As in past years, the Center has been host to visiting American and foreign scholars. During the previous year, these have included individuals from Ceylon, the Soviet Union, Japan, the United Kingdom, and the Universities of Denver and Maryland. The Center also sponsors an extensive program of seminars for the MIT community. These include special series focused on such program areas as arms control, south Asia, migration, risk management, Latin America, and the Middle East, as well as topics of general international interest.

EUGENE B. SKOLNIKOFF

Sloan School of Management

The principal major activities of the Sloan School continue to focus on research dealing with important management issues and on the education of both practicing and potential management professionals and of the educators of the next generation of management professionals and researchers.

The following sections report on the School's teaching programs and research during the past year and on the broad array of related professional activities in which the School's faculty and staff have engaged in that same period.

Our undergraduate program, but principally our master's program and executive education programs, are our principal opportunities for affecting the quality and practice of management, not only in this country but in others, through the dissemination of our own and many others' ideas impinging on that practice.

Our doctoral program is aimed essentially at the training of future educators of management professionals and at training these persons to engage in the serious research which must underlie any successful efforts at professional education.

Our research activities have continued to seek to create and replenish intellectual capital as the basis for understanding and resolution of important management issues, not just in relation to today's headline perspectives but geared for the longer term and thrust.

All of these activities continue to merit the high national and international repute of the School's programs and research.

The School has continued to make substantial progress in implementing the agenda it set for itself a few years ago. Our faculty regroupings into broader disciplinary and functional clusters have continued to work well and to encourage increased intellectual interaction amongst ourselves as well as to promote better linkages with others at MIT and outside the Institute.

During the year our Master's Program Committee and a variety of subsets of the faculty have continued to review in a most thorough and thoughtful fashion the core of our two-year master's program and we are at a stage where virtual consensus on proposed revisions for the program core has been reached. The revisions aim at providing both greater breadth and flexibility in the program core as well as at the effective and coordinated incorporation of the new information technology into our curriculum offerings.

We have continued to strengthen our efforts in external relations, including alumni/ae relations, our dealings with corporate sponsors, and our resource development activities.

Our physical plant renovations and refurbishings are virtually complete, and although we shall require some modest incremental space in the near term, we continue to profit immensely from the vast improvement in the quality of faculty and program life in consequence of the better learning, teaching, and socializing space which we have enjoyed in the past year in consequence of our investments in these physical plant renovations.

All of us have also continued to regard ourselves as extraordinarily fortunate in having the opportunity to work with persons throughout MIT who have both understood and who are sympathetic to the School's efforts in continuing to press for the attainment of a clear leadership role in addressing some of the complex managerial problems of our times and of the future.

The School's Annual Report published each year describes in more detail an update on the School's progress in our teaching and research programs and in our other activities. This report provides a somewhat less extensive summary of the School's annual activities during the 1983-84 year.

TEACHING PROGRAMS

Undergraduate Program

In the fall of 1983 the Undergraduate Program Committee proposed a new undergraduate program, together with a change in the designation of the Course XV SB degree. The new program contains roughly the same core of management subjects as are required in our current four programs. In addition, it contains an introduction to management science together with subjects in quantitative analysis that are appropriately rigorous for the study of management science. Each student must also take from three to five specified

subjects within one of four management science options: (1) Information Systems, (2) Operations Research, (3) Marketing Research, or (4) Behavioral Science. This new program would lead to the degree, "SB in Management Science," and it would replace the set of four programs currently offered.

The emphasis on management science and the more quantitative orientation of the new program is intended to match more closely the strengths and needs of MIT undergraduates. The option in information systems is expected to provide a significant new path permitting students to study computer technology and applications without having to major in Electrical Engineering and Computer Science. It may also help ease some of the current problems caused by the heavy enrollments in the Department of Electrical Engineering and Computer Science.

The new curriculum was approved by the Committee on Curricula on January 23, 1984. The change in degree designation was approved at a meeting of the MIT Faculty on February 15, and then by the Corporation on March 2. The new program will go into effect for the Class of 1987, i.e., this year's freshmen.

Two Open Houses for freshmen were held in the spring term as part of our effort to publicize the new program. These attracted about 100 freshmen. Twenty freshmen designated Course XV on their end-of-term course selection forms. This is a significant increase over the numbers selecting management in recent years:

| <u>Year</u> | <u>Number of Freshmen Selecting Course XV</u> | |
|-------------|--|----|
| | <u>Number of Students Graduating in that Class Three Years Later</u> | |
| 1980 | 9 | 31 |
| 1981 | 10 | 29 |
| 1982 | 8 | |
| 1983 | 10 | |
| 1984 | 20 | |

Based on responses to a questionnaire used at the Open Houses, we expect that a majority of these freshmen will choose the Information Systems option.

Total enrollment in Course XV for the 1983-84 academic year was 71. During the year, 29 students received the degree of Bachelor of Science in Management. Twelve of these degrees were from the (current) Management Science Program, 2 from the Behavioral Science program, and 15 from the following approved Special Programs: Information Systems (3), Marketing (3), Finance (2), International Management (2), International Finance, Accounting, Economics, Engineering Management, and General Management.

Five of our graduates also received bachelor's degrees from departments in the School of Engineering.

Enrollments in the four current programs for each year are summarized as follows:

| | <u>Program 1</u> | <u>Program 2</u> | <u>Program 3</u> | <u>Program 4</u> | |
|----------|-------------------------|---------------------------|---------------------------|---------------------------------------|--------------|
| | <u>Special Programs</u> | <u>Behavioral Science</u> | <u>Management Science</u> | <u>Dynamics of Management Systems</u> | <u>Total</u> |
| 4th year | 16 | 3 | 12 | 1 | 32 |
| 3rd year | 10 | 1 | 7 | 1 | 19 |
| 2nd year | <u>4</u> | <u>3</u> | <u>13</u> | <u>0</u> | <u>20</u> |
| Total | 30 | 7 | 32 | 2 | 71 |

Our undergraduate subjects continue to attract a significant number of students from other MIT degree programs. During the past year there were 361 enrollments by non-Course XV students, an increase of 20 percent over the year before. These enrollments are equivalent to an additional 41 full-time undergraduate students (over half the size of our own undergraduate body).

The Sloan School participated for the third year in a row in MIT's Undergraduate Seminar Program. The seminars in this program are six-unit pass/fail subjects, often on topics not normally found in regular

departmental curricula. This fall Professor D. Eleanor Westney offered a seminar titled, "Japan: Contemporary Society and Future Prospects." Fifteen students were enrolled in the seminar, 14 of whom were from departments outside of the Sloan School.

The Sloan School's program during the January Independent Activities Period (IAP) was even more successful this year than last. For the second year in a row, there were significant increases in the number of faculty participating and the number of students attending (although precise attendance data are not available). The most popular offering was a 10-hour series, "A Brief Introduction to Management," this year featuring Professors Michael S. Scott Morton, Glen L. Urban, Stewart C. Myers, Eric A. von Hippel, Stan N. Finkelstein, and Dr. John F. Rockart. The attendance for each of the five sessions averaged around 150. Twenty-two students participated in the Undergraduate Management Game this January, 16 from Sloan and 6 from other departments.

Charles Markham, a senior with a Special Program in International Finance, was awarded MIT's Karl Taylor Compton Prize this spring for his "outstanding contributions in promoting high standards and good citizenship within the MIT Community." Mr. Markham had previously served as MIT Undergraduate Association President. The Sloan School's Senior Prize, awarded for "high scholastic standing, leadership, and professional promise," was received by David Bromfield, a senior with a Special Program in Accounting. In October Rhonda Peck, Class of 1982, began a five-year term as a member of the MIT Corporation. Arlene Roane, Class of 1983, will also become a member of the Corporation this coming October. Ms. Peck and Ms. Roane were elected to the Corporation as two of five representatives from recent MIT classes. Both are former recipients of the Compton Prize.

The undergraduate program was chaired by Dr. Jeffrey A. Meldman, with Ms. Esther Merrill serving as program coordinator. Professors Thomas J. Allen, Finkelstein, Stephen C. Graves, Peter M. Senge, and M. Anthony Wong served as undergraduate advisors, together with Dr. Meldman and Ms. Merrill. Professor James B. Orlin served as the Sloan School's coordinator for MIT's Undergraduate Research Opportunities Program (UROP).

Master's Program

Master's Program Committee meetings this year continued to focus on the mission of the program and the structure of the core curriculum. Guidelines for revision of the core were proposed by faculty members and students early in the year and turned over to subcommittees from the School's three areas--Applied Economics and Finance, Behavioral and Policy Sciences, and Management Science--for study and recommendations. A subcommittee of the full committee then met regularly to consider the recommendations from the three areas and prepared a final report on the proposed restructuring of the core that is now in the hands of members of the full committee for consideration and discussion. Revision of the core requirement in intermediate-level economics has already been approved for the coming academic year.

Response to the Distinguished Speakers Series was again enthusiastic. The speakers chosen this year by the board of master's students included Douglas Fraser, former President, United Auto Workers; Charles W. Parry, Chairman and Chief Executive Officer, Aluminum Company of America (Alcoa); David M. Roderick, Chairman, Board of Directors, United States Steel Corporation; and William J. Weisz, Vice Chairman of the Board and Chief Operating Officer, Motorola, Inc.

Special awards for academic excellence and professional promise have been bestowed on our master's students this year. In 1979 the Alexander Proudfoot Company established two fellowships at the School to honor the memory of its founder and to develop an awareness that productivity is a major concern for American industry. The 1984 Proudfoot Fellows were first-year students Lance E. Murrah and Sarah A. Shoaf. John J. Becker was named the recipient of the Bendix Fellowship, established in 1982 to honor a first-year student. The Digital Equipment Corporation selected first-year students Patricia E. Grossman and Karilyn M. Perry as recipients of scholarships intended to encourage women with technical backgrounds to pursue management careers in the high technology industry.

The Henry Ford II Scholar for 1983-84 was Mary A. Spyropoulos. The Ford Motor Company established a fund at the School for presentation of an annual award to a second-year student. Mary A. Rorabaugh, another member of the Class of 1984, received the Henry B. du Pont Scholarship, established by the Crestlea Foundation with a gift from the late Henry B. du Pont. David H. Bridge and Thomas D. Overton III were named Seley Scholars, awards established by Mr. and Mrs. Louis E. Seley to honor a graduating master's student for outstanding academic achievement and exceptional promise of business leadership. Darren A. Walsh was selected to receive the Allied Fellowship in recognition of his intellectual capacity, ability and potential in management, breadth of interests, and leadership qualities. Recipients of the Thomas M. Hill Prize, for second-year students demonstrating excellence in the field of accounting, were Patricia K. Jacobson and Elizabeth W. Reiland. The prize was established by the late Professor Hill's friends and colleagues to honor his memory and distinguished service to the School for 30 years.

The Brooks Prize was established by E. Pennell Brooks, first Dean of the Sloan School, to honor the author of the best master's thesis. Stephen P. Gaskin was awarded the Brooks Prize for the best master's thesis in 1983; the thesis is entitled "Defender: The Test and Application of a Defensive Marketing Model." Mr. Gaskin's thesis supervisor was Professor John R. Hauser.

Receiving honorable mention for 1982-83 was Thomas J. Langan, whose thesis is entitled "Recent Diversification Strategy and Its Relation to Financial Performance of Major Companies in the Oil Industry." Professor Gordon B. M. Walker, Jr., was his thesis supervisor.

For the second time we have selected an entering class of 200 students--from a pool of almost 1,400 applicants. Our data-management system, refined and expanded following last year's experience, has enabled us to handle the admission process far more efficiently than in the past. Ready access to up-to-date information has allowed us to meet deadlines with confidence. Progress has also been made in the computerization of student records; we expect to refine and further test this system in the upcoming academic year.

The following table presents a profile of the graduating classes of 1984 and 1985.

| Profile of Graduating Master's Classes | 1984 | 1985* | | | |
|---|---------------------|---------|------|---------|-----|
| Number of Candidates | 152 | 193 | | | |
| | US Citizens | 127 | 137 | | |
| | Foreign Citizens | 25 | 56 | | |
| Women | 45 | 52 | | | |
| Members of Minority Groups | 4 | 16 | | | |
| Median GMAT Score (national average is approximately 460) | 640 | 650 | | | |
| Undergraduate Grade-Point Average (out of 5.0) | 4.3 | 4.4 | | | |
| Undergraduate Majors | | | | | |
| | Humanities | 5% | 5% | | |
| | Social Sciences | 34% | 33% | | |
| | Physical Sciences | 23% | 16% | | |
| | Engineering | 26% | 32% | | |
| | Pre-Professional | 12% | 14% | | |
| Average Years Full-Time Work Experience | 2.8 | 3.2 | | | |
| Age at Admission | | | | | |
| | Under 23 years | 18% | 19% | | |
| | 23-24 | 30% | 30% | | |
| | 25-26 | 28% | 18% | | |
| | 27-28 | 6% | 14% | | |
| | 29 and over | 18% | 19% | | |
| Geographical Areas Represented | Home | College | Home | College | |
| | New England | 43% | 50% | 28% | 36% |
| | Mid-Atlantic States | 16% | 14% | 20% | 17% |
| | South and Southeast | 6% | 5% | 6% | 4% |
| | Midwest | 7% | 7% | 9% | 8% |
| | Far West | 13% | 13% | 10% | 10% |
| | Foreign Countries | 15% | 11% | 27% | 25% |

* Projected.

This was also an active, successful year from a placement perspective for the Sloan School's Class of 1984. Increased company hiring, begun late in the 1983 recruiting year, continued through the 1984 season. The number of firms interviewing students on campus rose to 148, up 6 percent from last year. Compared with the Class of 1983, this year's graduates enjoyed a healthier job market and a greater element of choice in selecting among attractive work options.

On average, graduates received three job offers at salaries slightly more than 4 percent above last year's figures. The mean class annual salary stands at \$39,500. This compares very favorably with the figure of \$25,000 which was the average salary our students received prior to entering their MS program.

Consistent with last year, hiring was particularly active among high tech firms and the financial services industry. In terms of job functions, employers interviewed most actively to fill corporate/strategic planning, finance, and marketing roles. Recruiting by consulting firms rebounded after

tempered hiring during 1983. Interest in Sloan candidates on the part of investment banks rose from the prior year, with several new companies interviewing on campus. The students responded in kind, exhibiting increased interest in Wall Street opportunities. The combined total of second- and first-year students accepting employment in investment banking rose from 7 in 1983 to 19 in 1984.

Most noteworthy among trends in students' job choices was the number of graduates selecting marketing positions. Here the figures shifted from 9 percent of the 1983 graduates to 25 percent of the 1984 graduates! The Class of 1984 expressed an early interest in marketing roles, forming a Student Marketing Association in 1983 that spearheaded several major projects to gain visibility for club members, as well as for Sloan's marketing program. The two other job functions attracting larger numbers of students were finance (20 percent of the class) and consulting (14 percent of the class).

One-third of the 1984 graduates entered manufacturing organizations, with electronics firms leading the way by an overwhelming majority. Sixty-seven percent of the class selected non-manufacturing organizations, with consulting firms, computer service companies, and investment banks heading the list. Approximately two-thirds of the 1984 class chose to locate in either Massachusetts or New York City (43 percent and 23 percent, respectively.)

Employers hiring three or more students this year included AT&T Communications; Analog Devices, Inc.; Arthur Andersen & Company; Consultants for Management Decisions, Inc.; The First Boston Corporation; General Motors Corporation; Hewlett-Packard Company; McKinsey & Company; and Teradyne, Inc.

A more detailed 1984 Sloan School Placement Report will be available in September for all interested persons.

The Master's Program Committee, chaired by Professor Gordon M. Kaufman, continued the important and complicated process of reviewing the core curriculum of the program. Dr. Jeffrey A. Barks, Director of Graduate and Undergraduate Degree Programs, again provided imaginative and effective administrative leadership for the master's program. Miss Miriam Sherburne, Director of Master's Admissions and Counseling, and Harriet Barnett and James Gabbert, Master's Program Coordinators, labored diligently under great time pressures to complete the difficult process of evaluating applications to our master's program. Linda Stantial, who completed her first full year as Director of Master's Placement, displayed great skill in her new responsibilities.

Management of Technology Program

The Management of Technology Program was established in 1981 at MIT and is the only program of its kind. Administered by the Sloan School of Management and the School of Engineering, this 12-month, full-time program leads to a Master of Science in the Management of Technology. It is aimed at engineers and scientists with a minimum of five years of work experience, and strives to prepare these professionals for more senior roles in industry and government where they will generate and manage technology-based endeavors.

Program structure and a new curriculum were developed originally by a joint faculty committee from both the Sloan School and the School of Engineering. The curriculum includes an intensive core of analytic subjects taken during the summer and at least eight new subjects allowing intensive study of the management of technical people and programs. Subjects in Managing Professionals, Marketing/Technology Interface, Manufacturing/Technology Interface, and Current Issues in Engineering have attracted enthusiastic registration from graduate students throughout MIT, as well as from program students. All program attendees also write a thesis in the area of the management of technology, and company-sponsored individuals in particular find the thesis a golden opportunity to explore in great depth some issues of chief corporate concern.

The Management of Technology Program was conceived originally by Program Director, Professor Edward B. Roberts, of the Sloan School. Admissions and daily operations are ably handled by Jane M. Morse, Program Manager, who has been with the program since its beginning. From a pilot class three years ago of 6 students, the program expanded to 8 the next year, 13 last year, and enrolled 21 students for the 1984-85 class. Plans are to continue expanding to no more than 40-50 students per year. Though required to have at least five years of work experience before coming to the program, students average closer to 10-12 years of experience and tend to be in their mid-thirties in age. They come from a wide variety of fields, including aerospace, electronics, research and development, and the military. Less than a third of each class has been foreign, with representation from several countries in Europe, also China, Japan, Israel, Argentina, and Singapore.

Program implementation would not have been possible without the strong and effective collaboration of the Deans' Offices in both the School of Engineering and the Sloan School of Management. Substantial financial contributions to fund curriculum development from Pilkington Brothers Ltd. and Gillette Company are also greatly appreciated, as are gifts from Corning Glass Works, Rogers Corporation, and Computer Services Corporation (Japan).

The PhD Program

The Sloan School's doctoral program, which remains one of the most distinguished in the nation, experienced another successful year in recruiting an incoming class of highly qualified men and women. A total of 238 applications was received for fall 1983, an increase of 7.2 percent over the previous year. Admission was offered to 29 applicants, and 18 entered the program in September. The yield rate (entrants/admissions) of 62 percent was slightly above those realized over the past decade. The entering class included two women and nine citizens of foreign countries. The major fields chosen by the 1983 entering class were as follows:

| | |
|---------------------------------------|---|
| <u>Applied Economics and Finance</u> | 4 |
| Applied Economics | 2 |
| Finance | 2 |
| <u>Behavioral and Policy Sciences</u> | 7 |
| Health Care Management | 1 |
| International Management | 1 |
| Industrial Relations | 1 |
| Organization Studies | 1 |
| Strategy and Policy | 2 |
| System Dynamics | 1 |
| <u>Management Sciences</u> | 7 |
| Accounting, Planning, and Control | 1 |
| Management Information Systems | 3 |
| Marketing | 2 |
| Operations Management | 1 |

The proportion of foreign applicants continues to grow. The foreign share of all applicants has increased from 40 percent in 1970 to 69 percent in 1983. This shift has been reported by most other leading US management schools. We continue to cooperate with the efforts of the American Assembly of Collegiate Schools of Business (AACSB) to recruit more qualified US applicants, and we plan to increase our own efforts substantially in coming years.

The bulk of the program's graduates pursue academic careers. In 1983-84, 17 doctorates were granted in management. Of these, 12 (70 percent) assumed academic positions at the following institutions: Harvard (2), MIT (2), Columbia University, New York University, and the Universities of California (Berkeley), British Columbia, Texas (Austin), Georgia, New South Wales, and Pennsylvania. The remaining five have accepted or are considering non-university research positions.

The Doctoral Program Committee, headed by Professor Richard Schmalensee, has grappled with a number of difficult and interrelated problems. In recent years, the median time taken to complete the program has begun to creep above four years. After considerable study and debate, a number of changes were made in the program's pre-dissertation research requirements in order to facilitate more rapid progress. Maintaining the long-established size of the program (ideally, about 20 new students each year) without sacrificing quality has proven difficult in the face of stiffening competition from other management schools, even though demand for PhDs to staff management schools here and abroad continues to outstrip the available supply. Our main rivals are able to offer more attractive and longer-term financial awards to the most attractive applicants, and the aggregate supply of qualified US applicants has not responded to the excellent career prospects for management PhDs. Fellowship funding for the program was significantly increased this year in order to meet these challenges; for the first time in some years we will be able to make financial awards that are not grossly less attractive than those made by our principal rivals.

Administration of the doctoral program continues to be handled with great effectiveness by Sharon Cayley.

Alfred P. Sloan Fellows Program

On June 4, 1984, 55 Alfred P. Sloan Fellows were awarded the degree of Master of Science in Management. The Class of 1984 reflected a broad diversity of backgrounds and interests, and again was drawn from organizations from the United States and abroad. The Sloan Fellows Program was the first executive education program in the United States, and is now in its 53rd year.

Just prior to their graduation, the Sloan Fellows completed a three-week International Management Field Trip to Asia. They visited with leading government and industrial representatives in Hong Kong, the Peoples Republic of China, the Republic of Korea, and Japan.

A comparison of the Class of 1983-84 with previous classes follows:

| | <u>76-77</u> | <u>77-78</u> | <u>78-79</u> | <u>79-80</u> | <u>80-81</u> | <u>81-82</u> | <u>82-83</u> | <u>83-84</u> |
|------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <u>Industry</u> | | | | | | | | |
| United States | 25 | 26 | 31 | 30 | 31 | 30 | 28 | 26 |
| International | 11 | 14 | 10 | 11 | 13 | 15 | 13 | 15 |
| <u>Government</u> | | | | | | | | |
| United States | 8 | 8 | 5 | 5 | 8 | 7 | 10 | 8 |
| International | 1 | 5 | 2 | 1 | 0 | 0 | 2 | 5 |
| <u>Other</u> | | | | | | | | |
| World Bank | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Municipal Management | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Medical Management | 6 | 2 | 6 | 6 | 2 | 4 | 3* | 4* |
| University Management: | | | | | | | | |
| United States | 1 | 0 | 0 | 2 | 1 | 1 | 1 | 1 |
| Foreign | <u>0</u> | <u>0</u> | <u>0</u> | <u>1</u> | <u>1</u> | <u>0</u> | <u>0</u> | <u>0</u> |
| | 54 | 55 | 54 | 56 | 56 | 55 | 55 | 56 |

* Medical Management Sloan Fellows also counted in US Government and University columns.

The demand for the program continues to be strong and the quality of the nominations is extremely high. On June 15, 1984, the Class of 1984-85 arrived; there are 57 participants in the 1984-85 program. The new class is the largest in the history of the program.

Countries represented in the 1984 program are: Angola, Brazil, Canada, France, India, Indonesia, Ireland, Israel, Italy, Kuwait, Saudi Arabia, and the United Kingdom.

The Director of the Sloan Fellows Program, Alan F. White, is an alumnus of the program (Class of 1971) and once again performed efficiently and effectively in a very challenging role. Professor Arnoldo C. Hax served as chairman of the faculty program committee.

Health Management Executive Development Program

The ninth year of operations was completed by the Health Management Executive Program as an integral part of the Alfred P. Sloan Fellows Program. There were four Sloan Fellows from the medical field: G. William Bates, MD, Professor and Director of the Division of Reproductive Endocrinology at the University of Mississippi Medical Center; Olivier L. Brasseur, MD, Chief Medical Officer, Ministry of Health, France; Catherine D. Crone Coburn, Member of the Management Operations Team, Management Sciences for Health, Inc., Boston; and Marc Leveque, MD, Medical Consultant to the French Red Cross.

Program for Senior Executives

During 1983-84 the completion of the Brooks Center at the MIT Endicott House permitted a substantial increase in the number of participants in the program, from approximately 60 in earlier years to 91 in 1983-84. The recently redesigned program continues to attract outstanding senior executives from many industries and organizations around the world.

In addition to expanding the living area, the new building contains comfortable lecture and seminar rooms which greatly improve the teaching facilities available to the program members and the faculty.

The program is directed by Dr. H. Scott Duncan. Professor Scott Morton continued to serve as chairman of the faculty committee.

Greater Boston Executive Program

Continuing to serve as an important and vital link between MIT and the Boston area business community, the Greater Boston Executive Program enrolled 22 participants in the 1984 session held from January 27 to May 4.

The executives, 15 men and 7 women, met each Friday for 15 weeks for sessions on economics, finance, accounting and control, human resources management, marketing, and strategic planning offered by the Sloan School faculty.

Summer Programs

During the 1983 Summer Session, Sloan School faculty participated in 11 Special Summer Programs.

Two of the programs were of two-week duration: Corporate and Economic Policy: The System Dynamics Approach, directed by Professor John D. W. Morecroft of the System Dynamics Group; and Management of Research, Development, and Technology-Based Innovation, under the direction of Professor Roberts. Both of these programs have been offered for many years and continue to attract enthusiastic participants.

The rest of the programs were one-week offerings. In the finance area Professor Myers of the School and Professor Gerald A. Pogue of Baruch College, City University of New York, offered Modern Concepts in Financial Management and New Approaches to Financial Management and Strategy. Professor Donald R. Lessard directed Finance for International Managers.

Professor Roberts again directed The Dynamics of Health Service Systems: Strategic Planning for Complex Health Organizations and Professor Finkelstein directed Management of Medical Technology: Development, Utilization and Cost. These two programs were co-sponsored by Tufts University School of Medicine, Office of Continuing Education. Other faculty in these programs included physicians, economists, and other scientists from MIT, Harvard Medical School, Tufts University School of Medicine, The State University of New York at Stony Brook, and the National Institute of Health.

The other one-week programs offered were: Corporate Planning and Control Systems, directed by Dr. J. Morrison McInnes and other faculty in the Accounting, Planning and Control Area; Strategic Planning Systems, chaired by Professor Arnolde C. Hax; Critical Information System Technologies: Managing in the Information Area, co-directed by Professors John J. Donovan and Stuart E. Madnick; and Resource Management: A New Approach to Corporate Planning, under the direction of Professor Jeremy F. Shapiro, who also serves as Co-Director of the MIT Operations Research Center.

In addition to these programs offered as part of the Institute's Special Summer Program, several members of the faculty and staff directed and participated in two other seminars. The School's Center for Information Systems Research offered its eighth annual summer seminar--Current Issues in Information Systems: The Changing Role of Information Systems Management. The Marketing Center conducted its 16th annual symposium in May. This was a three-day seminar on Marketing Strategy in the Information Age. All sessions were held at MIT's Endicott House.

Industrial Liaison Symposia

Members of the School's faculty were responsible for several of the symposia sponsored by the Industrial Liaison Program. During the fall series, Professor Lessard chaired a program on Corporate Finance in an Era of Global Competition; Professor Urban was responsible for a symposium on Marketing Strategy and Models in the Information Age; and Dr. Rockart, Director of the Center for Information Systems Research, presented a program on The Information Era: Management Issues and Organizational Impacts. In addition, Professors Roberts and Allen of the Sloan School, and Professor James M. Utterback of the School of Engineering and Director of the Industrial Liaison Program, went to Paris, France, in January to conduct a three-day program on Management of Research, Development, and Technology-Based Innovation.

During the spring series, the Sloan School and the Industrial Liaison Office co-sponsored a program--Organizational Transformations: A Symposium in Honor of Professor Richard Beckhard. The program focussed on the many areas in the fields of organization development and organizational change in which Professor Beckhard had worked throughout his career and attracted participants from many organizations and countries.

RESEARCH

This section summarizes the major research efforts and accomplishments of the School. This work is both disciplinary and multi-disciplinary in character and is grouped here under three main headings corresponding to the major clusters within which the School's faculty are currently organized: Behavioral and Policy Sciences; Economics and Finance; and the Management Sciences areas. The section does not include detailed references to the substantial research efforts and participation of the Sloan School faculty and staff in the activities of many of the Institute's interdepartmental centers or laboratories. These are described in the separate center or laboratory reports.

Behavioral and Policy Sciences

The faculty of the Behavioral and Policy Sciences Area deal with a broad range of managerial issues ranging from context-specific subjects like health, technology, and human resource management through process activities like strategy and policy planning and on into the disciplinary foundations of management including organizational studies and behavioral theories of decision making. Amidst the diversity may be found certain important commonalities. In particular, the area faculty consistently employ the research methodologies of the behavioral sciences and, from their individual vantage points, they all display a continuing concern for policy issues.

The structure of the area fosters cross-disciplinary research and the past year has produced a number of important examples. Most striking is the "Management in the 90's" project organized by Professor Scott Morton, a member of the strategy and policy subgroup. The project is a multi-year, multi-million-dollar research effort sponsored by a consortium of about 10 companies and government agencies. It will examine the changing nature and content of management as these are affected by the new information technologies. The research team being assembled draws faculty from across the whole School, including individuals from strategy and policy, organization studies, industrial relations, international management, operations management, and information systems. Such a crossing of research areas is a hallmark of the Sloan School.

Any classification of the faculty's research is, to a certain extent, arbitrary, because of the overlap and intermixing of subject matter. In the descriptions that follow, we shall try to point out some of the interconnections.

Human Factors in Management. Human issues are central to the management of an organization and to the relation of organizations to each other and to the economic, social, and political environments within which they function. The faculty in the organization studies and industrial relations subgroups have their primary research in these areas and frequently overlap one another, particularly around the subject of human resource management.

In Organization Studies the faculty are concerned with understanding the dynamics of behavior in organizations, especially the relation between the individual and the organization. Professor Edgar H. Schein has been studying various aspects of organizational culture for several years and is presently finishing a book on the subject. Professors Lotte Bailyn and John E. Van Maanen, along with Professor Schein, are completing three volumes that report the results of their major project sponsored by the Office of Naval Research on careers, socialization, and organizational culture. Their work covers a broad range of theory, methods, specific findings, and practical applications.

Professor Bailyn, who has been doing research on the career dynamics of technical professionals in R&D laboratories, has now started collecting data at an important new site. Professor Van Maanen, on sabbatical leave this year in the United Kingdom, has been examining different socialization settings for indications of precisely how organizational cultures are transmitted from one generation of members to the next. Senior Lecturer Edwin C. Nevis has completed his study on the integration of organizational and individual needs in service organizations employing professionals in analytic and consulting roles. He is now moving into an active role in the "Management in the 90's" project.

A new research thrust for the School comes in the growing field of behavioral decision making. Two of the faculty who have joined the faculty this past year are active in this area. Professor John S. Carroll studies how people understand and make judgments about others and how those judgments translate into actions or decisions. He is finishing several projects on decision making in the criminal justice system, including, at one extreme, a study of how parole officers make decisions, and, at another, how shoplifters do. With Professor Max H. Bazerman he is also developing a project investigating negotiation strategies. The goal will be to determine how people conceptualize negotiations so as to achieve their cooperative and competitive objectives. This work is of high interest and relevance to the industrial relations field where negotiation is vital for resolving disputes.

Another new faculty member is Professor David G. Anderson. Among his research activities has been a corporate revitalization study. This is a retrospective study of how several large companies underwent major changes in strategy, organization, and culture that resulted in significantly improved capabilities and financial performance. The focus of the research is on the role of top executive groups in the revitalization.

In the other part of the Behavioral and Policy Sciences Area that focusses on human issues, the Employment and Industrial Relations subgroup is in the third year of a major project funded by the Sloan Foundation, "US Industrial Relations in Transition." As is apparent from many indicators, fundamental changes are taking place in industrial relations in this country and so it is a good time to analyze the current state of affairs and identify directions for the future. Professor Thomas A. Kochan, Professor Robert B. McKersie, and Research Associate Peter Cappelli have developed and published a "strategic choice" theoretical framework that is being used to guide the research in the project. A series of sub-studies conducted individually and jointly by the faculty, often in connection with graduate students, has made much progress. One of these, the effect of worker participation projects on local unions and on the collective bargaining process, will be published as a book. The important area of concession bargaining and the environmental pressures promoting it has been studied, along with the terms and changes involved.

Professor Harry C. Katz has completed a book on the evolution of labor relations in the auto industry during the postwar period. The work focusses on collective bargaining, particularly analyzing plant-level measures of industrial relations and economic performance, utilizing data drawn from General Motors.

Three PhD dissertations have been completed with project support and one of them, Casey Ichniowski's work on the effect of labor relations on productivity in a multi-plant firm in the paper industry, was honored by receiving the Sloan School's Zannetos prize for the best PhD dissertation of the year.

Two extensions of the project have recently been funded. The Department of Labor is sponsoring a study of the staying power in practice of various industrial relations innovations, and the National Science Foundation is supporting a micro analysis of changes in wage determination under collective bargaining.

Professor Katharine Abraham is exploring the determinants of short-term fluctuations in the unemployment rate. She finds that shifts in economic activities among sectors play nowhere near the role in generating short-term unemployment as has been claimed in certain previous work. Her research has distinct implications for national policy. In another piece of research that cuts across different areas of the School, Senior Lecturer Thomas A. Barocci has finished an extensive project in human resource management focussing on the information systems professional. This work has been done in conjunction with Christine Bullen of the Center for Information Systems Research. Dr. Barocci has also continued his case-based research on the design, measurement, and implementation of quality assurance and productivity programs in American industry.

The study of careers requires foresight and patience. Professor Phyllis A. Wallace started with the Class of 1975 to conduct longitudinal research on graduates of the Sloan School master's program. Her sample covers some 300 individuals from the Classes of 1975 through 1979. One of the primary objectives has been to chart how young managers, particularly women, move into middle management. One preliminary finding, which will be carefully followed since it differs from findings reported at two other business schools, is that five years after graduation, women graduates of the Sloan School who are full-time employees appear to do as well as their male counterparts.

Professor Bazerman conducts research that cuts across both organizational studies and industrial relations issues. His primary concern is the theoretical and empirical analysis of human judgment in situations, such as negotiation and arbitration, that have competitive aspects. His work looks at ways in which individuals deviate from common economic models of rational behavior. Implicit is an interest in identifying judgmental distortions so as to suggest how individuals can improve their performance. One stream of his research seeks to understand the characteristics of situations leading to "the winner's curse." This is the situation where, in competitive bidding, the winner regrets having won, or, in negotiation, the party making an offer is sorry when it is accepted.

System Dynamics. Research in system dynamics has focussed on corporate policy, national economic behavior, and organizational innovation. Professor Morecroft has devoted the past year to developing connections between mainstream strategy and policy research and system dynamics. He has found a substantial consistency of concepts and viewpoint in those parts of the strategy literature dealing with strategy, structure, and organizational processes and those parts of the system dynamics literature dealing with business decision making and feedback structure. This has led to the identification of strategic program design, which is the putting together of consistent business programs to support strategic initiatives, as an opportune area for application of system dynamics methods. He has further developed a two-phase framework for conducting model-based analyses for the area.

Work on the system dynamics national model has progressed steadily. An integrated theory has been constructed to understand the economic long wave and the national model has been expanded to include the effects of government deficits and deficit financing. Much of this research has been conducted by Professor Jay W. Forrester, Professor Senge, and Research Associate Alan Graham. A series of books describing the model and its implications has been outlined.

In addition to the national model, Professor Forrester has started an investigation of the dynamics of the arms race, believing that many of the policies being followed have low-leverage for changing the current disfunctional state of affairs. Professor Senge has also initiated a project around systems thinking and "the new management style." His initial objectives are to develop a statement of the nature and potential of non-hierarchical organizational structures and to identify generic dynamic structures of the new style.

Professor John Sterman has been primarily responsible for the endogenous dynamic theory of the long wave in the national model. He has also derived a simple model from the national model to show how the micro-level policies used by firms can result in the long wave at the aggregate level. This is related to his more extensive concern with local or bounded rationality and its representation in system dynamics models. He is developing methods to demonstrate the inner logic of local decision rules that may be rational at the local level but lead to unexpected or globally irrational behavior in the large.

Management of Technology. As US firms find increased competition at home and abroad in traditional markets, attention turns to technology as a source of new products and of improved productivity in manufacturing. Issues of managing technological innovation, capturing its benefits, and incorporating technological change into company strategy take on increased significance both for the firm and the economy. Professor von Hippel is in the late stages of completing a book on his well-regarded work on

innovation by users. He is also well along on his National Science Foundation-sponsored study on how innovators capture the benefits of their efforts and how this affects their motivation to innovate. In new work, in part joint with Professor Urban of the marketing area, Professor von Hippel is investigating the idea of employing "lead users" to improve the capacity of market research to generate and evaluate radical new product concepts.

In a continuing series of studies of international technology transfer in collaboration with foreign colleagues and former students, Professor Allen finds that it takes several years and more than one job change before engineers and managers leaving multinational companies reach indigenous industry in any sizable proportions, but that they eventually do and carry a significant amount of technology with them. In other work he finds that the effective transfer of technology from corporate R&D to operations is strongly affected by the attitudes between the two groups. Transfer is hindered by prejudice and stereotyping but can be fostered by increased communication between the two. Currently, Professor Allen is starting a study of the impact of electronic mail on technical communication. This last will tie into the "Management in the 90's" project.

Professor Roberts has extended his research on the product line strategies of small high technology firms. He finds that commercial success is most strongly associated with a well-focussed exploitation of a new, but not too new, technology. One of our new faculty members, Professor Anderson, whose disciplinary background lies in organizational studies, has been investigating the hypothesis that innovative products in many industries are best understood as aggregations and combinations of many small micro-innovations. Confirmation of such a theory would have significant implications for how to organize new product development.

Strategy and Policy. The pace of change and competition in the business world, both domestically and internationally, has heightened in recent years, causing corporations to put more emphasis on strategic issues. During the 70s a new strategy consulting industry grew at a remarkable rate, but by the early 80s was meeting heavy criticism for being too superficial. Clearly needed is more fundamental research on strategy development and its integration into the management process. Within Sloan a surprising number of faculty with disciplinary backgrounds have, over the past few years, become interested in the strategic problems of the firm. Several of them have gravitated to the strategy and policy subgroup where they have been joined by young faculty hired directly. Because of the wide interest within the School, the core group is interconnected well with such other areas as organization studies, international management, and the management of technology.

One of the group's recent immigrants, Professor Hax, who was previously in operations management, has actually been studying strategic planning systems for several years. His work has culminated in two books. One is on the design and implementation of formal strategic planning systems from an integrated perspective; the other, which he is editing, is a readings book on strategic management. Professor Hax's current research emphasizes the linking of managerial functions to the strategic planning process, with a special concern for the manufacturing-technology interface.

As mentioned earlier, Professor Scott Morton is off to a fine start on his ambitious and exciting project, "Management in the 90's." This is a five-year effort with multiple sponsors, six of which are already signed up. The premise of the project is that changes in the information technologies (computers, artificial intelligence, telecommunication, office automation, professional workstations, and so on) will have a significant impact on the way firms are structured and managed in the future and will also affect the strategies that they will choose to pursue. In his personal research Professor Scott Morton has focussed on the strategic opportunities opening up for non-technical firms as a result of information technology developments.

Professor Mel Horwitch studies large-scale enterprise. A special concern is the characteristics and limits of professional strategic management in attempting to deal comprehensively and explicitly with complex issues. He is also investigating the changing strategy-technology relationship in technology-based industries. Professor Walker looks at organizations using network models and transactional cost analysis. He is completing a study of interorganizational coordination by a set of child-care agencies. In another piece of research he finds that the network of relationships in a firm predicts individual differences in perceptions better than functional or hierarchical roles. Professor Walker is further analyzing make-or-buy decisions with transaction cost methods. One study is completed and others are in process. Professor Zenon S. Zannetos, although his major energies have been absorbed by School resource development, continues to do research on productivity and innovation as well as oil economics and transportation.

International Management. The same global forces that have highlighted technology and strategy have brought issues of international management and the multinational corporation into prominence. The Sloan School, like the rest of MIT, has always attracted and accepted substantial numbers of non-US students and its faculty have always traveled and lectured widely. The international management subgroup has added to its faculty and has expanded its purview, particularly with respect to Pacific rim countries. Professor Denis F. Simon, new this year, is doing research on technology transfer and the assimilation of technology

in developing countries with specialization in East Asia, particularly China. Japan is the focus of Professor Westney, who is completing a book on the adoption and adaptation of Western organizational forms in Meiji Japan. She is also undertaking a comparative study of the training, organization, and career paths of engineers in three Japanese and three US computer companies.

Professor Lessard has been doing research on the management of operating exposure to foreign exchange fluctuations. Working with Professor John Lightstone of New York University, he has developed new theory and methods of measurement for operating exposure and, in addition, has devised a financial contract that is appropriate for offsetting such exposures. He has also collaborated on a US Agency for International Development-financed study of geographical patterns of oil exploration. He finds that an overwhelming proportion of the activity takes place in developed countries, irrespective of geologic potential. He has devised fiscal and contractual explanations of this phenomenon using finance theory. The work has important implications for developing countries in managing their energy resource development.

Although Professor Richard D. Robinson has been on sabbatical leave this year, he has continued his comparative analyses of management practices in different countries. Along with Professor Simon he is involved in the preparation of a management conference to be held in China in the spring of 1985 that will focus on the role of foreign investment in national development, with particular reference to China.

Health Care Management. Health care and its efficient delivery represent major economic and social issues for the country. The Sloan School, through the research of its faculty and their involvement in the Division of Health Policy and Management of the Whitaker College, continues to play an active role. Professor Finkelstein, who is Director of interdisciplinary Laboratory for Health Care Studies in Whitaker, is doing research on a broad variety of topics, several of which are concerned with the link between medical evidence and clinical practice. These include such issues as the decision-making process in setting insurance reimbursements for a new technology and the impact of randomized clinical trials in changing health practices. In work that spans the technology and health areas Professor Roberts has been studying the formation and growth of biomedical firms, including the consideration of their linkages to medical schools and hospitals and the impact of FDA regulations.

Law. Although law has not traditionally been a research area at the School, Professor J. D. Nyhart makes a persuasive case that it should be. He himself (with colleagues in Ocean Engineering) has pioneered in the use of computerized mathematical models to assist negotiations with a well-publicized success story in the use of the MIT Deep Ocean Mining Model in the Law of the Sea negotiations. He has continued to be active in research on the law-technology interface. During the spring term Visiting Scholar Vincent Brannigan was in residence conducting research on the legal problems of computer software in the medical sciences. Dr. Meldman continues his work on privacy in relation to computer technology.

Professor Nyhart and Senior Lecturer Gordon F. Bloom are in the process of establishing an innovative organization called the Massachusetts Critical Issues Forum. This will be a committee composed of respected leaders from industry, government, and public interest groups, who will have as their objective the resolution of controversial issues through consensus supported by research. A blue-ribbon group of leaders has agreed to serve and the first topic for consideration will be visual display terminals and their impact on the employee.

Economics and Finance

The Economics and Finance Group is the second broad disciplinary area on which the School's teaching programs build and whose research contributes to the understanding of both important theoretical and practical problems relating economic and financial considerations to management concerns.

During the year, Institute Professor Franco Modigliani was active in research in several areas of macroeconomics and finance. He completed a National Science Foundation project, undertaken jointly with Professor Lucas Papademos of Columbia University, on the role of money and credit policy targets in an economy with highly developed financial intermediaries and flexible prices. He also continued his research on the economic consequences of government deficits and government debt, and the extent to which deficits "crowd out" private investments.

Professor Modigliani has a long-standing interest in the impacts of inflation on capital markets. With Professor Richard Cohn, of the University of Illinois, he completed a paper surveying what is known about the impact of inflation on corporate finance. He also chaired a panel set up by the American Economic Association to recommend whether large corporations should continue to be required to publish inflation adjusted financial statements.

Professor Ernst Berndt worked with David O. Wood, of the MIT Energy Laboratory, to develop procedures to measure the degree of obsolescence of physical capital due to the 1973-74 and 1979-80 oil price shocks. This work is now being extended to allow international comparisons of the impact on capital equipment values caused by shifts in energy prices.

A related project, conducted jointly with Mr. Wood and Professor Ann Friedlaender, of the MIT Department of Economics, seeks to understand how consumers respond to new product innovations in the US and Swedish automobile markets. This project has required development of new econometric techniques, since many of the relevant variables are not directly observable. Professor Berndt and Mr. Wood are also beginning a project which evaluates and compares the operating performance of a sample of electric utilities during the 1970s.

Professor Daniel M. Holland edited a new volume, Measuring Corporate Profitability and Capital Costs. This volume contains profitability studies for 10 countries. International evidence on profitability is rarely available in comparable form. The study for the United States was prepared jointly by Professor Holland and Professor Myers. Professor Holland continued as Editor of the National Tax Journal.

Professor Paul Krugman pursued two main lines of research during the past year. The first consists of theoretical work on trade under imperfect competition and economies of scale. Professor Krugman has written a book with Professor Elhanan Helpman, of Tel Aviv University, which provides a general approach to this topic. The second line of research analyzes proposals for US industrial policy, particularly proposals responding to 'other countries' industrial policies.

Professor Edwin Kuh continued as the Director of the Center for Computational Research in Economics and Management Science. He is contributing to that Center's new effort to develop expert systems to provide guidance for the process of econometric model building in economics and management. This research has received initial support from the National Science Foundation. In addition, he has completed a major project to develop the procedures for analyzing complex econometric models using linear systems methods.

Professor Robert C. Merton's major research work during the year has been conducted with Professor Terry A. Marsh. They have focussed on analyzing the recent empirical tests which purport to show that stock market prices are too volatile to be rational estimates of underlying economic value. Professors Merton and Marsh have developed a new model of the process determining stock prices and shown that the observed volatility of stock prices is fully consistent with that model. Their work so far has been confined to stock market indexes, but they are now extending it to individual companies.

In another paper, written with Professor Stanley Fischer of the Department of Economics, Professor Merton analyzes the macroeconomic role of the stock market, and attempts to bridge the gap between the theories of financial economics and macroeconomics. Finally, he has continued his research in the general area of private and public pensions.

Professor Myers completed his term as President of the American Finance Association. His Presidential Address reviewed traditional theories of corporate capital structure and advanced a new theory based on asymmetric information models. The new theory is largely based on his work with Professor Nicholas Majluf of the Universidad Catolica de Chile, on corporate financing and investment decisions under asymmetric information. As was mentioned above, he completed a study with Professor Holland on profitability and capital costs of the United States.

Professor Myers has also worked with Saman Majd, a doctoral candidate at Sloan School, to develop new procedures based on option pricing for analyzing corporate capital investment decisions. Their most recent work in this area analyzes the asymmetries in the US corporate tax system.

Professor Robert S. Pindyck studied the nature and behavior of business risk in the United States. His initial results indicate that poor performance of the stock market over the past decade may be due to an increase in the riskiness of the rate of return to capital. He also continued work on the ways in which uncertainties about prices and costs affect the investment, output, and pricing decisions of firms and the behavior of markets. One aspect of this work has been research on the effects of uncertainty on both renewable and exhaustible resource markets.

Professor Pindyck continues to work on various problems in American economic policy. Over the past year, he has studied oil prices and the implications of oil price uncertainty for business investment decisions and public policy. He and Professor Julio J. Rotemberg studied macroeconomic policies in response to energy price shocks.

Professor Lester C. Thurow has devoted much of his time during the last year to a new book developing recommendations for restoring productivity growth and making American industry competitive in world markets. The book will be published in early 1985. During the year, he was elected to the American Academy of Arts and Sciences and was the recipient of the Champion Media Award for distinguished writing.

Professor Schmalensee worked jointly with Professor Paul Joskow, of the Department of Economics, on the study of scale economies and technical change in coal-fired steam electric generation. He has also undertaken a broader study comparing production efficiency in over 70 industries during the period 1963-70. This study will investigate the relationships between industry profitability, market share, concentration, and advertising intensity. He has continued theoretical work on localized competition and nonprice competition.

Professor John C. Cox's recent research has been primarily in two fields. The first of these is intertemporal investment theory. In a specific setting, he has provided a complete characterization of path-independent policies. These policies are shown to be important for portfolio managers and a broad class of individual investors.

His second field of research has concerned optimal consumption and portfolio strategies. He developed a constructive way for deriving explicit optimal decision rules for any additive utility function whenever asset prices follow a multivariate diffusion process. His results have potentially important applications for research on asset price volatility and on consumption-based asset pricing models.

Professor Chi-fu Huang undertook theoretical investigations of intertemporal general equilibrium theory under uncertainty and continuous time, with particular emphasis on efficient intertemporal allocation mechanisms. He has also studied various issues related to arbitrage with asymmetric information in a rational expectations framework.

Professor Marsh's research with Professor Merton on the volatility of stock market prices was mentioned above. Professor Marsh's other research interests include the term structure of interest rates, the relationship between risk and accounting profitability, and the effects of gaps in trading on statistical estimates of stock price risks.

Professor Marsh was awarded a Batterymarch Fellowship for research during the academic year 1984-85.

Professor John E. Parsons completed a paper with Professor Arthur Raviv, of Northwestern University, which analyzes the market for new issues of stock made by listed corporations. The paper shows how the current institutional structure of US stock markets causes the price for a new issue to be set below the prior market price. They also analyzed the choice between a general cash offer and a rights issue. Professor Parsons spent the fall term at Humboldt University, where he studied the structure of loan contracts for major investment projects.

Professor Rotemberg continued research on business fluctuations caused by monetary movements, concentrating on the international transmission of these fluctuations. He also studied the effects on individual behavior of the inability to borrow unlimited, uncollateralized funds, and showed how this inability may affect both individual portfolios and individual consumption and savings decisions.

Professor Richard S. Ruback, working with professor Martin Zimmerman of the University of Michigan, completed a paper analyzing the impact of unionization on company profitability, as reflected in stock market prices. The paper uses the empirical techniques of modern finance to measure the effects of unionization. In another paper, "An Economic View of the Market for Corporate Control," he develops and extends a theory of the market for corporate control as an arena in which managers compete for the rights to manage corporate resources. The various forms of takeovers are analyzed within this framework. He also completed a paper showing the impact of corporate investments in the common stock of other corporations. This work was done with Professor Wayne Mikkelson of the University of Chicago.

Professor Ruback was also awarded a Batterymarch Fellowship for the year 1984-85.

Professor Thomas M. Stoker's work this year fell into two categories. First, he studied issues of aggregation of microeconomic and macroeconomic data. He wrote several papers on estimation of macroeconomic effects using cross section microeconomic data. This work shows how linear regression can be used to estimate such effects, regardless of the true form of the relationship between dependent and independent variables.

The second part of Professor Stoker's work concerns consumer demand. He has completed work on a model which characterizes the demands for energy and nonenergy commodities for individual US households, as well as the aggregate demand for these commodities. This model is applied to test various hypotheses on individual families' consumption and the proper construction of aggregate price indices. This work has been done with Professor Dale Jorgensen of Harvard University and David Slezneck of the University of Texas.

Management Sciences

As microcomputers continue to permeate the academic and business communities, they are changing the internal and external environment of organizations in unprecedented ways. In business, many managers now have ready desktop access to large data bases and to the power to manipulate and analyze this information. For the first time, popular publications, such as Business Week, are publishing articles and advertisements on linear programming, statistics, expert systems, and other decision support tools. In this environment, it is likely that within the near term, microcomputers and accompanying decisions support aids will become pervasive. Moreover, the microcomputer and microprocessor revolution is prompting managers everywhere to reconsider the importance of information, models, and analysis, even in situations removed from computer technology.

These changes pose significant challenges and opportunities for business schools, in general, and for the Sloan School in particular. The Management Sciences Area of the Sloan School has pioneered the development of decision support systems and their use in problem contexts as varied as marketing, production, distribution, communication, energy, computer networking, urban planning, and health care. Moreover, the area has been at the forefront in developing the underlying methods of optimization, statistics, information processing, and accounting and control. As illustrated by the following brief summary of research, which is organized by the subgroups within the Management Sciences Area, this past year the faculty has sustained its tradition of linking theory to practice across a wide variety of methodological and contextual domains.

Marketing. The Marketing Group continues to develop decision models for marketing analysis and to test these models in practice. For example, in their collaborative research on new consumer durables, Professors John R. Hauser and Urban have extended their analysis for assessing new product introductions and applied their methodology with a major automobile manufacturer. Professor Hauser has also refined his methodological investigations of agency theory and begun to study long-term defensive marketing strategies. Professor Urban has also worked on the timing of product entries and its effect on market share, on industrial segmentation, and on marketing/technology interfaces. Professor Leigh McAlister has completed long-term research on variety seeking behavior and has renewed her research on channels of distribution. Her research focus has shifted, however, to consumer promotions for which she has begun to develop underlying theory and basic models. Professor John D. C. Little, from the Behavioral and Policy Sciences Area, has pursued his study of modeling market response analysis, particularly on data collected by optical scanners at point of purchase. He has also built a prototype executive support system for a marketing vice president and is studying the use of such systems. Dean Alvin J. Silk has investigated a variety of organizational issues including questions of in-house vs. outside advertising agencies, the nature of client-agency relationships, and the role of copy testing in creative advertising.

Operations Management. With the nation's heightened reawareness of manufacturing and its central role in our economy, the planning efforts of the Operations Management Group become particularly important. Professor Gabriel R. Bitran has continued to direct several projects supported by industry, including the study of production scheduling in developing countries, the management of spare parts, and production scheduling of semiconductors. He has also initiated research on job shops with fabrication and assembly operations and on production planning of stylized goods. In collaborative effort supported by industry, Professor Graves and Senior Lecturer Harlan Meal have also studied integrated-circuit production planning, and are beginning a field study on manufacturing control and layout in multi-stage systems and job shops. Professor Graves has also developed a conceptual framework for resource planning in a community-based mental health care system and studied consolidation policies for less-than-truckload freight shipping. Professor Charles H. Fine has completed work on quality control and learning, and initiated research in several new areas--quality management, economics of flexibility, and manufacturing strategy.

Accounting, Planning, and Control. The Accounting, Planning, and Control Group continues to work on a broad range of issues related to the generation, analysis, and measurement of accounting data. As the first stage of a long-term project, Dr. McInnes and Professor Ram T. S. Ramakrishnan have completed a large data collection effort on the effects of uncertainty, risk attitudes, information, and related organizational factors on budgeting and management control systems. Dr. McInnes has also continued to study corporate management of productivity, and Professor Ramakrishnan has studied the determinants of synergy in mergers, and the implications of choices of accounting methods. Professor H. David Sherman has collaborated on this last topic and has also continued his long-term investigation of performance measures in service organizations. He has also begun to study control systems for new venture management. Professor Paul M. Healy has completed research on the effect of bonus schemes on accounting procedures and accrual decisions, and has also studied mergers in the auditing market. Since joining the faculty in January, Professor Sudhir Krishnamurthi has been refining and documenting his thesis research on security price reaction to quarterly earnings announcements and on market efficiencies for small firms.

Management Information Systems. The new information and communication technologies are changing management in fundamental ways. With both government and industry support, the Management Information Systems Group studies underlying technology, the management and use of information, and organizational implications of the new technologies. Working with Dr. Hoo-Min Toong, Professor Madnick has led the technology effort by studying a new high-speed, highly reliable computer architecture using hierarchical concurrency control. He has also investigated a design methodology for supporting software development. While on sabbatical, Professor Donovan has been synthesizing his earlier research on the design of computer systems. Professors John C. Henderson and Michael E. Treacy have worked in the general area of decision support systems. Professor Treacy has been particularly concerned with measuring the impact of decision support systems on business planning. Professor Henderson has been eliciting and using critical assumptions held by managers as a guide for developing support systems. Dr. Rockart has continued to refine his critical success factor methodology and has directed, through the Center for Information Systems Research, a number of field studies on the use of information and executive support systems in practice. Professor Marvin Sirbu has worked in the general area of telecommunications and public policy. As the first phase of a project on information standards, he has been assembling case histories on standards developed over the past 15 years; he is also studying directory services for electronic mail systems and the evolution of private and public telecommunications networks. Professor Thomas W. Malone has focussed

on organizational issues. He has developed theoretical constructs for explaining organizational designs, and has studied a variety of issues related to computer systems and their operation--user interface designs, use of computers to coordinate organizational activities, and designs based upon analogies with human organizations. In a related activity, Professor JoAnne Yates has continued her archival research on the evolution of internal communication systems in American business.

Operations Research and Statistics. The Operations Research and Statistics faculty work on statistical and stochastic modeling and on optimization, with a dual focus on developing methodology and applying it in a variety of applied contexts. Professor Kaufman completed a long-term research project with Brookhaven Laboratories on methods for projecting oil and gas supply from new discoveries. Professor Arnold I. Barnett continued to study criminal justice systems and air traffic safety, and also began new work on analyzing the effectiveness of subway systems. Professor Roy E. Welsch extended his long-standing research on regression diagnostics, bounded-influence regression, and generalized nonlinear regression. He has also initiated research on graphical methods using a new graphics system at the Statistics Center. Professor Wong has continued his investigations of clustering methods (e.g., sampling properties) and of classifying multi-angular data. In more applied work, he has studied counterfeit-related credit card losses, sub-typing of the hepatitis-B virus, and the analysis of human gait data. In the area of optimization, Professor Orlin has continued to clarify the intrinsic difficulty of many combinatorial optimization problems, including several with dynamic/periodic structure or that have particular algebraic structure. He has also been developing efficient heuristic procedures for an emergency scheduling and readiness problem faced by the Military Sealift Command. Professor Robert M. Freund has studied classical combinatorial results that relate to fixed point methods and polyhedra. He has also studied sensitivity analysis in linear programming and worked on depletable resource economics and coal reserve evaluation. Professor Shapiro's research has been increasingly directed to logistics and strategic planning for which he draws heavily on his earlier work in integer programming. Professor Thomas L. Magnanti continues to study network optimization in such settings as network design and network equilibria. In addition, he has directed an industry-sponsored study of point-to-point freight delivery systems.

Awards. The outside world continues to recognize the Management Sciences faculty in a variety of ways. This past year, Professor Hauser received an award from The Institute of Management Science for the best paper in the marketing sciences literature for 1982. Professor Orlin received a Fulbright Fellowship for research in the 1984-85 academic year in The Netherlands. Professor Little, the former head of the Management Sciences Area, has been elected president of The Institute of Management Science and is currently assuming duties as the president-elect. Professor Magnanti was listed in the first edition of Who's Who in the Frontiers of Science and Technology.

EXTERNAL RELATIONS

In 1983-84, the School concentrated its external relations efforts in the areas of alumni/ae relations, publications distributed both to alumni/ae and to members of the larger Sloan and MIT communities, and fund-raising.

In the area of alumni/ae relations, the School sponsored a third round of Summer Gatherings, social occasions for alumni/ae and current students of the master's and PhD programs. This year's gatherings took place in Cambridge in the newly refurbished Sloan lobby, in the corporate headquarters of the Bankers Trust Company in New York City, and at the Metropolitan Club high in the Sears Tower in Chicago. The MIT Alumni Association, Bankers Trust, and Baxter Travenol Laboratories helped to underwrite the cost of these gatherings, which were attended by the Dean and other members of the Sloan School administration and nearly 500 alumni and alumnae. Also, a regional convocation was organized by the Society of Sloan Fellows in Los Angeles, at which alumni from all Sloan programs were invited to attend. The theme of the convocation was "Excellence in Management" with featured speakers Dean Abraham J. Siegel, Professors Hax and Anderson, and Mr. White, Director of Executive Education Programs. Atlantic Richfield and Donald A. Henriksen, SF '68, graciously hosted the meeting.

Throughout the year, the Graduate Management Association (GMA), the alumni/ae association of the master's and PhD programs, organized additional regional alumni/ae gatherings at locations across the country: Cambridge, Washington, DC, Chicago, Los Angeles, San Francisco, and Seattle. Officers and governors of the GMA met at Sloan twice during the year to review progress of alumni/ae activities and to plan future activities and directions, including first-time reunions in Cambridge for classes celebrating their 5th, 10th, 25th, and 30th reunions.

Publication of SLOAN, the School's alumni/ae magazine, continued with two issues that focussed on important issues in the field of management and happenings at Sloan. Of course, the Class Notes is one of the best-read sections of the magazine. SLOAN has now appeared five times, and has been so well received that more than one other graduate management school's alumni magazine has begun to look like SLOAN.

In addition to the external relations activities addressed toward the alumni/ae, the School expanded its fund-raising efforts by seeking to increase the number of its corporate and individual friends and by acquainting them with the educational programs at Sloan and the research of its faculty. The number of

corporate sponsors increased by 15 during the year bringing our current total to 38 sponsors, each of whom provides the School with at least \$5,000 per year. It will take a few more years before we reach our goal of 100 such Sloan sponsorships.

We have also begun solicitation at corporate and foundation sources for unrestricted research funding and for support of special Sloan projects, particularly in the areas of finance and accounting.

We have also expanded our efforts to seek additional financial support for minority graduate students whose numbers in our programs we continue to try to increase (this year with better success than last).

A program for solicitation of potential individual donors to Sloan has been established after consultation with central resource development and Alumni Association staff. These individuals include both alumni and non-alumni who have indicated substantial interest in funding (and indeed have begun to fund) specifically targeted scholarship or other endowments at the School. We have initiated a campaign to establish a School fund honoring Miriam Sherburne's 40 years of major contributions to the School and to its thousands of alumni/ae.

We have already started enjoying the results of these efforts in terms of financial support, increased recruiting activity, and use of our executive education programs. We expect the effect of our external relations activities to accelerate over the years.

Enhancement of the relationships between the School and its external constituencies is one of the top priorities of the Sloan School. The Dean and the Chairman of the Faculty Committee for Resource Development, Professor Zannetos, plan to increase the amount of their time devoted to this area. Once again the help from others at MIT has been exceptional. Professor Samuel A. Goldblith and his staff, William J. Hecht and his colleagues at the Alumni Association, and Glenn P. Strehle, MIT's Treasurer, were extraordinarily helpful in both steering and joining our efforts.

STAFF CHANGES, PROMOTIONS, AND VISITORS

At the start of the 1983-84 academic year two members of the faculty were named to fill two newly endowed chairs at the Sloan School. Associate Dean and Professor of Management Science, Alvin J. Silk, was named the first Erwin H. Schell Professor of Management honoring Professor Schell who had served as department head of the undergraduate Course XV until his retirement in the 1950s. Professor Lester C. Thurow was named Gordon Y. Billard Professor of Economics and Management, named for the donor who received the SB degree from Course XV in 1924.

Former Sloan School Dean, MIT President, and Chairman of the Corporation, Howard W. Johnson, returned to the Sloan School as Special Faculty Professor; he will be teaching in the Behavioral and Policy Sciences Group.

One faculty member was granted tenure this year. Gabriel R. Bitran, Associate Professor of Management Science, has been a member of the Sloan School faculty since 1977, having previously held an appointment at the University of Sao Paulo in Brazil; he received his PhD in Operations Research from MIT in 1975.

Four members of the faculty were promoted to the rank of Associate Professor. M. Anthony Wong, who holds a PhD in Statistics from Yale, and James B. Orlin, whose Doctorate from Stanford is in Operations Research, are both members of the Management Science Area. Harry C. Katz, who holds a joint appointment with the Sloan School and the Department of Economics, earned his PhD in Economics from the University of California at Berkeley. Mel Horwitch, who received his Doctorate in Business Administration from Harvard, is a member of the Behavioral and Policy Sciences Group.

Three new appointments were made to the rank of Associate Professor. John S. Carroll joined the Behavioral and Policy Sciences Group; he previously taught at Loyola University, Carnegie-Mellon, and the University of Chicago and holds a PhD in Social Psychology from Harvard University. John C. Henderson earned his PhD in Operations Research from the University of Texas and is working in Management Information Systems. Former Visiting Associate Professor, John C. Cox, who joined the Economics and Finance Group, had been teaching finance at Stanford since 1975; he holds a Doctorate in Applied Economics from the University of Pennsylvania.

We were pleased to welcome 10 new Assistant Professors to Sloan's faculty. Joining the Behavioral and Policy Sciences Group were David G. Anderson, Max H. Bazerman, and Denis F. Simon. Professor Anderson received a PhD from Stanford and has been a consultant at McKinsey & Company; Professor Bazerman holds a PhD from Carnegie-Mellon and most recently taught at Boston University; Professor Simon, who was named Ford International Assistant Professor, received his degree from the University of California at Berkeley and has worked most recently for the US Government at the National Foreign Assessment Center.

The Management Science Group welcomed Robert M. Freund and Thomas W. Malone both of whose PhDs are from Stanford; Paul M. Healy from the University of Rochester; and Marvin A. Sirbu, KDD Career Development Assistant Professor in Communications and Technology, who holds an ScD in Electrical Engineering from MIT, and previously held teaching appointments in Mechanical Engineering and in Electrical Engineering and Computer Science.

Sudhir Krishnamurthi, a DBA candidate from Harvard Business School, accepted a joint appointment in Management Science and Finance. John E. Parsons, whose PhD is from Northwestern University, joined the Applied Economics and Finance Group. Chi-Fu Huang, a PhD from Stanford University, holds a joint appointment in Sloan's Applied Economics and Finance Group and in the Department of Economics.

Visitors to Sloan this year included Shlomo Maital, on sabbatical leave from Technion-Israel Institute of Technology, who, as Visiting Professor during the spring 1984 term, taught subjects in Applied Economics and Finance. Visiting Associate Professors were Scott A. Neslin from Dartmouth College and Paul R. Warshaw from McGill University, both of whom taught Marketing subjects during the spring semester.

Three Senior Lecturers were newly appointed in 1983-84. Russell W. Olive and Steven H. Star held half-time appointments in the spring semester. Thomas A. Barocci, formerly Assistant Professor in the Behavioral and Policy Sciences Group, received a two-year Senior Lecturer appointment.

Four part-time Visiting Lecturers taught at Sloan. Sheldon A. Borkin, a Project Manager at IBM, was responsible for Advanced Computer Systems. Donald B. Rosenfield, a consultant with Arthur D. Little, Inc., taught Operations Management; William F. Frank taught Management Information Technology II; and Karl H. Clauset lectured in System Dynamics.

Three faculty members spent the 1983-84 academic year on sabbatical leave. John E. Van Maanen spent the year at the University of Surrey in Guilford, England, on a Fulbright Fellowship. Henry D. Jacoby was in London studying and conducting research in Applied Economics and Public Finance. Eli Shapiro spent his sabbatical year reviewing the research in economics that has important relevance to the curriculum in management education.

Research Associates who joined Sloan's staff this year were Bernard Ichniowski and Joel E. Cutcher-Gershenfeld in the Industrial Relations Area, David Parker and Stephen Peters in the Center for Computational Research in Economics and Management Science (CCREMS), Junko Vietze in System Dynamics, and David DeLong and Diane D. Wilson in the Center for Information Systems Research (CISR).

Staff changes this year included the promotions to staff of Kathryn M. Bertrand, Administrative Assistant in the Management Sciences Area, and H. Janeal Austin, Administrative Assistant in the Behavioral and Policy Sciences Area. Wanda Osborn was hired to fill a similar position in the Applied Economics and Finance Area. Leo F. Briody was promoted from his position as Computer Operator to the staff position, Programmer Analyst in the East Campus Computer Facility. Paula Cronin, formerly Sloan's Director of Alumni/ae Relations and Information, became Editor of SLOAN Magazine. Donna Behmer was promoted to Assistant Director of Finance and Administration, and Gail Mann was promoted to Coordinator for Donor Relations.

Other new staff members include John Maglio, Microcomputer Network Administrator, and Sarah A. Finigan, Research Staff Administrator for System Dynamics.

We note the following departures from Sloan: Professor Eli Shapiro, since 1976 the Alfred P. Sloan Professor of Management, retired from the Economics and Finance Group. Professor Edward H. Bowman was eligible for early retirement and took that opportunity to accept a position at the Wharton School. Adjunct Professor Richard Beckhard, who has been on the faculty since 1963, also retired this year; he was a member of the Behavioral and Policy Sciences Group. Associate Professors Martin Zimmerman and Richard P. Bagozzi, Assistant Professors Dorothy Leonard-Barton and M. Lynne Markus, Lecturers John Feingold, James Paddock, Irwin Tepper, and Joseph F. Vittek, Jr. also departed.

Finally, with great sadness we record the death of Professor Emeritus Mason Haire. Dr. Haire, a renowned industrial psychologist and organization theorist, first served on Sloan's faculty from 1946-49. Dr. Haire returned to MIT in 1966 as Professor of Organizational Psychology and Management. During his tenure at Sloan, Professor Haire served as head of the Organization Studies Group and held the Alfred P. Sloan Professor of Management Chair.

ABRAHAM J. SIEGEL

School of Science

This is my third report to the President since becoming Dean of Science. I would like to note some accomplishments during the past year which will contribute to the continued excellence in teaching and research of the School. These accomplishments are:

- Strengthening of the five-year planning process for the departments and laboratories in the School of Science. These plans are an important guide for future action. An overall plan for the School of Science has been prepared for the first time. This School of Science plan discusses objectives of the School and both important long-term and short-term issues.
- Successful completion of the project to renovate the undergraduate chemistry laboratories.
- Establishment of a strengthened Statistics Center in the School of Science.
- Submission of a major project proposal to expand the Bates Nuclear Physics Laboratory.
- Recruitment of several outstanding new senior and junior faculty members to the School.

There have been several important personnel changes in the School. Arthur Mattuck succeeds Danny Kleitman as Head of the Mathematics Department. Danny's wit and intellectual judgement were welcomed in Science Council and he will be sorely missed. He has served the Department of Mathematics well by effective advocacy based on his engaging style. Gordon Pettengill succeeds Herb Bridge as Director of the Center for Space Research after six years of service. Herb has been an excellent director with considerable wisdom and experience about programs which often seem to float in outer space. His past leadership and contribution is much appreciated. Finally, after considerable deliberation, an excellent new director has been selected for the Experimental Study Group, Kim Vandiver of the Department of Ocean Engineering. He succeeds Bob Halfman who has led the ESG selflessly for the past ten years. The selection process revealed, once again, the important contribution that ESG makes to MIT by providing an alternative mode for undergraduate education. The program will continue to receive full support from the School of Science.

During the past year, I have become progressively aware of the opportunities which are presented by collaborative research and educational projects with individuals from the School of Engineering. Examples include biotechnology, fusion, electronic materials, polymers, and theoretical aspects of computer science. Such collaboration must come from faculty initiative and frequently will emerge from an interdepartmental laboratory or center. It is my intention to encourage such efforts as available resources permit, during the coming year.

Finally, I note the growing unease among the faculty that the continued emphasis on limited resources will impair the highest quality research and educational efforts. While it is unfortunately impossible to disregard resource constraints, I intend to make every effort to support a few major new initiatives during the coming year. Proposals for such initiatives are invited from any member of the School of Science.

ACADEMIC PROGRAMS

There were 742 undergraduates in the School of Science during the past academic year, approximately a seven percent increase from the previous year. The number of minority undergraduates increased by 76 percent, (reflecting substantial increases in the Hispanic and Asian-American population); the number of female undergraduates increased by 27 percent. Twenty-one percent of the Institute's upperclass undergraduates were enrolled in the School of Science.

Graduate enrollments in science decreased from 1,070 in the 1982-1983 academic year to 1,056 in the 1983-1984 academic year. The total enrollment represents approximately one quarter of the total graduate student population at MIT. The number of minority graduate students decreased slightly, and the number of female graduate students remained constant.

There were 281 faculty members in the School this past year. This represents a one percent increase from the previous year. The undergraduate student-to-faculty ratio was 2.6 to 1, and the graduate student-to-faculty ratio was 3.8 to 1.

RESEARCH

The FY84 research volume of the School of Science was slightly over \$81,000,000. This represents an 18 percent increase from the previous year.

FACULTY

In the Department of Physics, Professor Jerome Friedman was appointed Head of the Department and Professor Jeffrey Goldstone was appointed Director of the Center for Theoretical Physics.

On May 7, 1984 the Department of Biology was privileged to sponsor the Mayer Lecture in Life Sciences. The distinguished lecturer was Professor George Streisinger of the Institute of Molecular Biology, University of Oregon. The title of the lecture was "Genetic Analyses of Vertebrate Development: Experiments With Zebrafish."

Many faculty members received awards and honors during the year. In the Department of Biology, Professor Leonard Guarente was among 200 engineers and scientists selected to receive the first Presidential Young Investigator Award. Professor Alexander Rich, Sedgwick Professor of Biology, was elected to the French Academy of Sciences and Professor Phillip Sharp was elected to the American Academy of Arts and Sciences. The Graduate Student Council Award for Teaching in the Department of Biology was awarded to Professor Frank Solomon. Professor Graham Walker was among 283 scholars, scientists and artists selected for the 1984 John Simon Guggenheim Fellowship Award. In the Department of Earth, Atmospheric and Planetary Sciences, Professor Frank Spear was the recipient of the Graduate Student Council Award for Teaching. Recipients of honors in the Department of Mathematics include Professors Victor Guillemin and Harold Stark who were elected to the American Academy of Sciences and Professor Michael Sipser who received the Graduate Student Council Award for Teaching. The Graduate Student Council Award for Teaching in the Department of Nutrition and Food Science was given to Professor John Essigmann. Several faculty members in the Department of Physics were honored this past year. Among them were Professor George Benedek, Alfred H. Caspary Professor of Physics and Biological Physics, who was elected to membership in the Institute of Medicine; Professor Edward Farhi, who was selected as a Sloan Research Fellow, and Professor Walter H.G. Lewin, who was a recipient of a John Simon Guggenheim Fellowship Award.

The following faculty have been appointed to professorships effective July 1, 1984: Professor Rick Danheiser, Department of Chemistry, to the Roger and George Firmenich Career Development Chair; Professor George Clark, Department of Physics, to the first Breene Kerr Professorship; and Professor Jeffrey Goldstone, Department of Physics, to the Cecil and Ida Green Professorship.

We were saddened by the deaths of Dr. Stephen Panetitz, Assistant Professor, Department of Mathematics, Dr. Nathaniel Frank, Professor Emeritus of Physics, and Dr. Robert Harris, Professor Emeritus of Nutrition and Food Science.

JOHN M. DEUTCH

Department of Biology

During the 1983-1984 year, 260 undergraduates were registered as Life Sciences majors, and 81 received the degree of Bachelor of Science in the Life Sciences. Of these, 48 were in the regular Course VII Program, 22 in the VII-A Program, and 11 in the VII-B Program. Most of these graduates plan to attend either medical school or graduate school.

During the period from July 1, 1983, to June 30, 1984, 19 Ph.D. degrees were awarded in the Department and five in the Joint Program in Biological Oceanography with the Woods Hole Oceanographic Institute. The maximum number of Ph.D. candidates registered in the Department in 1983-1984 was 130, with another 22 in the Joint Program. The entering class in September, 1983, was 24 and the class arriving in September, 1984, will be 30.

EDUCATIONAL ACTIVITIES

A faculty committee charged with reviewing the undergraduate curriculum in the Department completed their detailed examination of the programs during this past year and made several recommendations for modifications which were approved by the Department, submitted to the Committee on Curricula, and approved for implementation beginning the fall term, 1984. The major modifications are as follows. (1) The establishment of a new subject, 7.08 Cell and Molecular Biology, that will be required of all majors in Life Sciences. This has been the most rapidly growing area of biology in recent years; this subject will enable us to make available to undergraduates far more information than has been possible in the past. (2) 7.01 General Biology will be a requirement for majors (nearly all Life Science majors have taken 7.01 as a restricted elective in the past). This subject gives an overview of modern biology for majors, and is the major means of exposure to biology of students who are not Life Science majors. (3) Some modifications will be made in 7.05 General Biochemistry, the most important of which is the transfer of the topics of DNA replication and the biosynthesis of RNA and proteins to the new subject on Cell and Molecular Biology, enabling both expansion of these topics in the new subject, and a more complete presentation of other important areas of biochemistry in 7.05. Additionally, both 7.01 and 7.05 will be offered in only one term rather than in both terms as has been the practice for several years. (4) The establishment of 18.05 Introduction to Probability and Statistics as a requirement for majors to replace the restricted elective requirement in mathematics, since the areas of probability and statistics are particularly relevant for the education of majors in Life Sciences. (5) The elimination of the restricted elective in science outside the Department. With the generation of the new required subject in Cell and Molecular Biology, and the reorganization of 7.05 to allow inclusion of more physical chemistry-oriented material, the need for an extra science subject is less important than it has been in the past.

The recipient of the annual John L. Asinari award for 1983-1984 for outstanding research by undergraduates in Life Sciences was Mark Segal (supervisor, Professor Monty Krieger).

RESEARCH

The research activities of the Department are in the areas of biochemistry, genetics, microbiology, cell and developmental biology, biophysics, virology, and immunology. Individual research projects are described in the annual publication, Biology Research Summaries, available in the Biology Headquarters office (56-511).

PERSONNEL

During the past year Dr. Robert T. Sauer was awarded tenure.

Dr. Salvador Luria, Institute Professor, Emeritus and Director, Center for Cancer Research, published his autobiography, A Slot Machine, A Broken Test Tube, this spring.

Professor Phillips Robbins spent his sabbatical leave at the National Institutes of Health, working on new approaches to the chemistry of normal and transformed cell surfaces. Professor Mary Lou Pardue was also on sabbatical leave. Professor Maurice S. Fox spent three months as Visiting Professor at the Université de Paris Sud, Centre Orsay, during the fall term.

Dr. George Maniatis, on sabbatical leave from the University of Patras, Greece, spent the year in Professor Vernon Ingram's research laboratory, and Dr. David Wilson from Cornell University spent his sabbatical year in Professor David Botstein's laboratory.

Dr. Steven Burden joined the Department as Assistant Professor of Biology in April. Dr. Burden received the B.A. in Molecular Biology from the University of Wisconsin-Madison in 1972 and the Ph.D. in Neurobiology in 1977, also from the University of Wisconsin-Madison. From 1977 to 1979 he was a post-doctoral trainee in the Neurobiology Department of the Stanford University Medical School. In 1979-1980 he was a post-doctoral trainee with Dr. M. C. Raff of the Neuroimmunology Project, University College, London, and from 1980 to 1984 he was Assistant Professor of Anatomy at Harvard Medical School. Dr. Burden's research program is concerned with the sequence of steps and the mechanisms in the formation of synapses, in particular, the steps of assembly of the post-synaptic membrane during synapse formation between nerve and muscle.

Dr. Paul T. Matsudaira has accepted the position of Assistant Professor of Biology, to be joint with the Department and the Whitehead Institute for Biomedical Research, and plans to begin his appointment in January. Dr. Matsudaira received the B.A. in Chemistry and the B.S. in Biology from the University of Washington in 1975 and the Ph.D. in Biology from Dartmouth College in March, 1981. He spent the remainder of the 1981 year as a post-doctoral fellow in the Department of Biochemistry, Max Planck Institute for Biophysical Chemistry, and from 1982 to the present he has been a post-doctoral fellow in the Structural Studies Unit of the MRC Laboratory of Molecular Biology. Dr. Matsudaira's research interests are in the area of the assembly, organization, and function of cytoplasmic structures.

Dr. Ronald D. G. McKay has accepted the position of Associate Professor in the Department of Biology and the Whitaker College of Health Sciences, Technology and Management. His appointment will be effective on July 1. Dr. McKay received the B.Sc. in Zoology in 1971 and the Ph.D. in Molecular Biology in 1974, both from the University of Edinburgh. From 1975 to 1978 he was a Research Fellow at the University of Oxford. He then moved to the Cold Spring Harbor Laboratory where he has been a Postdoctoral Fellow (1978-1980), Staff Investigator (1980-81), and Senior Staff Investigator (1981-present). Dr. McKay's research interests are in the area of neurobiology, particularly in the use of molecular biological techniques to investigate the nervous system.

Dr. William G. Quinn also has accepted the position of Associate Professor in the Department of Biology and the Whitaker College and plans to begin his appointment on July 1. Dr. Quinn received the B.A. in 1966 from Harvard College and the Ph.D. in 1971 from Princeton University. From 1971 to 1974 he was a post-doctoral fellow at the California Institute of Technology. Since then he has held the positions of Assistant Professor (1974-1980) and Associate Professor (1980-present) of Biology at Princeton University. Dr. Quinn's research interests are in the area of neurogenetics, particularly the genetic and molecular bases underlying learning and memory.

Dr. H. Earl Ruley has accepted the position of Assistant Professor of Biology in the Department and the Center for Cancer Research. His appointment will be effective July 1, 1984. Dr. Ruley received the B.A. in Anthropology from Stanford University in 1974 and the Ph.D. in Bacteriology and Immunology from the University of North Carolina, Chapel Hill, in 1980. He was a post-doctoral fellow at the Cold Spring Harbor Laboratory in 1982-1983, and has been a Staff Investigator at the Cold Spring Harbor Laboratory since 1983. Dr. Ruley's research interests are in the area of the mechanism of oncogenesis.

Dr. Richard A. Young has accepted the position of Assistant Professor, to be joint with the Department and the Whitehead Institute for Biomedical Research, and plans to begin his appointment in September, 1984. Dr. Young received the B.S. in Biological Sciences from Indiana University in 1975 and the Ph.D. in Molecular Biophysics and Biochemistry from Yale University in 1979. He spent the 1979-1980 year as a post-doctoral fellow in the Department of Molecular Biology of the Swiss Institute for Experimental Cancer Research in Lausanne, and has been a post-doctoral fellow in the Department of Biochemistry at Stanford University since 1981. Dr. Young's research interests are in the area of the regulation of development.

It is a pleasure to report the following honors and awards received by various faculty members in the past year. Professors Gerald R. Fink and Susumu Tonegawa were elected to the American Academy of Arts and Sciences; Professor Fink received the 1984 Yale Science and Engineering Award for the Advancement of Basic and Applied Science; Professor Tonegawa received the "Bunkakorosha" (Person with Cultural Merit) Award, given by the Japanese Government to as many as ten Japanese citizens who are selected from all the fields of science and art for unusual contributions to culture in general; Professor Phillips W. Robbins was selected for a Fogarty Fellowship to support his sabbatical year at NIH; and Professor Frank Solomon was honored by being named as the 1983-1984 recipient of the Graduate Student Council Teaching Award for the Department of Biology. Professor Robert A. Weinberg was the recipient of three awards during this past year: he was co-recipient (with Drs. J. Michael Bishop and Harold Varmus of the University of California, San Francisco, and Dr. Raymond Erikson of Harvard University) of the second annual Hammer Prize for Cancer Research, given to researchers who have made strides toward finding a cure for cancer; he received the Bristol-Myers Award for Distinguished Achievement in Cancer Research, for his group's discovery of cancer genes in tumors caused by chemicals and other environmental agents; and he was a co-recipient (with Dr. Geoffrey Cooper of Harvard Medical School) of the U.S. Steel Foundation Award in Molecular Biology (presented by the National Academy of Science), for the identification and characterization of cellular oncogenes.

Finally, I am happy to report that the Biology Department held its Centennial Celebration last November. Events included an opening banquet (with commentary from three past Department Heads and the present Head, and a talk by Dr. Manuel V. Ortega, Undersecretary of Education and Technical Investigation in Mexico, a former graduate student in the Department) and a day-long colloquium with a series of seminars presented by former graduate students in the Department. Many former graduate students returned to help us celebrate our first 100 years of modern biology, and an enjoyable time was had by all.

GENE M. BROWN

Department of Chemistry

Bachelor of Science degrees in Chemistry were awarded this year to 40 undergraduates. Most of the graduates will be attending graduate school in chemistry, medicine, or related disciplines, or have taken industrial employment. The Masters of Science degree was awarded to 8 people. A total of 36 Ph.D. degrees were awarded: 14 in September; 5 in February; 17 in June. To date 1744 Ph.D. degrees and 402 Masters degrees have been awarded by the Department.

PERSONNEL

Professor John S. Waugh, Arthur Amos Noyes Professor of Chemistry, and an authority on chemical physics, was named corecipient of the \$100,000 Wolf Foundation Prize in Chemistry for 1984. Professor Waugh was awarded the prize in Israel from Israeli President Chaim Herzog on May 20, 1984, at a special session of the Israeli Knesset.

Professor Mark S. Wrighton was awarded the E.O. Lawrence Memorial Award by the Department of Energy. He also was awarded the Gregory and Freda Halpern Award in Photochemistry at the 166th meeting of the New York Academy of Sciences on December 7, 1984. Further, Professor Wrighton was presented the Fresenius Award. Professor Wrighton, Frederick G. Keyes Professor of Chemistry, is best known for his work in photoelectric chemistry and the study of catalytic reactions in which the catalytic action is induced by the absorption of light.

Professor K. Barry Sharpless was among eight members of the MIT faculty elected to the American Academy of Arts and Sciences this year.

Two new faculty appointments at the assistant professor level have been made for July 1, 1984. Dr. Philip Phillips, a Miller Fellow at U.C. Berkeley, will join the Department with research interests in theoretical physical chemistry. Dr. Stephen Buchwald, a Bantrell Fellow at California Institute of Technology, has research interests in organic and organometallic chemistry.

Two new research activities began in the Department this year. Ms. Sylvia Lanza, Manager of the departmental computer system, joined the Department to coordinate research on the new VAX 700. John Dewan has joined the Department to supervise a new x-ray structure solving facility. These new activities both substantially advance the departmental research capabilities.

ACTIVITIES OF THE DEPARTMENT

The undergraduate chemistry curriculum has been substantially revised. Beginning with fall, 1984, the 5.40, 5.41, 5.42 course sequence is abolished and replaced by a new three-semester integrated sequence 5.11, 5.12, 5.13. This change reflects the faculty's interests in keeping the curriculum current and to provide the best undergraduate education in the freshman and sophomore years. The Department also initiated a research seminar course for Course V majors to facilitate interaction and access to departmental faculty.

The Department was privileged to host several lecture series during the past year. Dr. Robert Abeles from Brandeis was the T.Y. Shen Visiting Professor in Medicinal Chemistry. Professor Abeles gave three lectures the titles of which were: "Mechanism of Action of B₁₂-coenzymes; "Biochemistry of Ethers and Thioethers"; and "Suicide Enzyme Inactivators. Professor J.J. Turner from the University of Nottingham, was the Arthur D. Little Visiting Professor for the academic year. He spoke on "Intermediates in Organometallic Photochemistry". The first Smith, Kline, & French Lecture in Organic Chemistry was given this year by Professor Pierre Deslongchamps of the University of Sherbrooke. He spoke on the "Concept of Strategy in Organic Synthesis".

CHRISTOPHER T. WALSH

Department of Earth, Atmospheric, and Planetary Sciences

On July 1, 1983, the Department of Earth and Planetary Sciences merged with the Department of Meteorology and Physical Oceanography to form a new Department called Earth, Atmospheric, and Planetary Sciences. A Center for Meteorology and Physical Oceanography exists within the new Department, directed by Professor Peter Stone. Chairman of the merged Department is Professor William F. Brace.

The Earth Resources Laboratory, directed by Professor M. Nafi Toksöz, has become a major new research and teaching center within the Department of Earth, Atmospheric, and Planetary Sciences. Some 20 graduate and eight undergraduate students are involved, working alongside postdoctoral fellows and research associates on a number of fundamental seismological problems, and on new methods of oil and gas exploration. The research at ERL falls into five major categories: (1) theoretical seismology and seismic wave propagation in heterogeneous media; (2) full-waveform acoustic logging; (3) vertical seismic profiling (VSP); (4) rock physics; and (5) earthquake seismology.

FACULTY

Professor John Sclater resigned from the Department in September, 1983, to become Professor at the University of Texas at Austin. On July 1, 1983, Professor Richard Lindzen was appointed Sloan Professor, and three new Assistant Professors joined the faculty: Dr. David Jewitt, an optical astronomer, Dr. Brian Evans, an experimental geophysicist, and Dr. Kip Hodges, a structural geologist. Also on July 1, 1983, Professors Peter Molnar and Sean Solomon were promoted to Full Professorship, Professor Edward Boyle received tenure, Professors Frank Spear and Charles Eriksen became Associate Professors, Dr. Nobu Shimizu became Senior Research Scientist, and Dr. Arthur Cheng was appointed Principal Research Scientist. Professors John Edmond and Peter Molnar were Fairchild Professor at the California Institute of Technology in 1983 and 1984 respectively. Dr. Linda French became full-time Instructor in astronomy on September 1, 1983, and Dr. Edwin Schneider was appointed Principal Research Scientist on January 1, 1984. Professor Mark Cane left the Department at the end of February, 1984, to go to Lamont-Doherty Geological Observatory of Columbia University. Two of our faculty, Professors Frederick Sanders and William Pinson, will retire on July 1, 1984, and Professor Keiiti Aki will also leave the Department on that date to become W.M. Keck Professor of Geological Sciences at the University of Southern California. Professor Thomas Jordan will succeed Professor Aki as Robert R. Shrock Professor when he is appointed Full Professor on July 1, 1984. Professor B. Clark Burchfiel will take over the Schlumberger Chair to be relinquished by Professor Irwin Shapiro, the current holder, on July 1, 1984. Two new Assistant Professor appointments on July 1, 1984, will be Dr. Leigh Royden and Dr. Gregory Duckworth; Dr. Royden will also be the first holder of the Kerr-McGee Career Development Chair. Professor Gordon Pettengill will take leave on July 1, 1984, to become Director of the Center for Space Research at MIT. Promotions to take place on July 1, 1984, include Professor D. Edmunds Harrison to Visiting Associate Professor and Dr. Vernon Cormier to Principal Research Scientist. Dr. Bruce Fegley will be appointed Principal Research Scientist on July 1, 1984.

Honors

Professor Edward Lorenz was corecipient of the distinguished Crafoord Prize for 1983, awarded by the Royal Swedish Academy of Sciences; and in August, 1983, Professor Charles Counselman received the Carl Pulfrich Prize awarded by Carl Zeiss, Inc. Professor Counselman was also elected to Fellowship in the American Geophysical Union in February, 1984. Professor B. Clark Burchfiel was elected to the American Academy of Arts and Sciences in 1984.

ENROLLMENT

Because of the merger of the two departments, our graduate enrollment of 183 was considerably higher than last year, with 58 being Joint Program students at WHOI. The undergraduate enrollment - 41 - was slightly higher than last year. In addition to the annual geology field camp in Nevada in January, 1984, this year an astronomy field camp was organized for the first time by Professor James Elliot during the IAP period, which proved highly successful.

RESEARCH

Geology/Geochemistry

Currently Professor B. Clark Burchfiel has projects active in the western United States, Sweden, Bolivia, and China. He is studying the active faulting along the northeastern border of the Tibetan plateau in an attempt to document the block fragmentation of the Chinese continental crust that resulted from the impacting of India into southeast Asia.

Professor Roger Burns is studying the crystal chemistry, spectroscopy and geochemistry of transition metal-bearing minerals. Predictions about the todorokite crystal structure have been confirmed, providing explanations for the enrichment of nickel, copper and cobalt in deep-sea manganese nodule deposits. He also demonstrated that poorly crystalline ferric oxyhydroxide minerals are responsible for the color and magnetic properties of Mars' surface.

Professor Fred Frey has compared volcanic products erupted from intraplate oceanic (hot spot) volcanism with regions of plate divergence and convergence. Lavas from individual Hawaiian volcanoes exhibit systematic geochemical variations as a function of eruption age. These trends can be successfully modelled as resulting from complex mixing processes involving a diapir of "primitive" mantle (the hot spot) interacting with wall-rocks formed of oceanic lithosphere.

Professor Tim Grove has shown in his studies of Cascade volcanoes that the rhyolite lavas contain cognate inclusions that record the crystallization of an andesite precursor lava to produce the derivative rhyolite. The compositions of phases change little during the crystallization process, and indicate that the process occurs on a cotectic that is nearly horizontal in temperature-composition space and may aid in the generation of explosive silicic eruptions by increasing water contents rapidly during late stage crystallization.

Professor Stan Hart has delineated a large-scale isotopic anomaly in the southern hemisphere mantle, using available Sr and Pb isotopic data for basalts from oceanic islands. The anomaly is globe-encircling in extent, centered on 30°S latitude. The isotopic signature of this DUPAL anomaly requires a mantle source in which enrichments of Rb/Sr, U/Pb and Th/U have existed for periods of time in excess of 3 b.y. The presence of this old-large-scale, coherent mantle anomaly places severe constraints on models for mantle convection.

Professor Kip Hodges has been using mineralogic techniques of geothermometry and geobarometry in several deeply-dissected collisional mountain belts. He has been able to estimate depths of burial and erosion and test the hypothesis that these were once subduction zones.

Professor John Southard, in his experimental studies of stratification in sedimentary rocks, has demonstrated the important effect of fluid viscosity, and therefore of water temperature in subaqueous environments, on the scale of current-generated sedimentary structures.

Professor Frank Spear has developed a technique to decipher the pressure-temperature evolution of rocks from a thermodynamic analysis of compositional zoning in minerals such as garnet.

Geophysics

Professor Keiiti Aki has discovered an important change of coda envelope of local microearthquakes before major earthquakes. He now has very well-established cases from Kamchatka and Kurile, Tangshan, and Hawaii. A similar change in coda envelope was also observed at his crater station before a minor eruption in St. Helens.

Professor Brian Evans is investigating the interaction of porosity and plastic flow processes. The experiments indicate that surface energy effects provide sufficient driving force to cause dramatic reductions in permeability in short periods of time in quartz systems with pore fluids present at 400°C, even when the effective pressure is zero.

In his core motion studies, Professor Ted Madden is attempting to distinguish between convected features (westward drift) and wave propagation phenomena by examining the time variations of the velocities inferred.

Professor Marcia McNutt has mapped large, coherent zones of anomalous magnetization within young Pacific seamounts by subtracting the best-fitting uniform magnetization model from observed total magnetic field measured at the sea surface. By deploying a magnetic gradiometer from the deep research submersible Alvin, she has determined that field reversal explains the departures from uniform magnetization.

Professor Peter Molnar is continuing his field investigation of active faulting in China in collaboration with geologists from the People's Republic of China. He estimates an east-southeastward displacement of southeast China with respect to Siberia at an average rate of about 2 cm/year.

A global study of intermediate wavelength depth and geoid anomalies using GEOS-3 altimeter measurements has been completed by Professor Barry Parsons. Good correlations between depth and geoid anomalies are observed at these wavelengths, in particular over features like the Bermuda Rise. Theoretical work on the geoid and depth anomalies calculated for convective flows that have been determined using numerical methods suggests that such anomalies primarily reflect temperature variations within the upper thermal boundary layer of convection occurring beneath the lithosphere.

Professor Gene Simmons has shown that granites contained healed microcracks, that rare earth elements are mobile and have migrated in the geologic past, and that microcracks have provided the pathways for the migration of uranium.

Professor Sean Solomon and his students have been applying modern waveform synthesis techniques to study large earthquakes along mid-ocean ridges and transforms and within oceanic lithosphere. Along mid-ocean ridge axes, the largest earthquakes all occur beneath the inner floor of the median valley; these earthquakes are all extremely shallow, with centroid depths between 1 and 2.5 km. Outside of the median valley, most earthquakes in young oceanic lithosphere occur in the upper mantle.

Professor Nafi Toksoz founded the Earth Resources Laboratory, which now comprises a total of about 45 staff and students. The primary areas of research are based on the study of seismic waves in heterogeneous media and their application to subsurface imaging. Major advances are being made in seismic measurements in boreholes to determine rock properties and three-dimensional tomographic characterization of structures and petroleum reservoirs. Additional studies are directed to better understanding of earthquakes and their source properties.

Oceanography

Professor Edward Boyle has used the chemistry of annually-banded corals to examine the history of anthropogenic lead fallout into the ocean. A direct study of lead in seawater near Bermuda shows that there are significant season fluctuations in the upper 200m.

Professor Mark Cane is investigating large-scale atmosphere-ocean interactions, with emphasis on the equatorial ocean circulation and its temporal variations.

Professor John Edmond has begun a program of trace element analyses while at sea. Using gas chromatography with electron capture detection of fluorinated chelates of the elements, he has been able to produce accurate data for beryllium, aluminum and the two oxidation states of selenium rapidly and efficiently.

Professor Charles Eriksen has found vertically propagating equatorial waves of several kilometer wavelength at annual and higher frequencies from two years of deep moored measurements in the central Pacific. These waves represent an energy sink to wind-forced near-surface motions, including El Niño.

Professor Glenn Flierl theoretically derived general conditions under which strong vortices can be considered as isolated. He has shown that rings not only propagate as strongly nonlinear waves but also radiate energy in the form of Rossby waves in the deep ocean.

Professor Ed Harrison has shown that the vigorous ocean surface temperature response in the 1982 El Niño was initiated by the appearance of sustained westerly winds on the equator west of the Dateline, and that the westerly winds appear to be associated with the breakdown of a narrow jet of southerly flow that originated east of Australia in middle latitudes.

Professor Paola Malanotte Rizzoli has applied ocean acoustic tomography to the three-dimensional structure of the density and velocity fields in the ocean. She has simulated a forthcoming gyre-scale tomographic experiment in a model ocean reconstructed through a sophisticated numerical model focusing upon the measurement of the average properties (heat and vorticity content, heat fluxes, etc.) of the circulation in the subtropical gyre.

Professor Carl Wunsch is attempting to develop a global observational system for the ocean under the umbrella name of the World Ocean Circulation Experiment (WOCE). This ambitious program would bring together, over a 5-10 year period, a number of technologies developed recently which, for the first time, would make large-scale observations of the ocean a practical possibility. These technologies include satellite scatterometer, altimetric, and gravity measurements, acoustic tomography, chemical tracers (freons, tritium), drifting floats, and many others.

Meteorology

Professor Randall Dole has continued studies on the phenomenology of anomalous flow patterns that persist beyond the periods associated with synoptic scale variability. His work indicates that persistent anomalies typically occur in one of three primary regions: the North Pacific to the south of the Aleutians, the North Atlantic to the southeast of Greenland, and from the northern Soviet Union north-eastward to over the Arctic Ocean.

Professor Kerry Emanuel is working on a nonlinear analytical model of the formation of tropical cyclones which attributes the growth of the cyclone to a nonlinear instability based on air-sea interaction. He is also investigating the dynamics of two-dimensional precipitating convection using a simple linear model.

Professor Richard Lindzen is working on mechanistic models of the basic shear instabilities in hydrodynamics which include barotropic and baroclinic instability. He is also studying the very large-scale atmospheric waves - both stationary waves forced by surface variations and travelling waves.

Professor Edward Lorenz has derived a system of three ordinary differential equations which may constitute the simplest possible non-trivial model of the atmospheric general circulation. For various values of the constants it can exhibit steady, periodic, or irregular behavior. In the irregular regime it approximately reproduces the spectrum of large-scale atmospheric flow, in the range from a few days to a few months.

Professor Reginald Newell and his colleagues have used monthly mean data from the past twenty-five years to show that interannual atmospheric carbon dioxide concentrations are positively correlated with tropical sea surface temperatures, with the ocean leading by several months. The findings have been applied to explain the low values of carbon dioxide which occurred during the last ice age.

Professor Richard Passarelli is conducting field observations and analyses of winter storms aimed at understanding the mechanisms of formation of mesoscale precipitation bands and the New England Coastal front. Using an aircraft (supplied by the National Center for Atmospheric Research) the MIT doppler radar and radiosonde balloon measurements, these field studies have indicated that symmetric instability is an important mechanism of precipitation band formation and that the kinematic and thermodynamic structure of the New England coastal front is similar to a density current.

Professor Ronald Prinn and his collaborators have used five years of freon data from their Atmospheric Lifetime Experiment (ALE) to provide definitive evidence that the only atmospheric sink for the freons (CFCl_3 , CF_2Cl_2) is photodissociation in the ozone layer. They have also used the CH_3CCl_3 data from this experiment to provide the most accurate estimate yet obtained of the global tropospheric average hydroxyl radical (OH) concentration.

Coastal fronts in New England can be produced by either of two mechanisms, according to Professor Frederick Sanders. In either case there must be a marked contrast between colder air over land and warmer air over water. In the first instance this contrast is concentrated toward a frontal discontinuity by overland frictional retardation of broadscale onshore flow, such as occurs southwest of the center of a large anticyclone. In the other the frontogenesis results from the variable pattern of airflow in advance of a small cyclone which propagated northeastward along the coastal isotherms.

Professor Peter Stone has developed a method for diagnosing how the forcing of the atmosphere's mean zonal wind and temperature fields by large-scale eddies is influenced by eddy forcing of condensation. Calculations using the method show that the eddy forcing of the mean fields is on average two and one half times stronger when the condensation effects are taken into account.

Planetary

Professor Charles Counselman has developed an inexpensive, portable, geodetic instrument that can determine all three position coordinates of a point on the ground within less than one-millionth of the distance to a reference point.

Professor James Elliot has developed a method for studying the kilometer scale structure of the Uranian rings through least squares fitting of a diffraction model.

Professor David Jewitt has been using optical and infrared observations to investigate comets. Nucleus activity in short-period captured comets is regulated by the sublimation of water ice. However, several long-period comets appear to be more influenced by electrostatic processes.

Professor Gordon Pettengill has combined radar scattering and radio emission data to obtain a global map of the distribution of dielectric constant on Venus. The distribution appears to be basically bimodal, with over 95 percent of the surface showing values near five. The remainder has anomalously high values, some of which reach 27.

WILLIAM F. BRACE

Department of Mathematics

ACADEMIC PROGRAM

During the 1983-84 year there were 195 undergraduates and 113 graduates majoring in Mathematics. The Bachelor of Science was awarded to 57 students, including 16 second majors. There were 8 recipients of the Master of Science and 15 recipients of the Doctor of Philosophy in Mathematics.

Eight new National Science Foundation (NSF) Fellowships were awarded for 1984-85. This is the largest number in many years, and is a tribute to the strength of the graduate program.

John Stembridge, a graduate student in applied mathematics, was selected to receive one of the 25 Alfred P. Sloan Doctoral Dissertation Fellowships that were awarded nationally in this first year of the program.

Janice Hammond was awarded the Goodwin Medal for the most effective teaching by an MIT graduate student.

The Department was deeply saddened in early April by the sudden death of Jon A. Bucsela, the top-ranked senior in mathematics and one of the most talented pure mathematics students in years. From gifts from his parents, and by faculty, staff, and friends, the Jon A. Bucsela Prize is being created in his memory, to be awarded each year to the most outstanding senior in mathematics.

FACULTY

Professor Arthur P. Mattuck, Class of 1922 Professor, was named Department Head. He succeeds Professor Daniel J. Kleitman, who has served for the last five years.

Professor Franklin P. Peterson will succeed Professor Victor Guillemin as Chairman of the Pure Mathematics Committee. Professor David J. Benney will continue as Chairman of the Applied Mathematics Committee and Professor Nesmith C. Ankeny will continue as Chairman of the Graduate Committee.

Professor David Vogan was promoted to the rank of Full Professor and will become Chairman of the Undergraduate Mathematics Committee. Professors David Jerison, Frank Morgan, and Ka-Kit Tung were promoted to the rank of Associate Professor.

Professor Kenneth M. Hoffman has completed two and a half years (half-time) as Executive Director of the National Research Council's Committee on Resources for the Mathematical Sciences, which issued its report, Renewing U.S. Mathematics (National Academy Press), on June 6, 1984. Professor Hoffman is continuing his Washington work on behalf of the mathematical community as Executive Secretary for National Affairs for the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics.

The National Research Council's Commission on Physical Sciences, Mathematics, and Resources has appointed Professor Michael Artin for a three-year term as Chairman of the Board on Mathematical Sciences. The Board is expected to become an important force in maintaining the vitality of mathematics in the United States.

In May the Department feted Professors Francis B. Hildebrand, who was retiring after a 44-year career at MIT during which it was calculated that he taught some 42,528 students, and Daniel J. Kleitman, who was completing a five-year term as Department Head. Professor Hildebrand was given an MIT commemorative watch. Professor Kleitman was given an antique slide rule to add to his collection.

I.M. Singer will be rejoining the faculty as Full Professor after an absence of several years at Berkeley. He is a prize-winning analyst and will hold the John D. MacArthur Chair. Also joining the faculty will be Professor Daniel W. Stroock, an outstanding probabilist.

Faculty on leave during the year were: Michael Artin (Institute for Advanced Study and University of Texas); Herman Chernoff (Stanford, Australian National University, Hebrew University, and Columbia); Harvey P. Greenspan (CalTech); Louis N. Howard (Florida State); Victor Kac (Paris and Berkeley); Bertram Kostant (Berkeley); Gerald Sacks (CalTech); I.M. Singer (Berkeley); Harold Stark (Princeton); Michele Vergne (CNRS in France); David Vogan (Paris); William Goldman (University of Maryland); and David Jerison (Paris).

Visiting faculty during year were Miklos Ajtai (Hungary), Paul Seymour (Ohio State), and Audrey Terras (UCSD).

Faculty Honors

In January the American Mathematical Society awarded Professor Richard B. Melrose the Bôcher Prize, which is given every five years for a notable research memoir in analysis. Of the 15 prizes awarded thus far, more have gone to mathematicians from MIT than from any other university. Previous recipients have been Norbert Wiener, Norman Levinson, and I.M. Singer. Professor Melrose was cited for his solution of several outstanding problems in diffraction theory and for developing the analytical tools needed for their resolutions.

The 1984 Science Council Prize for excellence in undergraduate teaching was shared by Professor James R. Munkres. In citing Professor Munkres, the prize committee stated that, "In the 1984 Student Course Evaluation Guide, Munkres topped the School of Science with a 6.8 (out of 7.0) overall rating, and he did this in two different subjects. This is a unique accomplishment in the Institute."

Professor F. Thomson Leighton was one of three MIT faculty to receive a Presidential Young Investigator Award, a new program administered by NSF for the purpose of supporting research by outstanding young American scientists.

The Society for Industrial and Applied Mathematics awarded the Polya Prize in Applied Combinatorics to Dr. Anders Björner, who will join the Department as Assistant Professor of Applied Mathematics in the fall of 1984.

Alfred P. Sloan Fellowships were awarded to Professor Rodolfo Rosales and Gunther Uhlmann.

An NSF Postdoctoral Fellowship was held by Dr. David J. Wright. a C.L.E. Moore Instructor.

Professor Richard Stanley held a Guggenheim Fellowship.

California Institute of Technology awarded Fairchild Fellowships to Professors Harvey Greenspan, who spent the spring at CalTech, and to Gerald Sacks, who spent the year there.

Professor Herman Chernoff was awarded a citation as Distinguished Alumnus by Brown University. Professor Chernoff was also selected to receive an honorary doctoral from the Technion, the Israel Institute of Technology.

ARTHUR P. MATTUCK

Department of Nutrition and Food Science

The Department generally enjoyed a year of continued success with respect to its educational and research activities. The vitality of its research programs is reflected in the continued scholarly productivity of the faculty and students as well as their success in acquiring research support in an increasingly competitive environment.

EDUCATIONAL ACTIVITIES

During this academic year, a total of 36 undergraduate majors were enrolled in the program Applied Biology (Course VIIB). In addition, there was strong participation of faculty and staff in UROP projects for undergraduates. In all, a total of 15 faculty members supervised research projects for an average of 33 students during each of the academic terms (summer, fall, and spring). Other interactions with undergraduates included participation as freshman advisors (10) and premedical advisors (7).

With respect to its graduate degree programs, a total of 144 students were enrolled as SM or PhD degree candidates during the 1983-84 academic year. Doctoral degrees were awarded to 11 students, and SM degrees to 14.

In concert with changing backgrounds and research interests represented by members of the faculty, very extensive reappraisal has been made of the nature and content of the graduate curricula of the Department, and several important revisions have been formulated. Some of these were instituted during this academic year, and others will be implemented in the 1984-85 term. Formerly, a total of five graduate degree programs were offered, with relatively limited commonality in respect to course requirements and content. The objective of the proposed revisions is to consolidate these curricula into a single departmental degree program with maximal commonality in the early fundamental courses, while retaining an opportunity for specialization in advanced courses. In its present form, the curriculum reflects a consolidation of the former programs in food science and technology and biochemical engineering into an area of specialization in biotechnology. A partial consolidation has also taken place in the case of the areas of toxicology, neural and endocrine regulation and nutritional biochemistry into a program with a substantial common core of subjects followed by subjects in each of the three areas of specialization.

It is expected that further consolidation will take place as new subjects are developed taking advantage of the backgrounds and interests of members of the faculty currently being recruited.

FACULTY

Significant changes in the faculty of the Department have taken place during the 1983-84 academic year.

Dr. William G. Thilly, associate professor of Genetic Toxicology, was promoted to the rank of professor effective July 1, 1984. Also effective on that date, Dr. Paul M. Newberne, professor of Nutritional Pathology, and Dr. George Wolf, professor of Physiological Chemistry, assumed the status of Senior Lecturer/Professor Emeritus. Both will continue selective activities in research and teaching.

Resignations of three faculty members became effective at the end of this academic year. Dr. Henri Brunengraber resigned in order to accept a position in the Department of Nutrition, Notre Dame Hospital, University of Montreal. Dr. Carolyn Moyer, assistant professor of Comparative Pathology joined the Department of Pathology, University of Massachusetts Medical Center, Worcester. Dr. Noel Solomons, formerly associate professor of Clinical Nutrition, has accepted a position at the National Institute of Nutrition, Mexico.

FACULTY AWARDS

The Japanese government honored Professor Samuel Goldblith by presenting him with the Second Class of the Order of the Sacred Treasure during ceremonies at the Japanese consulate in Boston on June 1. The decoration was bestowed by the Emperor of Japan in recognition of Professor Goldblith's contributions over the years to the advancement of nutrition and food science in Japan and the promotion of friendly relations between Japan and the United States.

GERALD N. WOGAN

Department of Physics

In spite of financial stringencies during the past year, all major research programs in the Department have remained active and successful and some important new initiatives have been started, as described in the detailed accounts later in this report. The Department has continued to address the challenge it faces as a major component of the MIT educational program.

With regard to the latter, it has maintained a relatively constant credit units per faculty member as well as a relatively stable total of physics students, graduate and undergraduate, over the past 10 years. In this year the number of undergraduate majors was 220, and the number of graduate students was 299. The number of degrees awarded totaled 68 B.S., 15 M.S., 33 Ph.D., and 1 Sc.D.

The large number of graduate students reflects the substantial research funding which the Physics Department faculty has continued to receive, mostly from the Department of Energy (DOE), National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), and the Department of Defense (DOD). This has been particularly gratifying in view of the financial limitations which have been placed on these agencies with regard to the funding of basic research.

The members of the Physics Department continue to provide leadership for the major MIT interdepartmental laboratories. At present the directors of the Laboratory for Nuclear Science, Bates Linear Accelerator (BLA), Center for Space Research (CSR), Center for Materials Science and Engineering, National Magnet Laboratory, Spectroscopy Laboratory, and Plasma Fusion Center are members of the Physics Department.

In 1982-83 the total number of faculty was 91. The following members of the faculty received promotions during the year: to full professor, Claude Canizares; to associate professor with tenure, Nihat Berker. Visiting faculty during the year included Professors Hubert Flocard, Maurice Glicksman, John Reppy, and Anton Zeilinger.

The Department has continued to develop industrial connections through its workshops. Held in the fall of 1983, the third workshop focussed on surfaces and interfaces. The Department received for a third year a grant of \$25,000 from IBM as part of its program for "seed money" awards to leading departments of physics.

Faculty Sloan Fellows included Charles Alcock, Nihat Berker, Lennox Cowie, Alan Guth, and Scott Tremaine. Professor Walter Lewin was the co-recipient of the MIT School of Science Prize for Excellence in Undergraduate Teaching, and also received the Humboldt US Senior Scientist Award. Other awards and honors received by physics faculty were the following: George Benedek was elected to the American Academy of Arts and Sciences; Bruno Coppi was co-recipient of the first award for Excellence in Plasma Physics given by the American Physical Society (APS); Edward Farhi was recipient of the Graduate Student Council Department Teaching Award; Harald Enge received the Bonner Prize awarded by the APS; John Joannopoulos was elected as a Fellow of the APS; Vera Kistiakowsky was elected as a Fellow of the American Association for the Advancement of Science; Philip Morrison received the 1983 Glenn Seaborg Award from the International Platform Association, and also received the James R. Killian, Jr. Faculty Achievement Award; Miklos Porkolab received the Award for Excellence in Plasma Research, 1984 (APS); David Pritchard was elected as a Fellow of the APS; Rainer Weiss received the NASA Space Act Technical Brief Award; and V.F. Weisskopf was given the Julius Adams Stratton Award by the Friends of Switzerland, and also received an Honorary Doctorate from the University of Notre Dame.

With regard to student awards, it is significant to report that 164 students have been inducted into the MIT Chapter of Sigma Pi Sigma, the physics honor society associated with the National Society of Physics Students, operated under the auspices of the American Institute of Physics. This year 13 students, the largest group from an MIT department, were elected to Phi Beta Kappa: David Brahm, James Ernstmeier, Lincoln Greenhill, Seng-Tiong Ho, Andrew Mutz, David Nabors, Laurence Newell, Christopher Petti, David Shortt, Paraskevas Sphicas, Louis Vintro, Llewelyn Wixom, and Stanislaw Zygmunt. The Orloff Prize for physics seniors, an annual prize given by the parents of Joel M. Orloff, Class of 1978, in his memory, was awarded to Raymond Goldstein who also received the Apker Award (APS). The Polaroid Prizes were awarded to Joseph Minatto and Sheena Murphy.

Faculty on leaves of absence and sabbaticals during the year included Michel Barnager, Bruno Coppi, Lennox Cowie, David Frisch, Jeffrey Goldstone, Marc Kastner, Daniel Kleppner, June Matthews, Louis Osborne, Scott Tremaine, and James Young.

RESEARCH

Astrophysics

I. Space Plasma Physics. During the past year experimental research by the space plasma group has centered on a continuing analysis of data from the Voyager I and II spacecraft. These spacecraft are now probing the outer solar system beyond 14 A.U., and Voyager II is well on its way to a Uranus encounter (at 20 A.U.) in January 1986. The distant interplanetary medium seen at Voyager II in the last year continues to be the supersonically expanding solar corona. Voyager data is currently being used to study the sweeping of low-energy galactic cosmic rays out of the heliosphere at the last solar maximum. The decrease in cosmic ray levels with increasing solar activity has been shown to occur in discrete steps, with abrupt drops in the intensity of the cosmic rays occurring at the forward/reverse shock pairs associated with high velocity solar wind streams. In addition to these interplanetary studies, ongoing investigations of the data obtained during the Voyager flybys of Jupiter and Saturn have made considerable progress in understanding the magnetohydrodynamics of the giant magnetospheres of these planets. It is now apparent that the middle magnetospheres (where the magnetic field first begins to deviate significantly from dipolar) are inflated either by energetic particle pressure gradients (in the case of Jupiter) or by centrifugal forces (in the case of Saturn). In the inner magnetosphere of Jupiter, the flow of plasma near the Io flux tube (that bundle of Jovian dipolar field lines threading the innermost Galilean satellite) has been analyzed in the past year. Stimulated by the Io plasma observations, considerable theoretical effort at MIT has been put into understanding the spectrum of plasma waves radiated by a conductor moving through a plasma.

II. Radio Astronomy. Remarkable details in the structure of the jets and lobes of two radio galaxies, Hercules A and Cygnus A, have been brought to light in observations with the Very Large Array (VLA), carried out by the radio-astronomy group in collaboration with a group from Pennsylvania State University. They employed the VLA in a specially complete set of configurations during an extended campaign of observations and computer analysis which yielded radio pictures of unprecedented resolution and completeness. The extraordinarily high degree of collimation of the jets over distances of many tens of kiloparsecs, and the multiple shells of radio emitting matter that bloom from the ends of the jets, present exciting challenges to theories of cosmic magnetohydrodynamics. The radio-astronomy group is also collaborating in an intensive search for optical counterparts of some of the more intriguing radio sources found in their ongoing survey of radio sources, and during the past year this search yielded another multiple-image quasar caused by gravitational lensing.

III. X-Ray Astronomy. Continued analysis of X-ray data from the Einstein Observatory has led to several new results. The spectrum of an extremely luminous extragalactic object revealed a unique absorption feature probably due to material being ejected at relativistic velocities from the source. Studies of X-ray clusters of galaxies show the distribution of dark "halo" matter and show that intracluster gas is accreting onto the central galaxies. Doppler shifts in X-ray lines from a young supernova remnant give evidence for an asymmetric supernova explosion, possibly due to rapid rotation in the presupernova star.

A comprehensive survey of the soft X-ray sky has been completed, using data collected with the SAS-3 satellite. By comparing their survey with a survey of the column density of neutral hydrogen derived from radio-astronomy data, they found evidence that a substantial fraction of the intensity of soft X-rays in the energy range from 0.1 to 0.28 keV at high galactic latitudes comes from sources beyond the neutral hydrogen, possibly from a halo of high-temperature plasma that surrounds the galaxy.

Work has continued on design definition studies for the MIT all-sky X-ray survey instrument and data system for the X-Ray Timing Explorer, a satellite mission that NASA expects to start in 1986.

The systematic all-sky search for the optical counterparts of the X-ray sources detected with the A-3 experiment on the HEAO-1 X-ray satellite has yielded about 25 identifications in the past year. These include Seyfert galaxies, quasars, BL Lac objects, cataclysmic variables, and Be stars. These objects are preferentially the closest and most luminous members of their classes and hence are particularly amenable to detailed optical and X-ray studies. Most of these objects were previously uncatalogued, i.e., were unknown to optical astronomers.

IV. Gravitational Research. There has been progress in several areas by the Gravitational Research Group. Measurements of the 3K Cosmic Background Radiation (CBR) from several years of observations with balloon borne multi-channel differential radiometers have been analyzed. These results clearly show the dipole anisotropy in the CBR due to the Earth's motion relative to the last scatterers of the CBR and confirm the cosmic origin of the anisotropy. The results also indicate that thermal radiation by interstellar dust is a major contributor to the astrophysical background in the millimeter and sub-millimeter wavelength band. A new multi-channel balloon borne radiometer is being constructed to measure CBR anisotropies and to map the contribution by interstellar dust.

A ground-based observation has been carried out to measure the Compton scattering of the CBR by the plasma in galactic clusters. A search in four clusters has given an upper limit in the shift of the CBR spectrum

by Comptonization. This same experiment has set a limit on small scale anisotropies of the CBR on angular scales of eight minutes of arc.

Work is progressing on the data analysis strategy for the Cosmic Background Explorer Mission (COBE). The mission is scheduled to fly in late 1987 and will perform measurements of the spectrum and large scale angular anisotropy of the CBR as well as carry out an all-sky survey of diffuse infrared radiation between 300 microns to 1 micron.

The project to search for gravitational radiation from astrophysical sources has progressed in several areas. The 1.5 meter prototype laser interferometric antenna at MIT has come into operation. The system performs within a factor of two of the shot noise limit at frequencies above a few KHz for six milliwatts of fringe phase modulated power. This corresponds to a displacement sensitivity of six $E-15$ cm/Hz^{1/2}. With further improvements in ground and acoustic noise isolation to be made in this year, the system will be used to search for gravitational radiation from both periodic and impulsive sources.

A study of the feasibility, conceptual design and costs of a large baseline gravitational wave antenna system was completed by the MIT group. The study, commissioned by the NSF recommended the construction of two interferometric antenna at widely separated sites each consisting of an "L" with five km legs. The study formed the basis for a collaboration with the Cal Tech gravitational research group. The results of the study indicated that a large baseline antenna system could bring the sensitivity of the search to astrophysically interesting levels and hold out a reasonable promise of opening a new field in both physics and astronomy.

V. Theoretical Astrophysics. Work is in progress studying the role of quantum fluctuations during the phase transition in the current version of the inflationary universe model. It seems quite likely that these quantum fluctuations form the seeds which later give rise to the formation of galactic structures.

A study has also been initiated of radiative transfer in the atmosphere of a hot neutron star, with a view toward understanding the spectral properties of type I cosmic X-ray bursts.

There has been an investigation of quasi-static winds from hot neutron stars as a mechanism for explaining apparent mass-loss phenomena (such as effective radius variations) in some type I cosmic X-ray bursts. In a related study the interaction between such a wind and the surrounding accretion disk has been explored as a model to account for the puzzling phenomenon of super-Eddington luminosities in many type I bursts.

Using 3C273 as prototype, a model for collimated relativistic (superluminal) jets as sources of giant radio clouds and high-energy gamma rays has been developed. This model, which does not invoke shock re-acceleration, accounts for the production of gamma rays by the mechanism of proton-proton collisions within the condensations formed in the slowing unstable beam.

It has been shown that conventional models for galaxy clustering, which obey Peebles' two-particle correlation function, cannot reproduce the large angular size gravitational lenses that have been observed in distant extragalactic space.

A new technique has been developed for modeling galaxies such as the nearby giant elliptical M87. Recent optical work has suggested that M87 may contain a supermassive black hole in its nucleus. The new models are constructed by linear programming; in the present study the program maximizes parameters such as the black hole mass. It has been found that all available observations are consistent with models containing no black hole; such an object may be present, but definite evidence for it must await Space Telescope (ST). It is likely that the center of M87 will be one of the first objects observed by ST, and the modeling techniques that have been developed represent the best available method for analyzing these data.

Atomic, Condensed Matter, and Plasma Division

I. Atomic, Molecular, and Laser Physics. New results have been obtained in studying atoms in highly excited states, called Rydberg atoms. These states provide the possibility for study of suppressed spontaneous emission, higher precision measurement of the interaction of the atom with fields and of the Rydberg constant.

Experimental work on molecular collisions in which there is a change in vibrational and rotational energy have been carried out. Resonant vibrational energy exchange processes have been studied, which are potentially useful to transfer energy from laser excited molecules to the entire excited rotational manifold of a population of molecules.

Studies are also being conducted in the George Russell Harrison Spectroscopy Laboratory of velocity changing collisions of quantum superposition states in ^{174}Yb by means of sensitive velocity selective photon echo techniques which permit measurement of both classical and wave mechanical features of superposition state kernels. The goal of the program is to investigate the general quantum transport properties of

anisotropic moments in vapors and to understand the relationships with superposition state scattering. In these experiments it has been possible for the first time to directly invert photon echo data by Fourier transform techniques to obtain the velocity changing collision kernel for an optical radiator. A second experiment is investigating collision kernels which involve magnetic superposition state scattering. In this case a new type of "multipole" photon echo has been developed which studies the collisional evolution of a pure multipole moment of the 3P_1 state. These studies have revealed an unexpected two-component structure of the 3P_1 orientation kernel.

Studies of a free-electron laser have demonstrated the predicted tuning with energy. The emission of a PbTe laser in high magnetic fields has been studied.

II. Biological Physics. Light scattering is being used to study the Brownian motion of molecules within a single living cell. Applied to red blood cells, it has provided the first *in vivo* confirmation of the mechanism for sickle-cell anemia. The same apparatus has also been used to study the synthesis of the lens-specific protein crystalline as it occurs during the development of the chick embryo. Study of other intracellular processes, such as the transformation of normal to malignant cells, is envisioned.

The development of a scanning description molecule microscope with micron spatial resolution was completed in 1982. The apparatus uses focussed pulses of laser light to desorb molecules which are detected by a mass spectrometer. With anticipated improvements in efficiency, nanometer resolution should be possible.

Light scattering studies of transformations in the structure and density lipoprotein model systems has elucidated the precise mechanisms for transportation and degradation in cholesterol *in vivo*. These findings are of fundamental importance in understanding the molecular basis for atherogenesis.

III. Condensed Matter Physics. Renormalization-group techniques are being applied to random systems such as spin glasses. Activity has continued on explaining the properties of gases adsorbed on the surface of crystalline solids, with particular emphasis on the recently discovered behavior of a solid phase that melts as the temperature is lowered. The motion of electrons in quasi-one-dimensional systems has been examined. Numerical calculations of the total energy in a microscopic model for chemisorption on crystalline solids and inter-defect correlation energies in amorphous semiconductors have been successfully carried out.

In ordinary three-dimensional (3D) solids the periodicity extends out to infinity. In liquids and glasses, on the other hand, any periodic component of the density decays exponentially with distance. One of the salient features of two-dimensional (2D) matter is that the order may decay algebraically with distance so that 2D "solids" are neither solid nor liquid in the conventional sense. Using high resolution synchrotron X-ray techniques at the Stanford Synchrotron Radiation Laboratory, it has been shown that the bromine molecules in bromine-intercalated graphite are indeed ordered in an algebraic state.

Experimental studies of liquid crystal materials have been extended to ordered phases of soaps, and preliminary results indicate that the statistical mechanics of surface active molecules can be elucidated by the same experimental and theoretical tools as conventional liquid crystal materials.

There has been considerable progress on investigations of the quantum fluid formed by spin polarized atomic hydrogen. A new technique, based on mechanical compression, enabled the production of record densities of spin polarized gas. Studies of three-body recombination and its role in destabilizing the gas are in progress.

Experiments to use submicron fabrication techniques to produce devices in which a quasi-one-dimensional electron gas can be studied have been successful. Measurements showed changes from metallic to insulating behavior and back again as electrons were added to the gas. There has been progress in understanding the electronic properties of amorphous semiconductors.

Progress has been made in understanding a new class of semiconductors, semimagnetic semiconductors.

IV. Plasma Physics. The stability of magnetically confined plasmas is a problem of high current interest. Theoretical work at MIT dating from 1978 has been applied to explain the formation of energetic ion populations in the upper atmosphere of the Earth's auroral region and resolve a long-standing debate. These ideas are now being used to guide the design of laboratory magnetic confinement experiments.

The lower-hybrid resonance heating project for the Alcator-C tokamak has been very successful. During ohmic operation of this facility a record high value of the Lawson parameter $n\tau \approx .8 \times 10^{14}/\text{cm}^3\text{-sec}$.

Nuclear Division

I. Heavy-Ion Reactions. Heavy ion physics is the study of nuclear structure and reaction mechanisms using beams of energetic heavy ions. Heavy ion reactions are particularly well suited for the study of the properties of nuclei at high angular momentum and high excitation with the added feature of enabling the investigation of these properties for nuclear species far removed from the stable nuclei found in nature.

MIT has designed and constructed recoil mass separators, at both Brookhaven National Laboratory (BNL) and Oak Ridge National Laboratory, which have helped advance the investigations of these reactions.

The recent approval of the program to inject the Alternating Gradient Synchrotron (AGS) at BNL with heavy ions will enable for the first time the study of heavy-ion reactions with energies up to 15 GeV per nucleon. This is completely new energy regime for heavy ion reactions, which possibly will yield observations of a new state of matter - a quark-gluon plasma. The Heavy Ion Group is presently working on a proposal for the first round of experiments for the AGS and is actively pursuing this new domain of heavy ion reactions. The group has recently made measurements of proton-nucleus collisions at the AGS in order to obtain necessary background data for relativistic heavy ion collisions.

II. Medium Energy Nuclear Physics. The principal activity in this field is centered at the BLA, which functions under the direction of Professor Ernest J. Moniz. This accelerator has become a national facility for intermediate energy nuclear physics, where a major experimental program to study the properties of the atomic nucleus, using intermediate energy electrons and photons to generate a wide variety of reactions, is underway. MIT faculty and Bates staff physicists, and some 125 user physicists (111 domestic, 14 foreign) from 37 other universities and laboratories in the US, Canada, Japan, and Europe, are presently engaged as initiators or collaborators in active experiments. Twenty-eight MIT graduate students were associated (during the past year) with the intermediate energy nuclear physics programs.

The Bates intermediate energy program continues to center about the electron-scattering experiments which use the very high precision energy-loss spectrometer. This unique spectrometer facility is being utilized to address a variety of fundamental questions in the structure of atomic nuclei, including the shape and collective motions of heavy deformed nuclei, the electromagnetic structure of few-body systems, and the role of mesons in determining the short-range structure of nuclei. Many of these experiments have been made possible by the increase in the maximum beam energy to 750 MeV by beam recirculation; the maximum energy is now being increased to 850 MeV, with a further increase to one GeV anticipated next year.

A major program of studies characterized by large energy transfer to the nucleus is underway in the second experimental hall. This program, involving the electromagnetic production of pions and/or the emission of energetic nucleons, has been made possible by the completion of three large-acceptance magnetic spectrometers and a neutral-pion spectrometer. These studies address issues associated with fundamental understanding of nuclear reactions and of the nuclear force.

A polarized electron source, built in collaboration with Yale University physicists, is under construction at Bates. This will be used first in a unique test of the unified theory of electromagnetic and weak interactions and subsequently in a variety of nuclear studies. Longer range plans for the laboratory center on construction of a pulse stretcher ring to provide continuous electron beams. Building upon previous developments, this upgrade will provide important new research opportunities through intermediate energy coincidence studies.

Complementary to the Bates experiments are investigations by the MIT group at other accelerator facilities. A program of studies of pion-induced reactions, such as charge-exchange and absorption, at the Los Alamos Meson Physics Facility is directed at obtaining a good understanding of pion-nucleus interactions. Other investigations at Los Alamos, at the Indiana University Cyclotron Facility, and at Bates have been crucial for making efficient use of the complementary nature of nuclear probes.

Another group in intermediate-energy nuclear physics is collaborating with physicists at BNL in a study of hypernuclei using a separated K meson beam in order to investigate the binding of Λ^0 and Σ particles in nuclear matter. Data have been obtained which have allowed detailed comparisons with nuclear model calculations. This group is also exploring jointly with physicists at Bell Laboratories the feasibility of constructing a detector which will measure both the flux and spectrum of low-energy solar neutrinos.

III. Experimental Particle Physics. A. Counter Spark Chamber (CSC) Group. The CSC Group is involved in a Fermilab-based program of studying the structure of the nucleon and the structure of the weak interaction using neutrinos as a probe. The major focus now is on the analysis of the data obtained last year to determine the structure functions of the nucleon, as sensed by the weak neutral current, and to make detailed comparisons of the neutral and charged current interactions with the nucleon. These results will allow detailed comparison with the expectations based on other data and the predictions of weak-electromagnetic unified theories (e.g., the Weinberg-Salam theory).

The group is eagerly awaiting the increase in energy to one TeV at Fermilab (FNAL) (the "Tevatron II") at which time they will extend their neutrino studies to the new energy domain.

In addition the group has more recently entered into two other major collaborative programs. (1) The use of μ mesons at the Tevatron to study nucleon structure and the mechanisms of particle production. The group is participating in the construction of a spectrometer to be used in these studies. (2) The use of 50 GeV e^+e^- colliding linac beams (SLC) at the Stanford Linear Accelerator Center (SLAC) to investigate the physics of the intermediate vector boson Z^0 . The collaboration has proposed an advanced detector, called

SLD, which would exploit the new energy region to investigate a number of physics issues. In particular, they will search for Higgs particles, produced in the decay of Z^0 , and for processes involving heavy quarks with hitherto undiscovered flavors.

B. Electromagnetic Interactions Group. The group is engaged in two efforts in experimental high-energy physics: one at the presently highest energy electron-positron colliding beam accelerator, PETRA, in Hamburg, Germany, and the other at the newly-approved 100 GeV electron-positron accelerator, LEP, in Geneva.

The work at PETRA: After its discovery of gluons, this group has concentrated on the study of properties of gluons to increasingly high orders of accuracy. Of particular importance is the group's recent work on the determination of the second order coupling constant between gluons and quarks, showing that the general theory of strong interactions between quarks and gluons is understood. In addition, they have shown that the expected sixth quark, known as the top quark, is much heavier than previously expected. Their measurement of direct muon production has yielded a much better understanding of the ways in which different quarks transform themselves into ordinary subatomic particles. The group plans to continue to take data to search for new types of electrons and new, heavier quarks.

The work at LEP: The group is leading a large construction effort, which involves 350 Ph.D. physicists from 12 nations, to build a large detector to measure photons, electrons, and muons precisely. The experiment is the first large-scale collaboration between physicists from the Soviet Union, The People's Republic of China, and the United States. The construction of this experiment is proceeding according to schedule and will be ready for data-taking by the end of 1988. The purpose of this experiment is to understand the properties of the Z^0 boson and to search for the Higgs particle, heavy quarks, and heavy leptons.

C. Accelerator Physics Collaboration Group. This group is conducting experimental research on the nature and interactions of photons, hadrons, and neutrinos at two of the country's national accelerator laboratories, the SLAC in California and the FNAL in Illinois. In the Stanford experiment the goal is to study the photoproduction of vector mesons containing charm.

An experiment at FNAL, presently being analyzed, was designed to study hadron production. For this study a unique device was developed that identifies each particle produced. The device, called CRISIS, worked well and will provide unique information.

Apparatus is now being designed and built for an experiment that has been approved for running at FNAL in 1986. The goal of the experiment is to search for a proposed but undiscovered particle, the tau neutrino. Proof or non-verification of its existence will have major theoretical consequences. This experiment will use a new technique being developed explicitly for it, holographic bubble chamber photography. The technique will provide a factor of 10 improvement in resolution over conventional bubble chamber photography.

All of these experiments are being done in collaboration with a consortium of universities in Japan, China, Israel, Italy, France, and the United States. The Accelerator Physics Collaboration Group has been the organizer of the FNAL experiments and of the consortium.

Theory Division

Particle Theory. It is presently believed that the particles which are at the basis of all matter are quarks and leptons, which interact with one another through gauge fields. There is currently a gauge field theory of the strong interactions called "quantum chromodynamics" or QCD and another, the Weinberg-Salam-Glashow theory, that unifies the electromagnetic and weak interactions. Both of these theories, which agree with experiment insofar as they have been tested, and gauge theories in general, are being investigated by the particle theorists. Studies are also being made of "grand unified theories" which attempt to unify weak, electromagnetic, and strong interaction gauge theories, as well as other speculative theories which attempt to encompass them.

One topic in QCD which has much current interest and which was studied in the theory group this past year is the proposal that the most stable form of nuclear matter is not the matter present in the atomic nucleus, but a new form called "strange" matter which is composed of relatively equal numbers of up, down, and strange quarks. The group also studied other dynamical questions in QCD which is a topic of lasting interest in the group.

The group has also extended studies of (1) non-perturbative structure in field theories, especially those related to topological properties, (2) models of particles and interactions, including supersymmetric theories, (3) and new theory of cosmogenesis, "the Inflationary Universe", based on grand unification models and leading to detailed calculations of the properties and development of the very early universe.

Nuclear Theory. The nuclear theory group has addressed a wide range of problems, including the interactions of nuclei with mesonic and electromagnetic probes, the structure of nuclei spanning the periodic table, and heavy ion reactions from below the Coulomb barrier to relativistic energies. The role of nucleon internal degrees of freedom in nuclear structure and dynamics has been a central theme.

A substantial theoretical effort directed at a microscopic understanding of nuclear static and transition densities has been motivated by the high-precision electron-scattering experiments performed at the BIA. Significant progress was made in nuclear many-body theory and the time-dependent theory of nuclear dynamics. These investigations, many of them based on the mean field functional integral approach, have improved the understanding of collective phenomena and have been used to describe spontaneous and induced fission. Methods of calculating the results of a field theoretical model of nuclear structure are being developed, and the consequences of the Dirac particle nature of nucleons are being studied.

A study of nucleon-nucleon forces that incorporates excited hadron degrees of freedom at long-range and quark degrees of freedom at short-range indicates that the first six-quark resonances should be observable with present or planned intermediate energy accelerators. It also shows the importance of excited nucleon states for static deuteron properties such as the magnetic moment. The study is now being extended to determine the effects of the quark and excited nucleon components on the deuteron structure at medium and high momentum transfers. The consequences of quark gluon degrees of freedom in nuclear matter and heavy ion collisions are being studied with a suitable model.

Meson-nucleus interactions are being studied in terms of isobar-nucleon hole collective doorway states, with a complex isobar-nucleus interaction potential playing a central role. The microscopic basis of the model has been elucidated, and associated predictions have been tested against data.

A continuing program of inter-relating semi-leptonic weak and electromagnetic interactions in nuclear phenomena is being pursued. A study of electromagnetic nuclear reactions with polarized beams and targets (which will be available at new facilities) shows that they will enable a much more complete determination of nuclear structure. Predictions of hypernuclear states produced by higher energy collisions of electrons with nuclei will also be tested by new facilities.

JEROME I. FRIEDMAN

Cell Culture Center

The Cell Culture Center at MIT has been established and funded by the Human Cell Biology Program of the National Science Foundation. It is intended to serve as a facility and resource for cell biologists throughout the United States.

The Center is headed by Professor Phillips W. Robbins, Principal Investigator, and Donald J. Giard, Director. The mission of the Center is to produce cells and viruses on a large scale in order to allow scientists to conduct novel and important experiments in basic cell biology that could not be accomplished with the materials and resources in the investigator's own laboratory. The Center is working directly with individual scientists on basic research problems and, in addition, is conducting an active program in the development of new techniques for large-scale cell and virus production.

Production

During the period July 1, 1983 to June 30, 1984, the Cell Culture Center provided cells and/or virus material to 38 research groups throughout the United States. Cells are routinely produced either in suspension culture or as roller bottle (RB) cultures. During this period, the demand for suspension culture continued to increase over the preceding years. Approximately 10^{13} cells were produced. Examples of projects completed during the past year include:

720 RB of SV-80 cells for the University of Illinois, Urbana, Illinois.
240 mgs of Monlony MuLv for MIT, Cambridge, MA.
150 liters of HeLa S-3 cells for Brandeis University, Waltham, MA.
823 liters of HPB-ALL cells for Dana Farber Cancer Institute, Boston, MA.
130 liters of conditioned media for Syracuse University, Syracuse, New York.
300 RB of CV-1 cells for Harvard Medical School, Boston, MA.

Cost-Appportioning Program

The Center recovers a substantial part of its total operating costs through a user charge known as the Cost-Apportioning Program. Under this Program, users are required to pay for all expendable materials and services as well as some of the labor costs. The Center receives almost 100 percent return on all materials, services, and labor costs billed.

Cell Sorter Laboratory

The Cell Sorter Laboratory was established in 1980 as a discrete element of the Cell Culture Center to serve as a local facility and resource for cell biologists primarily in the Northeastern United States. Its purpose is to provide analysis and separation of cells and other small biological particles for qualified researchers who have insufficient resources and equipment in their own laboratories for using this type of specialized technique.

The laboratory offers many options for cell analysis and separation including:

- 1) immunofluorescence assays using indirect or direct antibodies labeled with fluorscein or rhodamine;
- 2) DNA analysis using a variety of stains such as propidium iodide, DAPI, ethidium bromide and methramycin;
- 3) membrane potential using several classes of synanine dyes;
- 4) sorting on the basis of light scattering parameters as a measure of cell complexity and development.

During the past year, the Cell Sorter Laboratory completed twenty-two approved projects. The demand for its services has steadily increased, and currently the laboratory is involved in projects representing a wide range of the various applications described.

Research and Development

Most of the research and development efforts at the Center have focused on the development of an improved microcarrier system for the large-scale production of animal cells and their products. Following the development of the microcarrier system by Levine et al, studies were conducted to examine a number of potential applications of microcarriers, including the large-scale production of viruses and fibroblast interferon. The most productive studies involved the optimization of conditions for interferon production and culminated in the development of a highly improved, low-cost method for producing human interferon.

During the current reporting period emphasis was placed on:

- 1) Optimization of conditions for the production of human gamma interferon using genetically engineered CHO cells.
- 2) Studies on the biochemistry of high-density mammalian cell culture.

During the next year, emphasis will be placed on the following areas of research:

- 1) Engineering aspects in the purification of human gamma interferon.
- 2) Optimization of conditions for production of animal cells in serum-free media.
- 3) The development and application of microcarrier and other cell production systems.
- 4) The use of computer technology and instrumentation to optimize conditions for cell production.

DONALD J. GIARD

Center for Cancer Research

The academic year 1983-1984 has been a year of steady progress for the Center for Cancer Research, highlighted by the achievements of Professor Robert Weinberg's group in the area of oncogene isolation and cancerogenic activity. We have added to our faculty Dr. David Raulet as Assistant Professor of Biology, replacing Associate Professor Michael Bevan as a member of our Immunology Group.

Several significant recognitions were won by our faculty during the past year. Professor Phillips Robbins was a Fogarty Scholar-in-Residence at the National Institutes of Health, where he spent the academic year 1983-1984. Professor Susumu Tonegawa received a number of awards for his outstanding research on the genetics of immune response: the David Pressman Memorial Award of the Roswell Park Memorial Institute, the Edward C. Franklin Award of the European Marketing on Plasma Proteins in Clinical Diagnosis, Milano, the V. D. Mattia Award of the Roche Institute for Molecular Biology, the Gairdner Foundation International Award, and the Bunkakorsha (Person of Cultural Merit) Award of the Japanese Government. Professor Robert Weinberg was the recipient of the Robert Koch Medal, the Armand Hammer Cancer Prize, the U. S. Steel Foundation Award in Molecular Biology of the National Academy of Sciences, the Howard Taylor Ricketts Award, and the Bristol-Myers Award, for his work on oncogenes.

Visitors of faculty rank in the Center during the year include Mark Pasternack, M.D., of Harvard Medical School and Massachusetts General Hospital, David Williams, M.D., Dana-Farber Cancer Institute, Gilbert Lenoir, D.V.M., World Health Organization, and James Gusella, Ph.D., Massachusetts General Hospital.

SALVADOR EDWARD LURIA

Center for Space Research

The Center for Space Research (CSR) conducts an active program of research in space science and technology, with emphasis on experimental and theoretical investigations in support of various NASA missions. Although the primary source of support is from NASA, a substantial fraction of the research program is sponsored by the NSF and DOD. Specific areas of research include X-ray astronomy, planetary magnetospheric and interplanetary space plasma physics, the life sciences, properties of planetary surfaces and atmospheres, and optical and radio astronomy. A major part of this program concerns the analysis and interpretation of data from flight experiments carried out in these areas. The current long-range NASA flight program includes several missions in which MIT and the Center are heavily involved. Among these are the Venus Radar Mapper (VRM), the Advanced X-ray Astronomy Facility (AXAF), a large area X-ray Timing Experiment (XTE), a large-scale investigation of the plasma environment of the earth as part of the International Solar Terrestrial Physics program (ISTP), and an Air Force program designed to investigate the plasma environment experienced by the Space Shuttle in a typical polar orbit. The Center also supports a program in theoretical astrophysics and a program of optical investigations carried out at the McGraw-Hill Observatory as described elsewhere in this report. An overview of CSR activities during the past year follows.

RESEARCH IN X-RAY AND γ -RAY ASTRONOMY

Analysis of Data from Past X-ray Astronomy Missions

During the period from 1975 to 1981 various instruments developed by members of the X-ray Astronomy Group were flown on three NASA satellites, SAS-3, HEAO-1, and HEAO-2. The archives of data from these missions continue to be valuable sources of material for research on the properties of galactic and extragalactic X-ray sources which is carried out in the X-ray astronomy computation facility at CSR. The HEAO-2 satellite, otherwise known as the Einstein Observatory, carried a Bragg-reflection X-ray spectrometer developed by Professors George W. Clark and Claude R. Canizares.

During the past year, analysis of X-ray images and spectra obtained with the Einstein Observatory has continued. Results on supernova remnants, clusters of galaxies, galaxies in the local group and quasars have been used to address a variety of current astrophysical problems. These include the distribution of hidden mass in clusters of galaxies, the cooling and accretion of intracluster gas into central galaxies, the elemental enrichment of the interstellar medium by supernovae and the nature of the X-ray sources in our neighbor galaxy M33.

The Explosive Transient Camera (ETC)

Several years ago an MIT graduate student discovered that γ -ray bursts are apparently associated with a brief enhancement of optical emission from the celestial source. This discovery led to a major effort by Dr. George R. Ricker and his colleagues to develop an efficient "all-sky camera" capable of observing the short optical flashes. Initially it is planned to operate this device at a ground-based observatory and correlate the optical data with γ -ray observations made by satellite-borne instruments.

The all-sky camera has been under development for about two years (see past reports) and a prototype to demonstrate that the concept was sound was successfully tested at the Mauna Kea Observatory (Hawaii) in 1982. The actual instrument is now under construction and final development. It consists of a compact "fly's eye" array of 16 CCD cameras each of which views an adjacent $\sim 15^\circ \times \sim 20^\circ$ portion of the sky. The 16 cameras use inexpensive fast 35mm camera lenses and are microprocessor controlled. With the present design, all objects as faint as 10th magnitude can be examined once per second over about 60 percent of the accessible hemisphere and compared with objects seen in previous scans. Any "new objects" detected will be electronically flagged and information describing their location and intensity will be stored on site and also transmitted to MIT. It is clear that the operation just described requires an extensive data processing and data storage capability. This capability is provided by a computer also developed by the group which is described in a following section of this report (see the section below on the "generic computer").

In December 1983 the Advisory Board of the Association of Universities for Research in Astronomy approved the siting of the Explosive Transient Camera (ETC) on Kitt Peak in Arizona. Two sites on the mountain have been recently selected and surveyed and a sublease agreement is under negotiation. Initially, the

ETC arrays will be housed in two small buildings. Transparent roofs over each array will be opened and closed by an overseer microcomputer, based on its assessment of sky clarity and cloud cover measurements made through the roof. Human intervention should be necessary only for preventative maintenance.

The ETC will be able to detect brief (1-10 sec duration) flashes of optical light with an efficiency about three orders of magnitude better than previously used astronomical methods. Based on the established sensitivity, we can expect to detect and precisely locate ~100 such events per year with the ETC. To detect a comparable number with traditional methods (for example, using the Mount Palomar Schmidt telescope) would require ~500 years of observation.

Rocket-Borne X-ray Experiments

During the past several years, the MIT X-ray Astronomy Sounding Rocket group, under the direction of Professor Saul Rappaport, has designed and constructed a new wide-field soft X-ray camera. The instrument features three nested Wolter-Schwarzschild grazing incidence mirrors, and a 50mm diameter microchannel plate imaging detector at the focal plane. The camera has an 8° field of view and is sensitive over the energy range 50Å-250Å. We plan to use this instrument to carry out an all-sky survey in this relatively unexplored wavelength band. It is expected that important new astrophysical information will be obtained for a wide range of astronomical objects. The payload was launched from White Sands last October and recorded an anomalously high background count rate, probably due to leakage of geocoronal Ly α radiation. We have modified the payload to prevent a recurrence of this problem and are scheduled for a third flight early this fall. A satellite-borne version of this experiment, with its longer exposure times, would allow a high-sensitivity all-sky survey to be carried out using this technique. Accordingly, a scaled-up version of this instrument has been successfully proposed by a consortium of British astronomers as an ancillary experiment on the German satellite ROSAT.

A proposal has been submitted (July 1984) to NASA for support of a Low Energy X-ray Spectroscopy (LEXS) experiment as part of NASA's new SPARTAN program (an extension of NASA's Sounding Rocket Program). The proposed instrument would carry out spectroscopic investigations in the ~40-120Å band, an important area of astrophysics not presently accessible. The LEXS would permit a sensitive search for low-temperature ($3 \times 10^5 < T < 3 \times 10^6$ K) gas in astrophysical objects and the general study of the soft X-ray spectra ($E \sim 1/4$ keV).

RESEARCH PROGRAMS IN SPACE PLASMA PHYSICS

Interplanetary and Magnetospheric Plasmas

The IMP-8 spacecraft was launched in 1973 into an eccentric earth orbit. It has provided a continuous database of solar wind plasma conditions at 1 Astronomical Unit (AU) for the past ten years. At the present time, there are no other operational solar wind experiments in earth orbit. Thus, the MIT IMP-8 results constitute the only available solar wind database. The data are processed routinely, and are used by many investigators for various studies of solar wind properties. This program is supervised by Dr. Alan J. Lazarus.

Solar wind data are also being routinely received and analyzed from the Voyager 2 spacecraft, which is now well beyond the orbit of Saturn. Voyager 2 flew past Saturn in August 1981, and will encounter Uranus in January 1986. Preparation of detailed plans for the measurements to be made at Uranus is nearly complete and final preparations for the encounter will be made during the coming year. If the spacecraft is still operational after the Uranus encounter in 1986, NASA plans to direct it to an encounter with Neptune in August 1989. Professor Herbert S. Bridge is the Principal Investigator for the Voyager Plasma Experiment. Professors John W. Belcher, Stanislaw Olbert, Ralph McNutt, and Drs. Alan Lazarus and John Richardson are involved in mission operations and data analysis.

An Ion Mass/Velocity Spectrometer for the Mission to Halley's Comet (Giotto)

The European Space Agency (ESA) has authorized a mission to Halley known as the Giotto Mission. MIT is involved with one of the experiments which is being developed under the leadership of Professor Johannes Geiss of the University of Bern.

The objectives of this investigation are to study the physical and chemical processes occurring in the ionospheres of comets and to understand the interaction of comets with the solar wind. Limited funding has been made available by NASA for US investigators on this mission, and a group led by Dr. Marcia Neugebauer of the Jet Propulsion Laboratory submitted a successful proposal. Dr. Lazarus and Professor Bridge are Co-Investigators. The Giotto spacecraft is scheduled for a shuttle launch in the fall of 1985

and will encounter Halley's Comet in the spring of 1986. Testing of the spacecraft and the experiments is proceeding on schedule.

Physics of Space Plasmas in the Earth's Magnetosphere and Ionosphere

In August 1979 a program of theoretical research on the physics of the terrestrial magnetosphere and ionosphere was initiated under sponsorship of the United States Air Force. These studies apply the basic kinetic theory of charged particles moving in a magnetized environment to problems in weak and strong plasma turbulence, plasma instabilities, and collective effects on wave-particle interactions. The specific phenomena considered in this research program include: diffuse, discrete, and flickering aurora; the onset of magnetic substorms; the origin of the auroral kilometric radiation; the formation of non-Maxwellian ion and electron distributions; VLF whistler modes; lower- and upper-hybrid instabilities; the trapping and precipitation of energetic charged particles; plasma processes near the Earth's bow shock; and beam-plasma interactions. Drs. Tom S. Chang and Geoffrey Crew and Professor Olbert are currently involved in this program.

In February 1983 an experimental program also under Air Force sponsorship was initiated to study the plasma environment encountered by a space shuttle in polar orbit. This work is being carried out by Dr. Joseph H. Binsack and Professors Bridge, Belcher, and Olbert.

PLANETARY STUDIES

Venus Radar Mapper (VRM)

The main purpose of this NASA mission to Venus (formerly the Venus Orbiting Imaging Radar Mission - VOIR) is to map the surface of this cloud-shrouded planet using a Synthetic Aperture Radar (SAR). The data from the radar will be processed into mosaics to yield a global map of the planet at varying resolutions with many regions approaching 120-meter resolution. This map will be used to describe and locate the major geological regions in an attempt to understand the processes that have shaped the surface of Venus and led to the evolution of its distinctive atmosphere.

Professor Gordon H. Pettengill of the Department of Earth and Planetary Sciences and the Center's new Director is the Principal Investigator of the SAR. The VRM launch is scheduled for the spring of 1988.

SPACELAB VESTIBULAR EXPERIMENTS

This program, being carried out under the direction of Professor Laurence R. Young of the Department of Aeronautics and Astronautics, will provide a series of experiments to test theories of human reaction in the gravity-free environment of space. The Center furnishes management and engineering support for the program under the general direction of Dr. William F. Mayer.

Two sets of flight equipment were delivered to NASA for the Spacelab-1 mission (SL-1). This mission was successfully completed in December 1983 and analysis of the data is currently in progress. Upgraded versions of these vestibular experiments were selected to fly on the German D-1 Spacelab mission (launch scheduled in October 1985) and the NASA Life Sciences Spacelab-4 mission (scheduled for January 1986). The flight hardware for D-1 was delivered in January 1984. For each mission, seven separate experiments are planned, some in collaboration with Canadian and European Space Agency investigators. The experiments range from the measurement of various responses to head motions, to hopping experiments which will test otolith changes during weightlessness. Memory/disorientation experiments and motion sickness susceptibility experiments will be conducted to provide an understanding of the problems experienced by astronauts in the Apollo, Skylab, and Space Shuttle missions. Professor Young is assisted in these Spacelab experiments by Dr. Charles M. Oman of the Department of Aeronautics and Astronautics and by Dr. Byron K. Lichtenberg of the CSR research staff.

DETECTOR AND INSTRUMENT DEVELOPMENT

X-ray Spectrometry - AXAF Spectrometer Proposal

Work directed by Professor Canizares on new techniques for X-ray spectroscopy of astronomical objects continued. A major proposal to perform High Resolution of X-ray Spectroscopy on NASA's planned Advanced X-ray Astrophysics Facility (AXAF) was prepared and submitted with Professor Canizares as Principal

Investigator. The instrument proposed for AXAF incorporates new techniques for Bragg crystal spectroscopy using an improved version of the instrument flown on HEAO-2 and also includes a Transmission Grating Spectrometer. The latter uses unique thick, high spatial frequency gratings that are being developed in collaboration with Professor Henry Smith's Submicron Structures Laboratory. We have recently fabricated such a grating and demonstrated diffraction of 9 keV X-rays with >40 percent efficiency.

X-ray CCD Camera Development

Development of an imaging X-ray photon camera for flight on the NASA AXAF has been the central goal of Dr. Ricker and his colleagues since the MIT CCD development program was initiated in 1975. Progress toward this goal continued during the past year. The principal tool used in this work has been an extremely flexible X-ray test camera developed in 1982.

A replica of the MIT test camera has been constructed for X-ray measurements of laser-induced plasmas at Lawrence Livermore Laboratory in collaboration with the Livermore Laser Diagnostic Group. This camera incorporates a simplified modular electronic system closely similar to that used in the optical CCD cameras developed by this group.

During the past year, the X-ray test camera and associated equipment have been used to investigate a number of problems related to the use of virtual phase CCD devices as low energy X-ray detectors. The details of the collection of charge within the CCD and the effect of the electrode structure of the surface are of particular interest for this application. These investigations, carried out as a senior thesis project by Mr. Kevin Soch, are a collaborative program between MIT, Texas Instruments, and JPL and have been under the general direction of Dr. John Vallerga. In the course of this work various X-ray apertures (pinholes, slits, and even a Fresnel zone plate) were used to probe the CCD at sub-pixel scales. The zone plate images were deconvolved to yield an image of the anode of the X-ray tube source; this is the first use of a CCD as a coded aperture X-ray camera. The results also demonstrate that the CCD can be used to form X-ray images below 1 keV, an important regime for the application of these devices to the AXAF instruments.

As part of our general investigation of CCD detectors, work continued on the evaluation of noise sources in these systems. Programs were developed which allow the data acquisition system of the camera to measure its own noise spectrum and the noise spectrum of the device itself. Some improvements were made in the clock drivers and methods to reduce clocking noise were investigated.

AXAF Imaging X-ray Camera

In response to the AXAF Announcement of Opportunity a proposal for an imaging CCD X-ray camera was submitted by a consortium of MIT, the Jet Propulsion Laboratory (JPL), and Pennsylvania State University (PSU). Dr. Gordon Garmire of PSU is the Principal Investigator for the proposed instrument; the MIT effort is the responsibility of Dr. Ricker and several members of the MIT X-ray group who are Co-Investigators on this proposal. The heart of the instrument is a large array of CCD sensors sensitive to X-rays. Its design and development are the result of several years of research by Dr. Ricker and his group, part of which is described above. However, an equally important aspect is the design of a data processing system which can reduce the millions of bits per second of raw data from the CCD sensors into a meaningful data stream which can be handled by the satellite telemetry system. The design of this onboard data system will be the main responsibility of MIT if the proposal is accepted by NASA.

Development of a "Generic" Image Processing Computer

In 1982 Dr. John Doty and his colleagues investigated ways to obtain adequate image processing capability to support an astronomical CCD camera on a modest budget. The concept arrived at was a "generic" computer based on industry standards rather than on the approach of a specific manufacturer. This system promised high performance at very modest cost, due to the highly competitive nature of the market for standard computer components.

Since early 1983, when the original system arrived, tremendous progress has been made. That system is now in routine use as a image processing system and a highly interactive, visually oriented photometry program has been developed. A similarly interactive spectroscopy program is the senior thesis project for Mr. Kip Kantz and is nearly completed. Using these programs, the parameters of the image display can be very rapidly and interactively adjusted to provide the best possible picture in black and white or in false color. Special attention has been given to the problem of rapid access to the raw data. Moreover, a high-speed serial data acquisition link has been developed which allows a computer of this type to acquire images directly from the A to D converter in the front end of a CCD camera. This link has been used to support X-ray and optical CCD cameras used by the group and by outside users.

"Generic computers" similar to the original system are now in use at the Livermore Laboratories, the Goddard Space Flight Center (GSFC), and by other groups at MIT.

OPTICAL ASTRONOMY

The University of Michigan, Dartmouth College, and MIT are constructing a 2.4 meter telescope at Kitt Peak in Arizona. It is scheduled to be completed in January 1985. During 1983-84, in support of this project, Dr. Jeffrey E. McClintock has consulted closely with the project leader, Professor W. A. Hiltner, and made several trips to the telescope maker, the optician, and to the site. Dr. McClintock is constructing an intensified CCD television camera which will be used routinely on the new telescope to acquire and to guide on the images of faint stars. Several members of the CSR staff, led by Professor Canizares, developed a detailed proposal for an observatory computer modeled after the generic computer work stations currently operating in CSR.

FUTURE MISSIONS

The Center is involved in several NASA flight programs which vary greatly in status. Some are fully approved and have relatively firm flight dates; some are in a study phase with tentative launch dates; some are more nebulous. Two proposals for the AXAF mission have been described above, a partial list of other programs follows.

X-ray Timing Explorer (XTE)

This is an NASA X-ray astronomy satellite program which has been proposed for the late 1980's and early 1990's; experiments have been selected by NASA but full funding awaits final scheduling and approval of the mission. The main objective is to study the time-variability of celestial X-ray sources on a wide range of time scales from milliseconds to years. A CSR group under Professor Hale V. Bradt is participating in mission studies and is beginning development of the scientific instrumentation for which MIT has primary responsibility. As part of this program, the Center is conducting analytical and computer studies of the Scanning Shadow Cameras, which will serve as X-ray all-sky monitors. The Center has also begun the preliminary design and construction of a breadboard of the On-Board Data System, which is a sophisticated onboard electronics/microprocessor package designed to handle the large data flow from the Proportional Counter Array which is the set of large area X-ray detectors. The MIT group is collaborating in this project as an equal partner with the X-ray astronomy group at the NASA/Goddard Space Flight Center.

Reflectance Spectrometer Research for Possible Inner Solar System Planetary Orbiters

The Center is conducting preliminary design and breadboard development of a reflectance spectrometer instrument (RSI) to demonstrate the capability of an optical/IR spectrometer of moderate resolution, in order to determine the composition of material of solar system bodies by studying their reflectance spectra. In addition, by incorporating detectors in the direction perpendicular to the spectral dimension at the focal plane, spatial information is simultaneously obtained for several selected wavelengths. Detector evaluation is continuing, as well as optical and electronic design, so that a specific instrument can be designed readily for a potential planetary or asteroid mission. A ground-based version of this instrument has been fabricated at CSR and delivered to the University of Hawaii, for evaluation using ground-based telescopes there. The research program is under the scientific direction of Professor Thomas B. McCord of the University of Hawaii. Supervision of the technical program at MIT is provided by Dr. Binsack of CSR.

Orbiting VLBI Network Utilizing the Space Shuttle and Other Satellites

This research program, under the direction of Professor Bernard F. Burke of the Department of Physics, is to investigate the concepts and methods of implementing an orbiting Very Long Baseline Interferometer (VLBI) terminal in space. Earlier investigations concentrated on small antennas fixed-mounted inside the Shuttle. Current concepts will draw on other NASA studies of large deployable antennas of 50-100 meter diameters. Antenna-pointing accuracies, stability and dynamics, RF feed configurations, and data-handling techniques are being investigated by MIT in conjunction with the Marshall Space Flight Center (MSFC) and JPL. Possible international collaborative projects (e.g., QUASAT) are also being investigated and a workshop on Orbiting VLBI was held in the summer of 1984. Professor Burke is assisted by Professor David Roberts of Brandeis University.

International Solar Terrestrial Program (ISTP)

The ISTP program (formerly the OPEN program) consists of a series of four satellites at various positions in the Earth's magnetosphere which monitor its response to changing conditions in the solar wind. These solar wind conditions are recorded by another satellite, the WIND, at the libration point upstream of the magnetosphere. A plasma experiment proposed jointly by GSFC and MIT has been selected for this program and preliminary design is in progress.

HERBERT S. BRIDGE

Clinical Research Center

The Clinical Research Center (CRC) is an Institute resource established for the support and care of subjects participating in research studies conducted by MIT investigators and their collaborators. Its purpose is to facilitate and enhance research in human health and disease under optimum conditions of care. The past year continued to be highly productive for the CRC as investigators continued to make heavy use of its resources. Research studies conducted at the Center involved 2894 inpatient days and 1683 outpatient visits under 46 different research protocols. More than 50 scientific articles were published or accepted for publication as the result of work associated with the Center. Bed occupancy averaged 73.6%. MIT departments using the CRC include Nutrition and Food Science, Mechanical Engineering, and Psychology.

The CRC's wide variety of research protocols and multiple observations per patient continue to place heavy demands on its specialized computing facility. The major improvement in the CRC over the past year was the strengthening of our computer resources. The computer software was adapted by the MUMPS Collaborative from "user-friendly" software developed for hospital management applications. Although the system contains a basic statistical program, more complex statistical analyses can be performed through a hardware linkage to a VAX 780 in the Whitaker College of Health Sciences and Technology. In addition, MEDUS/A (a user-definable data base) makes possible the entry and organization of other data for which the original MUMPS software is less suitable. The new system duplicates the linkage between the core laboratory, nursing station, outpatient department, and dietitians present in our previous PDP-12 system. The principal advantage of the new system is that all patient data can be stored on-line due to the greater storage capacity. Because many of the studies conducted in the MIT CRC are longitudinal or are based on previous studies, this development enhances the investigator's ability to compare responses of the same subject or different subjects over time.

The new system also improves the ability of our CRC to facilitate and support a variety of collaborative studies. One study that is currently seeking funding is a proposal to use the CRC computing facility for data acquisition and storage for a consortium for the study of Alzheimer's disease. A second is to use the CRC nutritional expertise, dietary intake programs and computing facilities to support studies of diet, nutrition, and cancer. In both cases, the large on-line storage capacity of the system is clearly advantageous for such varied functions as the interim analyses of trends, or for specifying in advance the dates of patient visits and the analyses to be performed. The linkage to other computers capable of complex and highly sophisticated statistical analyses is a clear strength, particularly because the costs of storage on the other systems is avoided.

Research training is an integral part of the research program conducted at the CRC. Physicians participating in the Clinical Nutrition Training Program offered by the Department of Nutrition and Food Science, in collaboration with five area hospitals, utilize CRC facilities to initiate new research protocols and participate in ongoing projects supervised by senior investigators and faculty. Over the past year 15 physicians representing the specialties of internal medicine, surgery, pediatrics and obstetrics/gynecology have been active in the program. Five of these physicians have been supported by a continuing training grant from the National Institutes of Health (NIH). Their research interests include the use of stable isotopes to evaluate amino acid and protein metabolism; non-invasive methodologies for studying intestinal absorption; and developing and testing novel protein sources for human consumption. Following their training, physicians in this program have entered clinical departments of medical schools or hospitals and have been responsible for developing effective programs in training, research and patient care. Several recent graduates of the program have remained in the Boston area and have continued their research programs in collaboration with area hospitals and the MIT Clinical Research Center.

A wide variety of investigators utilized the CRC this past year. For example, studies under the direction of Professor Vernon Young have continued to explore protein and amino acid metabolism in healthy adult subjects and its response to dietary factors. Using stable isotope tracers, Professor Young has demonstrated that mechanisms associated with the maintenance of body homeostasis are linked to the amino acid protein requirements of the individual. He has also begun to develop stable isotope techniques to determine the contribution made by the intestine and liver to the metabolism of meal-derived amino acid. These new methods promise an increased understanding of human amino acid requirements of under varying conditions of health and disease.

Dr. Michael Holick continues to investigate the photobiochemistry of the events that lead to the formation of vitamin D in human skin. He has shown that during minimum exposure to sunlight, provitamin D₃ is converted to previtamin D₃. After formation previtamin D₃ slowly converts in the skin to vitamin D by a temperature dependent process. During excessive exposure to sunlight, previtamin D₃ is converted to two biologically inactive photoisomers. It therefore appears that the photochemistry of provitamin D₃ is an important regulator of the sun-mediated synthesis of vitamin D₃ and is an explanation for why individuals with excessive exposure to

sunlight do not become vitamin D intoxicated. An analysis of provitamin D₃ content in human epidermis has revealed that aging significantly decreases the ability of the skin to produce vitamin D. Studies involved in determining the evolutionary origin of vitamin D have revealed that most, if not all, living organisms exposed to sunlight have the capability of photosynthesizing provitamin D.

Dr. William Dietz has concluded one major series of studies regarding the metabolism interrelationships between protein and glucose that occur in obese adolescents in response to hypocaloric diets. Studies of the optimal diet for weight reduction in this population have been infrequent. Dr. Dietz's studies represent a novel application of stable isotope technology under rigorous experimental conditions to a widespread and significant public health problem. In a second series of studies, Dr. Dietz is comparing energy expenditure in obese and non-obese adolescents using the newly developed doubly labelled water technique. Energy expenditure in adolescents matched for sex and lean body mass is being compared over a 14 day period. In addition, a subset of the same subjects will be restudied during a 14-day period of overfeeding. These studies should determine whether differences in energy expenditure account for an increased susceptibility to obesity.

Professor Nevin Scrimshaw has conducted studies of the tolerability and the nutritive value of novel proteins in the outpatient department of the CRC for the past 15 years. During the last year a filamentous microfungus produced on sulphite liquor, a by-product of paper production by a Finnish process, was demonstrated to be suitable for human diet.

Dr. John Udall has continued his studies of gastrointestinal development. He has shown in studies of animals and humans that the gastrointestinal trace of infants compared to that of adults is less efficient in digesting macromolecules, and allows the increased transport of potential antigens and toxins across the intestine early in life.

Professor Richard Wurtman's research group has continued to examine 1) the effects of high protein or carbohydrate meals on human mood and performance; 2) the effects of caffeine on human behavior; 3) the characteristics of food choice in people with obesity; 4) effects of various foods and of various nutrients or food additives on plasma amino acid ratios, when given at various times of day; 5) effects of aging on plasma amino acid responses to various foods and nutrients. Professor Wurtman's neuroendocrine studies currently focus on the secretion and actions of the pineal hormone melatonin.

Dr. Judith Wurtman was able to measure 24h patterns of calorie and nutrient intake among obese inpatients admitted to the Clinical Research Center. Previous measurements indicated that a subset of obese individuals had a particularly strong appetite for carbohydrate-rich snack foods despite consumption of amounts of calories and nutrients at meals. Evidence that the carbohydrate hunger is controlled, in part, by the brain neurotransmitter serotonin is suggested by the observation that drugs that increase serotonergic neurotransmission decrease carbohydrate but not protein intake. Dr. Wurtman is currently extending these findings by studying the long term effects of administering a drug that enhances serotonergic neurotransmission (d-fenfluramine) to obese subjects who snack exclusively on carbohydrates and to those who snack on both protein and carbohydrate foods.

The outpatient department continues to support the research of Professor Padmakar Lele who is investigating the toxicity and response to local hyperthermia generated by focused ultrasound in patients with superficial head, neck, or chestwall cancer. Special simplified, manually operated instruments and techniques have been developed to generate hyperthermia confined to tumors in spite of the restricted portal and curvature of the neck, presence of bone and air in the treatment area, and respiratory excursions. Intratumoral and surface temperatures were measured by fine, nonperturbing thermocouples. Treatments were given weekly at tumor temperatures of 42.0° or 42.5°C for 20 minutes. In more than 20 patients treated to date, the objective response, as determined by regression of 50% or more in the product of perpendicular cross-diameters of the tumors, and subjective response, reported as relief of local pain, occurred in over 70% of patients. There has been no apparent local toxicity as judged by local injury or pain. Based on these results, the studies are now being extended to deeper and larger tumors by utilizing a computer-based technique for production and maintenance of uniform levels of hyperthermia in the tumor. Furthermore, the synergistic effects of hyperthermia with radiation and chemotherapy are under intensive examination.

The Neuropsychology Research Group under the direction of Dr. Suzanne Corkin, has extended its investigations of brain-behavior relationships with seven different populations of subjects: 1) patients with chronic global amnesia; 2) veterans with penetrating head injuries sustained during World War II; 3) patients who received a neurosurgical procedure, either cingulotomy or leucotomy, for the relief of chronic pain or psychiatric disease; 4) children and adults with craniopharyngiomas, tumors that invade the third ventricular region; 5) women with Turner's syndrome, a chromosomal disorder characterized by ovarian dysgenesis; 6) patients with Alzheimer's disease, the most prevalent type of senile dementia; and 7) healthy elderly subjects. To understand the brain mechanisms that are affected in the seven different groups, they have used quantitative behavioral tests, to sample cognitive, sensory, and sensorimotor functions, as well as motivation and affect. They have then related the data thus obtained to the concomitant morphological or chemical alterations in brain.

NEVIN S. SCRIMSHAW

Experimental Study Group

The fifteenth year of the Experimental Study Group (ESG) was marked by transition in staffing in the program. Professor Robert Halfman retired at the end of the year after serving as ESG's Director for the past ten years. Under his leadership, ESG has thrived as an individualized alternative to the MIT freshman year for 445 students. Many of them have expressed their appreciation for Professor Halfman's gentle but firm guidance over the years: in the words of one alumnus (Matthew Stein '78), "I am grateful to Professor Halfman for the time and energy he has devoted to ESG, education, and the many individuals who have benefited from his guidance, instruction, and influence." We are pleased that Professor Halfman has indicated that he intends to remain associated with ESG in an informal capacity, tutoring a few students each term.

The ESG community was saddened by the sudden passing of Professor Emeritus Nathaniel Frank in February. Professor Frank was a member of the physics staff at ESG since its second year, and his commitment to excellence in undergraduate education was legendary. One former student, Jonathan Weitsman '83, recalled in his eulogy for Professor Frank that "for Professor Frank, no problem had anything called 'the answer.' A problem was, in fact, more of an adventure, always with more questions to be asked, more subtleties to be understood. One was never 'done.' One simply moved on." Professor Frank's presence at ESG and his dedication to our program will be missed.

After an extensive search involving contact with over 100 members of the MIT faculty, Professor J. Kim Vandiver of the Department of Ocean Engineering was appointed ESG's new Director, effective July 1, 1984. Professor Vandiver has been at MIT since 1968 when he began his doctoral program in Ocean Engineering and comes to ESG highly recommended by his students and fellow faculty members. We welcome him to ESG and look forward to working with him in the future.

Student Statistics

This past year ESG enrolled 48 freshmen, 24 sophomores (who had been in ESG as freshmen) and one international transfer student. The freshmen completed approximately 52 units each term, taking an average of three subjects in ESG and two subjects in the regular curriculum (primarily humanities subjects and undergraduate seminars which aren't offered in ESG). Last year's freshmen in ESG achieved a median grade point of 4.2 during their sophomore year, marking the fourth consecutive year that ESG sophomores have had a higher median grade point than their counterparts in the regular curriculum. Half of these sophomores continued to take one or two subjects in ESG. Three ESG upperclassmen received awards or fellowships from MIT at the end of the year: William Doherty '85 (Stewart Award), Mihai Manoliu '84 (Eloranta Fellowship), and Edwin Seidewitz '84 (Compton Award). We applaud the efforts of these students and the contributions they have made to the MIT community and to ESG.

Administration

Professor Halfman and Associate Director Holly Sweet oversaw the administration of the program in conjunction with the ESG Advisory Committee. The Committee, headed by Professor Alan Davison, spent an active year searching for a successor to Professor Halfman and worked closely with the ESG community to accomplish this task. Professor Davison was joined by fellow Committee members Professor Arthur Kaledin, Dr. Alan Lazarus, Professor Arthur Mattuck, and Associate Provost Frank Perkins. Professor John Deutch, Dean of the School of Science, oversaw the selection process of the new director and handled fiscal responsibility for ESG's budget.

Staffing

ESG continued to offer core freshman subjects through a variety of methods, including tutorials, seminars, study groups, and supervised independent projects. The math staff consisted of Dr. Kari Vilonen and three graduate students: Mark Haiman, Jeffrey Schapiro (fall term), and Montgomery McGuire (spring term). The physics offerings were supervised by Professors Frank and Halfman and three graduate students: Eduardo (Jay) Olaguer, John Tsai (fall term), and Craig Watkins (spring term). Miguel Mitchell, in his second year as a chemistry staff member at ESG, tutored students taking 5.41 Introduction to Structure, Bonding, and Mechanism and 5.40 General Chemistry during the fall term. The humanities staff included Dr. Janet Murray, Ms. Sweet, and Thomas Cuda (a visiting graduate student from the University of Southern California Department of Philosophy). Eight different humanities subjects were offered: Intentionality and Logic,

Introduction to Philosophy, 21.004 Major Poets, The Myth of Success in American Society, Philosophy of Mind, Philosophy of Science, Three Approaches to Psychology, and Writing Workshop. The ESG staff was assisted by 34 student tutors, with an average of 24 students tutoring each term. This year several tutors assumed responsibility for serving as teaching assistants in courses such as 6.001 Structure and Interpretation of Computer Programs and 5.42 Organic Chemistry, which were taught jointly through ESG and the regular curriculum, an arrangement which we hope to continue in the future.

Current Developments

Dr. Murray's proposal for a joint project with the Foreign Languages and Literatures section and ESG to develop a new generation of lab materials for teaching languages received funding from Project Athena this year. Dr. Murray has recently submitted a proposal, under the aegis of Project Athena, to the Annenberg Foundation for \$1,390,000 to continue the project on a five year basis.

ESG saw an increase in student involvement in community activities this year, including a student-run seminar on computer basics, and the establishment of the ESG Projects Group, a group of students and staff members who help maintain the administrative and academic operation of ESG. The computer seminar was organized by two student tutors in the fall and offered to six freshmen in the spring on an informal basis. Based on its success, a proposal for continuing the seminar with a new group of freshmen in the fall has been submitted to Project Athena. The Projects Group was active not only in overseeing and improving the tutoring system at ESG this year but also in assisting the Advisory Committee in its director search. As a result of the numerous positive connections made with faculty members during the search process and Professor Vandiver's interest in bringing more faculty into ESG, we are planning to increase faculty involvement in the program through the development of a series of ESG undergraduate seminars and UROP projects and the expansion of the role of the Advisory Committee members.

HOLLY B. SWEET

George Russell Harrison Spectroscopy Laboratory

The George Russell Harrison Spectroscopy Laboratory is engaged in fundamental and applied research in modern spectroscopy for the purpose of advancing our knowledge of the structure and dynamics of atoms and molecules and the properties of liquids and solids. Techniques include the use of lasers and high-resolution spectrometers.

An interdepartmental laboratory, the Spectroscopy Laboratory encourages participation and collaboration among members in the various disciplines of science and engineering. This past year several MIT departments have pursued research projects in the Laboratory, including Chemistry, Physics, Biology, Electrical Engineering and Computer Science, Mechanical Engineering, Architecture, Materials Science and Engineering, and Food and Nutrition. Participation from several outside academic and industrial organizations has further strengthened the interdisciplinary research activities of the Laboratory.

MIT LASER RESEARCH CENTER

The Laser Research Center, a National Science Foundation Regional Instrumentation Facility housed in the Spectroscopy Laboratory, enables researchers from academic, industrial and other types of institutions to pursue research in broad areas of laser spectroscopy and dynamics, to develop new types of coherent sources and techniques, and to perform diagnostic studies of various substances and materials. Its unique facilities, which include a broad range of lasers and ancillary equipment, constitute one of the largest and best-equipped centers devoted to spectroscopic research. They are made available free of charge to qualified scientists and engineers from outside organizations. Professor Michael Feld, Department of Physics, is director of the Center; Professor Jeffrey Steinfeld, Department of Chemistry, is its scientific coordinator, and Dr. Ramachandra Dasari, Spectroscopy Laboratory, is project coordinator.

Current available equipment includes continuous wave (CW) and pulsed dye lasers in the visible and near ultraviolet, CW and pulsed CO₂ lasers, a tunable diode laser spectrometer, and a laser Raman spectrometer. All are interfaced with microcomputers which control experiments and collect and analyze data. Auxiliary equipment includes a transient digitizer and an optical multichannel analyzer with digital read-out. During the past year, 57 projects have been initiated at the Center in: atomic, molecular and solid state physics (16); physical and inorganic chemistry (20); biochemistry and biology (11); medical science (4); and engineering and applied sciences (6). 40% of these projects have been originated by Core and other MIT faculty, 50% by researchers from outside academic institutions, and 10% from industry and government laboratories.

RESEARCH HIGHLIGHTS

Professors Richard Lord and Gregory Petsko of the Department of Chemistry have investigated the structure of Hayfever-associated allergen Ra5, a small disulfide-rich protein, from two species of ragweed. They found that the two structures differ substantially, despite partial sequence homology and cysteine location. These differences are expected to be related to antigenic activity, as the two forms of Ra5 do not immunogenically cross-react. Many aspects of this work were performed in conjunction with Dr. Lawrence Goodfriend of Royal Victoria Hospital, McGill University, Montreal, Quebec.

Professor Mark S. Wrighton of the Department of Chemistry is studying the structure and reactivity of short-lived, photogenerated species, including electronic excited species and their electron transfer products from bimolecular quenching processes. The key spectroscopic technique employed, transient Raman spectroscopy, is used to obtain vibrational spectroscopic data for species generated by a 20 ns laser pulse. Systems under investigation include [(CH₃CN)Re(CO)₃(2,2'-bipyridine)]⁺, the derivatives of which may give unidirectional, excited-state electron transfer as in the primary step of natural plant photosynthesis.

Professor Menachem Gutman from Tel Aviv University, a visiting scholar in the Department of Chemistry, and Dr. Mark Levy, a researcher from Professor W.H. Orme-Johnson's group in the Chemistry Department, have investigated the degree of hydration of enzyme-bound, metal-ATP complexes. The number of water molecules associated with Eu³⁺-ATP complex when bound within the active site of hexokinase and chloroplast reversible ATPase were estimated by changes in the fluorescent lifetimes of the hydrated rare earth metal. The results were found to be consistent with previously known mechanistic and structural considerations for the two enzymes.

Professor Stephen J. Lippard of the Department of Chemistry has continued his studies of the resonance Raman spectra of complexes containing a μ -oxo- μ -bis(acetato)diiron core. These complexes appear to be

excellent models for the bimetallic center in the marine invertebrate oxygen-carrying protein, hemerythrin, and the related diiron core of ribonucleotide reductase. The peak in the excitation profile of one of the model complexes clearly shifts with a change in solvent, although the visible spectrum appears unchanged. Studies of a model with a different "capping" ligand have shown that the major features in the visible and vibrational spectra, and in the excitation profile, are most likely due to the triply bridged $\text{Fe}_2\text{O}(\text{O}_2\text{CR})_2$ core.

Professors Lippard and Richard R. Schrock of the Department of Chemistry, together with Drs. Irene Feinstein-Jaffe and Dani Gibson, have investigated application of Raman spectroscopy to the characterization of W(VI) oxo-alkyl complexes formed as hydrolysis products of W(VI) alkylidyne ($\text{W}=\text{CR}$) precursors. In particular, Raman and infrared spectroscopic assignments of infrared and Raman active bands of the W(VI) dimer, $\text{W}_2\text{O}_3\text{Np}_6$, possessing a rather unique structure having a linear $\text{O}=\text{W}-\text{O}=\text{W}=\text{O}$ backbone, have facilitated the complete characterization of this interesting molecule. This compound, as well as other similar W(VI) oxo alkyl complexes, may represent homogeneous analogues of catalytically active heterogeneous systems of early transition metals.

Professor Robert Field and Dr. Steven Rice, both of the Department of Chemistry, and Professor Colan Linton of the University of New Brunswick, Canada are studying high resolution spectroscopy of diatomic molecules. Studies include Doppler-free spectroscopy of metastable CaO , sub-Doppler Zeeman spectroscopy of CeO , and selectively-detected fluorescence spectroscopy of DyO , EuO , HoO , YbO and LaF . The rare earth experiments have demonstrated the power of Ligand Field Theory to predict and relate disparate electronic structural properties of most diatomic molecules.

Professors Field and James Kinsey and Dr. George Scherer, both of the Department of Chemistry, and Dr. Maurice Lombardi of Universite Scientifique et Medicale de Grenoble, have been conducting stimulated emission pumping studies of the acetylene electronic ground state and Zeeman and Stark quantum-beat studies of excited singlet-triplet interactions. This has resulted in an unprecedentedly complete characterization of the low energy portion of the acetylene ground state potential surface and, at higher energy, to the first evidence for the existence of "quantum chaos". The quantum-beat experiments are yielding information about the dissociation energy of acetylene and about the barrier to isomerization of triplet acetylene to vinylidene.

In addition, Professors Field and Kinsey are collaborating with Professor Richard Redington of Texas Technical University on stimulated emission pumping studies of H-atom tunneling in the molecule tropolone. This is the first attempt to record stimulated emission pumping spectra of molecules cooled rotationally in a supersonic jet. The purpose of the study is to determine the effect of various types of vibrations on the barrier to H-atom tunneling.

Professor Steinfeld and his colleagues have set up a coherent anti-Stokes Raman spectroscopy (CARS) apparatus. The second harmonic of a high-power Nd:YAG laser beam and a tunable dye laser beam, combined in the sample of interest, generate a CARS beam colinear with the two pump beams. A computer is used to retrieve the integrated intensity of the CARS signal, calibrate the frequency difference between the dye and second harmonic laser beams, and normalize for pulse variation in laser intensity. This apparatus is being used to measure decay kinetics of vibrational excitation in low-pressure gases. A CO_2 laser pulse populates excited vibrational states in small polyatomic molecules such as SF_6 , and the synchronized CARS measurement is used to probe population in various vibrational levels following the excitation pulse.

Professor Regis M. Pelloux of the Department of Materials Science and Engineering is employing a pulsed Nd:YAG laser to introduce small surface defects in nickel-base superalloy specimens to serve as initiation sites. Small size ($\sim 10 \mu\text{m}$) dictates the use of laser radiation. The objective of this research is to establish criteria for life prediction for critical jet engine components.

Dr. Larry Brown and Professor Robert Langer, both of the Department of Nutrition and Food Science, have been developing polymer-based controlled release systems for the long term delivery of macromolecules. In these systems constant release rates are achieved when an ethylene acetate copolymer/drug matrix is coated with an impermeable layer of the polymer. A 100 to 500 μm aperture is drilled through the polymer coating, restricting drug release through this opening. An Nd:YAG laser is being used to drill these apertures in a more reproducible fashion.

Professors Irwin Pless and Elizabeth Hafen and Dr. Padmanabhan Haridas, all of the Department of Physics, and Professor Stephen Benton of the Department of Architecture, continue their work in bubble chamber holography by recording holograms with targets at wide angles. A resolution of 30 μm at wide angles was obtained. This required an object beam four times more intense than for small angles. Holograms recorded on film and plates with targets immersed in a liquid to simulate a bubble chamber are currently being examined. Improved resolution and diffraction efficiency by effectively enlarging the dimensions of the recording area by means of conical mirrors is now being studied.

Professor Feld and Drs. Dasari and John Thomas, of the Spectroscopy Laboratory, continue their research

on laser-induced nuclear orientation, i.e. the laser optical pumping of atoms with unstable nuclei in a vapor cell. Frequency resolved laser-induced gamma ray anisotropy has been achieved and used to measure the D1 hyperfine structure of $1 \mu\text{s}$ $^{85\text{m}}\text{Rb}$ atoms. The experiment was performed in a sealed cell containing radioactive ^{85}Kr and natural Rb. The nuclear magnetic dipole moment and the isomer shift relative to ^{85}Rb have been measured. Aspects of this work have been done in collaboration with Dr. Daniel Murnick of AT&T Bell Laboratories, and Professors Charles Holbrow of Colgate University and William W. Quivers, Jr. of Wellesley College.

Professor Feld and Drs. Thomas and Dasari have developed a high resolution infrared double resonance spectrometer with a CO_2 laser pump and a tunable diode laser probe. This apparatus has been used in cw and transient modes to study energy storage and transfer processes in CH_3F . Velocity conserving J-changing collisions, up to $\Delta J=6$, vibrational exchange collisions which populate the manifold of K states, and vibrational decay have all been studied.

Professor Feld and Dr. Thomas are studying velocity changing collisions of quantum superposition states in ^{174}Yb by means of sensitive velocity selective photon echo techniques which permit measurement of both classical and wave mechanical features of superposition state kernels. The goal of the program is to investigate the general quantum transport properties of anisotropic moments in vapors, and to understand the relationships with superposition state scattering. In these experiments it has been possible, for the first time, to directly invert photon echo data by Fourier transform techniques to obtain the velocity changing collision kernel for an optical radiator. In addition, a new type of "multipole" photon echo technique has been developed which studies the collisional evolution of a pure multipole moment of the ^{174}Yb $^3\text{P}_1$ state.

Professor Feld and Dr. Thomas are investigating transverse effects in the superfluorescence (SF) of a sample of excited rubidium atoms using dye laser excitation. Coherent ringing has been observed in Rb SF pulses at $2.7 \mu\text{m}$ by using an iris to restrict the light reaching the detector to a small zone from the center of the SF sample. This experiment clarifies the outstanding discrepancy between SF theory and experiment, and demonstrates the transverse coherence properties of SF pulses.

Professor Feld and Dr. Carter Kittrell of the Spectroscopy Laboratory, Dr. Barry Sachs of Leonard Morse Hospital, Drs. John Kramer, Floyd Loop, Burr Ratliff and Ross Garrity of Cleveland Clinic and Ron Ehmsen and Edward Malk of American Hospital Supply Corporation are developing a system for treating atherosclerosis using laser light. *In vitro* tissue removal of both plaque and healthy tissue in wet and dry fields has been demonstrated using cw argon and krypton ion laser light delivered through an optical fiber. Plasma breakdown caused by 10 ns Nd:YAG laser pulses are also found to effectively remove tissue, although the mechanism is different. A dynamic model of the laser-tissue removal process is being developed. A multiple fiber array provides selective tissue removal. Spectral fluorescence indicates that healthy tissue can be distinguished from plaque, providing a suitable diagnostic to permit removal only of diseased tissue.

MICHAEL S. FELD

Laboratory for Nuclear Science

The Laboratory for Nuclear Science (LNS) provides support for research by faculty and research staff members primarily in the fields of basic nuclear and elementary particle physics, including the activities of the Center for Theoretical Physics in these fields. LNS also supports some projects involving application to other fields of experimental techniques developed through its primary activities. In addition, it provides a computing facility for its program. The primary experimental programs are in three areas: the largest effort is in intermediate energy nuclear physics, centered at the Bates Linear Accelerator Center in Middleton, Massachusetts. The second area is high energy physics, with major projects at Fermi National Accelerator Laboratory (FNAL) in Batavia, Illinois; at the European Center for Nuclear Research (CERN) in Geneva, Switzerland; at the Stanford Linear Accelerator Center (SLAC) in Palo Alto, California; and at the German Electron Synchrotron Laboratory (DESY) in Hamburg, Germany. The third field is heavy ion physics with activities at Brookhaven National Laboratory (BNL) and Oak Ridge National Laboratory (ORNL).

Intermediate Energy Nuclear Physics

The principal activity in this field is centered at the Bates Linear Accelerator Center, which functions under the direction of Professor Ernest J. Moniz. This accelerator has become the national facility for intermediate energy electro-nuclear physics, where a major experimental program to study the properties of the atomic nucleus, using intermediate energy electrons and photons to generate a wide variety of reactions, is underway. MIT faculty and Bates staff physicists, and 125 user physicists (111 domestic, 14 foreign) from 37 other universities and laboratories in the US, Canada, Japan, and Europe, are presently engaged as initiators or collaborators in active experiments. Twenty-eight MIT graduate students were associated during the past year with the intermediate energy nuclear physics programs.

The Bates intermediate energy program continues to center about electron scattering experiments using the very high precision energy-loss spectrometer. This unique spectrometer facility is being utilized to address a variety of fundamental questions in the structure of atomic nuclei, including the shape and collective motions of heavy deformed nuclei, the electromagnetic structure of few-body systems, and the role of mesons in determining the short-range structure of nuclei. Many of these experiments have been made possible by the increase in the maximum beam energy to 750 MeV by beam recirculation. The maximum energy is now being increased to 850 MeV, with a further increase to 1 GeV anticipated next year.

A major program of studies characterized by large energy transfer to the nucleus is underway in the second experimental hall. This program, involving the electromagnetic production of pions and/or the emission of energetic nucleons, has been made possible by the completion of three large-acceptance magnetic spectrometers and a π^0 spectrometer. These studies address issues associated with the fundamental understanding of nuclear reactions and of the nuclear force.

A polarized electron source, built in collaboration with Yale University physicists, is under construction at Bates. This will be used first in a unique test of the unified theory of electromagnetic and weak interactions and subsequently in a variety of nuclear studies. Longer range plans for the laboratory center on construction of a pulse stretcher ring to provide continuous electron beams. Building upon previous developments, this upgrade will provide important new research opportunities through intermediate energy coincidence studies.

Complementary to the Bates experiments are investigations by the MIT group at other accelerator facilities. A program of studies of pion-induced reactions, such as charge-exchange and absorption, continues at the Los Alamos Meson Physics Facility. These experiments, as well as the photo-pion studies at Bates, are important to obtain a good understanding of pion-nucleus interactions. Other investigations at Los Alamos, at the Indiana University Cyclotron Facility, and at Bates have been crucial for making efficient use of the complementary nature of nuclear probes.

Another group in intermediate energy nuclear physics is collaborating with physicists at Brookhaven National Laboratory in a study of hypernuclei using a separated K meson beam in order to investigate the binding of Λ and Σ particles in nuclear matter. Data have been obtained which have allowed detailed comparisons with nuclear model calculations. This group is also exploring jointly with physicists at Bell Laboratories the feasibility of constructing a detector which would measure both the flux and spectrum of low energy solar neutrinos.

Experimental High Energy Physics

The Electromagnetic Interactions (EMI) Group is engaged in two efforts in experimental high energy physics: one at the highest existing electron-positron colliding beam accelerator, PETRA, in Hamburg, Germany, and the other at the newly approved 240 GeV electron-positron accelerator, LEP, in Geneva, to be operating in 1990.

The work at PETRA: After its discovery of gluons, this group has concentrated on the study of the properties of gluons to increasingly high orders of accuracy. Of particular importance is the group's recent work on the determination of the second order coupling constant between gluons and quarks, showing that the general theory of strong interactions between quarks and gluons is understood. In addition, they have shown that the expected sixth quark, known as the top quark, is much heavier than previously expected. Their measurement of direct muon production has yielded a much better understanding of the ways in which different quarks transform themselves into ordinary subatomic particles. The group plans to continue to take data to search for new types of electrons and new, heavier quarks.

The work at LEP: The group is leading a large construction effort, which involves 350 Ph.D. physicists from 12 nations, to build a large, accurate detector to measure photons, electrons, and muons precisely. The experiment is the first large-scale collaboration between physicists from the Soviet Union, the People's Republic of China, and the United States. The construction of this experiment is proceeding according to schedule and will be ready for data-taking by the end of 1988. The purpose of this experiment is to understand the origin of the masses of elementary particles.

The Accelerator Physics Collaboration (APC) Group is conducting experimental research on the nature and interactions of photons, hadrons and neutrinos. The experiments are performed at two of the country's National Accelerator Laboratories: The Stanford Linear Accelerator in California and the Fermi National Accelerator Laboratory (FNAL) in Illinois. In the Stanford experiment, the goal is to see how photons, which are massless vector quanta of the electromagnetic force, change into vector mesons, which are massive quanta of the nuclear force. Since one of the vector mesons which the photon can change into is the D meson containing a charmed quark, these charmed mesons are being studied intensively.

An experiment at FNAL, completed two years ago, was designed to study how hadrons made up of one set of quarks generate hadrons with other types of quarks or other combinations of the same type of quarks. For this study, a unique device was developed that identifies each particle produced. The device, called CRISIS, worked well and should give information never previously available. The data from this experiment are currently being analyzed.

A future experiment has been approved for running at FNAL in 1985, apparatus for which is being designed and built now. The goal of the experiment is to search for a hitherto undiscovered particle, the tau neutrino. Proof or denial of its existence will have major theoretical consequences. This experiment will use a new technique being developed explicitly for it, the holographic photography of a bubble chamber. The technique will provide a factor of ten improvement in resolution over conventional bubble chamber pictures. All of these experiments are being done in collaboration with a consortium of universities in Japan, China, Israel, Italy, France and the United States.

The Counter Spark Chamber (CSC) Group in a collaborative effort has constructed a major new detector for high energy neutrinos at FNAL. The initial experimental program for this apparatus is the detailed study of the weak neutral currents predicted on the basis of the electro-weak theory and discovered experimentally several years ago. The first experimental run was carried out to study the nucleon structure functions associated with the neutral weak current. This detector, consisting of 350 tons of instrumented target material followed by a muon spectrometer, will be used for a continuation of these studies when the FNAL Tevatron comes into operation. The group is also collaborating in the construction of a high energy muon scattering facility at Fermilab which will be used to study nucleon structure as well as the dynamics of quark jets in nuclear matter.

In the past year the group has undertaken a major role in the new detector development for the Stanford Linear Collider (SLC) which is under construction at SLAC. SLC will be a " Z^0 factory" operating at and above the mass of the newly discovered intermediate boson, the Z^0 . The CSC group has undertaken a construction responsibility for this new detector, viz, the construction of the warm iron hadron calorimeter.

Also, under a Department of Energy (DOE) Junior Investigator Award, one member of the group is participating in an experiment at SLAC to search for anomalous single photons in electron-positron annihilation.

Heavy Ion

Heavy ion physics is the study of nuclear structure and reaction mechanisms using beams of energetic heavy ions. Heavy ion reactions are particularly well suited for the study of the properties of nuclei at high angular momentum and high excitation with the added feature of enabling the investigation of these properties for nuclear species far removed from the stable nuclei found in nature. The LNS Heavy Ion Group has designed and constructed recoil mass separators, at both the Brookhaven National Laboratory and the Oak Ridge National Laboratory, which have helped advance the investigations of these reactions.

The recent approval of the program to inject the Alternating Gradient Synchrotron (AGS) Accelerator at BNL with heavy ions will enable for the first time the study of heavy-ion reactions with energies up to 15 GeV per nucleon. This is a completely new energy regime for heavy ion reactions and hopefully will yield observations of a new state of matter - a quark-gluon plasma. The LNS group is presently working on a

proposal for the first round of experiments for the AGS and is actively pursuing this new domain of heavy ion reactions. The group has recently made measurements of proton-nucleus collisions at the AGS in order to obtain necessary background data for relativistic heavy ion collisions.

Applications of Nuclear Techniques

The Medical Imaging group has continued its collaboration with similar groups from Brigham and Women's Hospital (BWH), Harvard Medical School (HMS), and Massachusetts General Hospital (MGH) in the development of new clinical instruments. A prototype positron emission tomography (PET) system is under test at BWH and a larger unit for cardiac imaging is under construction at MIT. As part of this project new reconstruction algorithms for three dimensional imaging have also been developed, which may have application outside of medical imaging. In conjunction with this same group at BWH a gas scintillation camera for cardiac imaging has also been developed which is presently under test at MIT. The present unit has improved energy resolution compared to present instruments and should result in increased reliability in cardiac diagnostic procedures. Work is continuing on a device for measurement of bone loss associated with osteoporosis.

Another group, in collaboration with Professor Alexander Rich of the Biology Department, has developed an X-ray diffraction facility for protein crystallography based on a wire drift chamber detector originally developed at CERN. Initial crystallographic studies are now in progress.

Also, LNS, through its high energy program, is partially supporting the efforts of a group who are developing cryogenic techniques of producing polarized protons for use in targets, jets and sources. In collaboration with a group at Brookhaven, a design is being undertaken of a cold jet of nuclear polarized atomic hydrogen for use in the AGS. At MIT the production of solid nuclear polarized molecular hydrogen is being studied.

Particle Theory

It is presently believed that the particles which are at the basis of all matter are quarks and leptons, which interact with one another through gauge fields. There is currently a gauge field theory of the strong interactions called "quantum chromodynamics" or QCD and another, the Weinberg-Salam-Glashow theory, that unifies the electromagnetic and weak interactions. Both of these theories, which agree with experiment insofar as they have been tested, and gauge theories, in general, are being investigated by the particle theorists. Studies are also being made of "grand unified theories" which attempt to unify weak, electromagnetic, and strong interaction gauge theories, as well as other speculative theories which attempt to encompass them.

One topic in QCD which is of much current interest and which was studied in the Particle Theory Group this past year, is the proposal that the most stable form of nuclear matter is not the matter present in the atomic nucleus, but a new form called "strange" matter, which is composed of relatively equal numbers of up, down and strange quarks. Other dynamical questions in QCD, which is a topic of lasting interest in this group, have also been studied.

Investigations have also been extended in the areas of (1) non-perturbative structure in field theories, especially those related to topological properties; (2) models of particles and interactions, including supersymmetric theories; and (3) a new theory of cosmogenesis, "the inflationary universe," based on grand unification models and leading to detailed calculations of the properties and development of the very early universe.

Nuclear Theory

The nuclear theory group has addressed a wide range of problems, including the interaction of nuclei with mesonic and electromagnetic probes, the structure of nuclei spanning the periodic table, and heavy ion reactions from below the Coulomb barrier to relativistic energies. The role of nucleon internal degrees of freedom in nuclear structure and dynamics had been a central theme.

A substantial theoretical effort directed at a microscopic understanding of nuclear static and transition densities has been motivated by the high precision electron scattering experiments performed at the Bates Accelerator Center. Significant progress was made in nuclear many-body theory and the time dependent theory of nuclear dynamics. These investigations, many of them based on the mean field functional integral approach, have improved our understanding of collective phenomena and have been used to describe spontaneous and induced fission.

A study of nucleon-nucleon forces that incorporates excited hadron degrees of freedom at long range and quark degrees of freedom at short range indicates that the first six quark resonances should be observable with present or planned intermediate energy accelerators. It also shows the importance of excited nucleon states for static deuteron properties such as the magnetic moment. The study is now being extended to determine the effects of the quark and of excited nucleon components on the deuteron structure at medium and high momentum transfers.

Meson-nucleus interactions are being studied in terms of isobar-nucleon hole collective doorway states, with a complex isobar-nucleus interaction potential playing a central role. The microscopic basis of the model has been elucidated and associated predictions have been tested against data.

A continuing program of inter-relating semi-leptonic weak and electromagnetic interactions in nuclear phenomena is being pursued.

Summary of Support

Participants in the various research programs during the past year amounted to approximately 430 people. This includes 54 academic staff members, 91 graduate students, and at least 46 undergraduates from MIT and other institutions. The latter were involved in senior theses, Undergraduate Research Opportunities Programs (UROP), work-study, and similar programs. There were 76 research staff members with Ph.D.'s, including visitors and guests, and 162 employees in supporting categories such as engineers, technicians, machinists, computing and administrative personnel. At least sixteen Ph.D.'s, three M.S.'s, and four B.S.'s were awarded based on thesis research withing LNS.

Support during fiscal year 1984 from the contract with the US Department of Energy (DOE) is expected to total \$19,069,000. This represents an increase of about 11 percent over the preceding year. This sum breaks down as follows: operations costs (salaries, wages, materials, services, travel, and overhead) were \$13,855,000; of this \$4,520,000 was for experimental and theoretical high energy physics, \$7,695,000 was for intermediate nuclear energy physics for the support of the Bates Linac facility and research program both at Bates and elsewhere, and \$1,640,000 was for nuclear structure theory, hypernuclei, and heavy ion experiments. Equipment costs are expected to total \$4,364,000; of this, \$3,299,000 will be for high energy physics and \$1,065,000 for medium energy and heavy ion physics. A total of \$850,000 will be expended for accelerator improvement, energy conservation, general plant, and construction projects associated with the Bates Linear Accelerator Center. Support for relatively new Laboratory programs relating to the problems totaled some \$28,000. Support for other programs within LNS, including support from other institutions and laboratories for collaborative work undertaken directly by LNS, is expected to total about \$40,000.

ARTHUR K. KERMAN

McGraw-Hill Observatory

The McGraw-Hill Observatory, established in 1975, is located on Kitt Peak near Tucson, Arizona. The 1.3m telescope and the other facilities of the observatory are shared by observers from the University of Michigan, Dartmouth College, and MIT. In January 1985 a major new telescope of 2.4m aperture is scheduled to go into operation at the observatory. The telescope, without optics, is presently housed in its completed building on the mountain; the primary and secondary mirrors are scheduled to arrive there shortly. The start-up of operations will be especially timely -- it will precede the launch of Space Telescope by more than a year. The 2.4m telescope will provide opportunities for frontier research in astronomy and for the development of advanced instrumentation. MIT observers will be entitled to one-third of the available time on the 2.4m and the 1.3m telescopes. During the 1983-1984 academic year, MIT observers made 40 trips to the observatory; half of these trips were made by students. The focal-plane instrument used by most MIT observers continues to be the CCD spectrometer/camera built by Dr. George R. Ricker and his collaborators.

The past year's research includes the following: In the X-ray astronomy group, Professor Claude R. Canizares and John Kruper have continued to study active galaxies and quasars detected by the Einstein X-ray Observatory satellite, and have also discovered several X-ray selected clusters of galaxies. Professor Canizares and John Culver have searched for optical filaments in galaxies located in clusters, and have thereby set limits on the rate at which galaxies accrete matter from the intracluster medium. For the third consecutive observing season, Dr. Jeffrey E. McClintock and Ronald Remillard have observed the quiescent X-ray nova A0620-00. Their findings on this neutron-star binary, including the discovery of a 7.8-hour period, allowed them to compete successfully for large telescope time. They will make spectroscopic observations of this 19th magnitude system with the Kitt Peak 4m telescope in January 1985. Professor George W. Clark and Peter Vedder have continued to obtain CCD images of elliptical galaxies in a search for possible isophotal twisting, and for faint peculiar jets and ripples. They have thus far imaged 20 galaxies including Hercules A, which has a known radio and X-ray jet structure. Professor Hale V. D. Bradt and Ronald Remillard continue to search for the optical counterparts of X-ray sources detected by the A-3 Experiment on the HEAO-1 satellite. During the past year, at the McGraw-Hill Observatory and elsewhere, about 25 X-ray sources were optically identified with Seyfert Galaxies, quasars, BL Lacertae objects, cataclysmic variables and Be stars. Dr. George R. Ricker has been involved in several projects. With Professor Saul A. Rappaport and Thomas Loredó, he searched for pulsed optical emission from radio and X-ray pulsars using a new stroboscopic technique in which an image of a star field is scanned across a CCD detector at a frequency equal to the pulse frequency. Unpulsed objects appear as smeared images whereas a pulsar will appear as a point. A series of observations with the 1.3m telescope followed by observations on the Kitt Peak 4m telescope have yielded important upper limits on the optical brightness of a newly discovered class of fast pulsars, the "millisecond" radio pulsars. With Dr. Bradley E. Schaefer, Dr. Ricker has searched for the optical counterparts of gamma-ray burst sources to a limit of 23rd magnitude. Several faint stars have been detected in the fields of three of the burst sources, but none of them are convincing candidates. Dr. Ricker and Roland Vanderspek are in the process of analyzing data on the nuclei of Seyfert galaxies in a search for rapid optical variability. Such variability has been reported at X-ray wavelengths on timescales as short as about one minute.

In Professor James L. Elliot's planetary astronomy group, James Klavetter and Samuel Conner observed a stellar occultation by Saturn's rings by modifying the MIT CCD Camera to obtain short, three-second exposures. If the signal-to-noise ratio of their data proves sufficient, they can study the structure of the rings at a spatial resolution of 50 km -- substantially better than with other Earth-based techniques. Professor Edward W. Dunham and Samuel Conner completed their photometric observations of the Saturnian satellite Hyperion. Their observations are consistent with a 13 to 14 day rotation period, suggesting a 2:3 resonance with Hyperion's 21 day orbital period. It is thought, however, that neither the rotation period nor the pole orientation is stable; Hyperion should be tumbling and further observations are required. Professor David C. Jewitt and Ronald Remillard have taken continuum spectra of distant comets which they hope will constrain the properties of the primitive cometary dust grains. It appears, for example, that cometary dust grains are significantly larger than the dust particles of the interstellar medium. Dr. Linda M. French obtained spectra of the asteroid 1219 Britta, which is a prime candidate for a flyby by the Galileo spacecraft, and she also obtained spectra of Chiron, an object in orbit between Saturn and Uranus. During IAP, Dr. French and two undergraduates made photometric observations of stars which will soon be occulted by Saturn and Uranus.

In Professor Bernard F. Burke's radio astronomy group, work continues on a search for faint optical counterparts of radio sources from the MIT 5 GHz survey. Dr. Charles R. Lawrence (MIT Ph.D. thesis 1983) has devised a system of classification of the rich and varied radio structure of these sources, and

Jacqueline Hewitt and others are investigating the correlation of optical properties with this classification. A small number of gravitational lens candidates are among these sources, and direct imaging with the McGraw-Hill telescope is a first step in identifying any gravitational lenses. Professor Lennox L. Cowie and Dr. Antoinette Songaila-Cowie, currently at the Space Telescope Science Institute, obtained imaging data on gas in X-ray luminous cluster cores in the light of $H\alpha$ and other emission lines. They also made broad band color measurements of bright central (cD) galaxies. Professor David C. Jewitt, in collaboration with Dr. George R. Ricker, obtained 0.8 - 1.1 micron optical spectra of several planetary nebulae. This understudied region of the optical spectrum contains unexpected lines from neutral carbon. These lines come from regions of the nebulae which are shielded from the ionizing radiation of the central star.

JEFFREY E. MCCLINTOCK

George R. Wallace, Jr., Astrophysical Observatory

The George R. Wallace, Jr., Astrophysical Observatory is a teaching and research observatory located in Westford, Massachusetts. Its facilities consist of a 24-inch reflecting telescope, a 16-inch reflecting telescope, several 8- and 14-inch reflecting telescopes, and a small building that houses a workshop, darkroom, computer, and observers' quarters.

This year several improvements were made to the Observatory facilities. Corbin Covault and Karl Horita (both in the Class of 1985) constructed a grating spectrograph, which can be used with either of our larger telescopes. Michael Ressler (Class of 1986) has completed a computer-based data recording system for use with the photometers on our smaller telescopes. Also, a sliding-roof building that can house four small telescopes was constructed. This latter addition will allow us to accommodate larger astronomy classes, greatly improving the teaching capabilities of the Observatory.

Professor William Pinson's astronomy classes 12.113 and 12.114 had several sessions at the Observatory, and the observing seminar 12S23, conducted by Dr. Linda French, made extensive use of the Observatory during both the fall and spring terms. Students in the observational laboratory course, (8.237J-12.117J), taught by Professor James Elliot and Dr. French, conducted a variety of photometric, photographic, and spectroscopic projects during the fall. Throughout the year, several Undergraduate Research Opportunities Program (UROP) projects involving photometry of variable stars were carried out. A senior thesis for the Department of Physics, based on four-color photometry of the Scuti star AD Canis Minoris, was completed by David Martin (Class of 1984) under the supervision of Professor Pinson.

The Observatory's Independent Activities Period (IAP) activities included a three-week visit to major astronomical facilities in Arizona for eight undergraduates. Highlights for this activity -- jointly sponsored by the Department of Earth, Atmospheric, and Planetary Sciences and led by Professor Elliot and Dr. French -- included an observing run at MIT's McGraw-Hill Observatory and participation by the students in ongoing research projects at the Lowell Observatory in Flagstaff, Arizona, where most of the time was spent. The results of these research projects included the discovery of an asteroid by one of the participants, Joseph Wagner (Class of 1986). The asteroid has been designated number 3045 by the Minor Planet Center, and as the discoverer, Mr. Wagner has been given the opportunity of naming it.

This spring, Professor David Jewitt and Karen Meech began photometric programs involving the central stars of planetary nebulae and short period variables.

JAMES L. ELLIOT

Dean of the Graduate School

The Annual Report of the Dean of the Graduate School appears in two parts. The first is a set of separate narrative reports by the Dean and his two Associate Deans. The second is a set of tables of statistical information for the Graduate School. These are presented in formats similar to those used in past years in order to facilitate comparisons over time.

DEAN OF THE GRADUATE SCHOOL

Considerable attention was devoted in last year's report to a proposed change in policy regarding the way in which the tuition of graduate research assistants is charged to contracts. In the past, tuition had been included as a direct charge to MIT sponsored research contracts and had, therefore, been included in the salary paid to research assistants. Starting on June 1, 1983, the tuition for both research and teaching assistants was incorporated into our employee benefit pool. Major reasons for this change were to make the cost of research assistants more competitive with the cost of nonstudent research associates and postdoctoral employees, and to reduce the level of direct charges to MIT sponsored research contracts thereby making some projects more cost competitive with similar projects at other schools. It was anticipated that this change in policy would, in the long run, result in greater financial support for graduate research assistants and, therefore, an increase in graduate enrollments.

We have now completed one full year under the new policy. Transition to and implementation of the new system proceeded remarkably well from an administrative point of view. Thanks to the prescient planning efforts of the then Dean, Kenneth R. Wadleigh, and an ad hoc group which he chaired, most potential problems had been identified in advance and incorporated into the operational aspects of the new policy. Aside from relatively minor details relating to the timing of appointments, the disposition of external tuition sources for students with combined fellowships and part-time assistantships, and a number of special cases, the only major problem arose from a failure of some departments to anticipate fully the negative impacts of a larger than usual increase in the employee benefit pool and the extension of employee benefit charges to almost all categories of student employees.

In the case of the College Work Study Program (CWSP) allocation for graduate students--an allocation administered by the Graduate School Office--the impact was particularly severe and unanticipated. To deal with this problem, a special additional allocation from Institute funds was made available to all departments for one year only. Starting on September 1, 1984, that allocation will be terminated, and the CWSP allocation will also be subject to the new employee benefit rate without supplementation. The net effect, of course, is a reduction in the numbers of graduate students that can be supported with a fixed CWSP allocation.

Of special interest is the impact of the new policy for charging tuition of graduate assistants to the employee benefit pool on the graduate enrollment. Recall from last year's report that the total enrollment of regular graduate students had just experienced its first decline in many years. From the fall of 1981 to the fall of 1982, that enrollment had dropped from 4,541 to 4,489, a decline of 52 students. This decline followed a ten-year period in which there had been uninterrupted growth at an average rate of more than three percent per year. The enrollment drop was attributed at that time in large part to the drop in real-dollar levels of research funding which had been experienced in the two preceding years.

The past year saw a return to the familiar pattern of growth in graduate enrollments with the fall 1983 figure of 4,631 regular graduate students representing an increase of 142 students, or 3.2 percent, over the 1982 figure. Is that increase a direct result of the new tuition policy for graduate assistants? Although it is too early to answer that question with certainty, the answer is probably, "No." The major portions of the increase (from both a percentage and an absolute sense) occurred in the School of Engineering and in the Sloan School of Management. In Engineering the graduate enrollment increase can be attributed to recent increases in the real-dollar levels of research funding. In the Sloan School the increase resulted from a planned expansion of their Master's degree programs in which graduate assistants are not a factor. In the School of Science, where the increased use of nonstudent research associates and postdoctoral employees was perceived to be most seriously in competition with graduate assistants, graduate enrollment actually declined for the second year in a row (from 1,098 to 1,079, a drop of 19 students, or 1.7%). Even there, it is difficult to separate out the effects of the new policy from those of funding levels and undergraduate interests. The experience of a second year may afford some clarification.

A related issue which captured the attentions of the Dean and the Committee on Graduate School Policy (CGSP) is that of the relative size of the graduate and undergraduate enrollments. In 1960 the ratio of graduate to undergraduate enrollment, G/U, was less than 70 percent and growing rapidly. In the mid-1960's and early 1970's, the ratio stabilized at around 85 percent. Departmental quotas on graduate enrollments were

eliminated in 1973, and shortly thereafter the ratio began to increase until in the fall of 1981 it exceeded unity for the first time ($G = 4,541$, $U = 4,502$; $G/U = 1.01$). With last year's graduate enrollment decline, the ratio dropped to 0.98. In the fall of 1983, it rose again to its highest value yet, 1.02, and is expected to be even higher in the next year.

Thus, we appear to have entered an era in which the graduate enrollment at MIT may always exceed the undergraduate enrollment. The CGSP took note of this development and concluded that, although there is no special significance to the condition, $G/U = 1.0$, the issue of relative enrollments should be watched carefully. The Graduate School Office, in conjunction with the Undergraduate Academic Support Office, has begun to assemble data from which to prepare a statement of the issues which are involved.

On the national scene there have been two developments of particular interest to the Graduate School. First was the publication of the final report of the Graduate Education Subcommittee of the National Commission on Student Financial Assistance, entitled "Signs of Trouble and Erosion: A Report on Graduate Education in America." This report, which has come to be known as the Brademas Report, after the Subcommittee Chairman, Dr. John Brademas, President of New York University, focused national attention on the importance of graduate education and research; and has been instrumental in alerting the Congress, the President, and, to some extent, the general public to many of the problems confronting graduate education. The report defines an agenda for Federal action which includes continued and expanded Federal support for graduate education.

The second national development of special interest to the Graduate School is the set of Congressional initiatives taken at least in partial response to the Brademas Report. In the United States House of Representatives, Representative Paul Simon (D-Illinois) introduced legislation, as part of the re-authorization of the Higher Education Act of 1965, which was specifically designed to expand support for graduate schools, graduate students, and young faculty. Although not successful in the current session, it is expected that similar legislation will be considered in the coming year. Similarly, Senator John C. Danforth (R-Missouri) and others sponsored a bill, S.1537, "The University Research Capacity Restoration Act of 1983," which would have increased Federal funding by about \$1 billion annually over a five-year period for six Federal agencies that provide 95 percent of Federal support for university basic science and engineering research. These and other Congressional initiatives demonstrate the importance of bringing issues of graduate student education and support to national attention.

Let me turn now to activities of the CGSP other than those previously mentioned. The CGSP carried out its academic performance review function at the end of each term by reviewing grades, issuing academic warnings where appropriate, and terminating the registration of several students whose performance was unsatisfactory. In these reviews an attempt was made to work towards a greater degree of uniformity and consistency among the 21 graduate departments. The CGSP also reviewed and recommended candidates for advanced degrees.

The CGSP completed an important task which had been started in the preceding year; viz., development of a policy for graduate students who must discontinue registration because of serious illness. The resulting policy statement, which was adopted by the CGSP and which will appear in future editions of the Graduate School Manual, provides for a special category of continued but limited affiliation with the Institute for graduate students in cases of serious medical condition. Eligibility for this status is determined by the Dean of the Graduate School with the advice of a special committee. Individuals on this special status will not be charged tuition but will be responsible for paying the Student Health Fee and the costs of hospitalization insurance for which they will be eligible. Adoption of this new policy eliminates a potential source of uncertainty which had created a number of difficult problems in previous years.

The CGSP evaluated and recommended adoption of a proposal for a Master of Science Degree in Real Estate Development to be offered by departments in the School of Architecture and Planning. The new degree was subsequently voted on favorably by the faculty and approved by the Executive Committee of the Corporation. Establishment of the new degree was part of a larger effort in the School of Architecture and Planning to establish a Center for Real Estate Development and a program of research in that field.

The CGSP also reviewed the Management of Technology Program, a joint undertaking of the Sloan School of Management and the School of Engineering, which was in its third year of a three-year trial. This review led the CGSP unanimously to approve continuation of the program on a regular basis with no further review by the CGSP.

Leaders of the Graduate Student Council (GSC) met with the CGSP to consider proposed changes in the way in which the Bursar's Office bills and collects nontuition fees (e.g., housing and dining fees) from some graduate students. The GSC offered a counterproposal in which essentially all graduate students with nontuition fees in excess of \$150 per term would be able to pay their bills in equal installments on a monthly basis without a finance charge. This counterproposal was based on the observation that graduate students typically receive stipend payments on a monthly basis and that some, but not all, graduate housing billing is already on a monthly basis. The CGSP adopted a motion in support of the GSC position, and later the Dean met with the Bursar and others to effect a one-year extension of current policy which is essentially consistent with the GSC proposal.

The CGSP reviewed the status of foreign language requirements in the doctoral program of all graduate departments. This review was initiated in response to a decision of the Foreign Languages and Literature Section to eliminate their intensive reading subjects which have often been used in the past by students to prepare for the doctoral language examination. This review showed that of the 21 graduate departments only five have retained a language requirement for the doctorate, and only three expect to be seriously impacted by the disappearance of the intensive reading subjects. As of the date of this report, mechanisms for dealing with this issue in the seriously impacted departments have not been established.

A portion of CGSP meetings was also devoted to general discussion of other issues on which no formal actions were required. These included a review of the several programs in the Harvard-MIT Division of Health Sciences and Technology (HST), the MIT English Evaluation Test (EET) which is mandatory for all incoming graduate students whose language of instruction in elementary and secondary schools was not English, and Graduate School criteria for graduation.

I and my colleagues in the Graduate School Office wish to express our thanks and appreciation to the members of CGSP for their service the past year. A special note of thanks goes to Professor Warren M. Rohsenow who completed 24 years of service as the representative of the Department of Mechanical Engineering. Others terminating their service this year and their replacements are:

Chemistry

Professor Glenn A. Berchtold to Professor Dietmar Seyferth

Linguistics and Philosophy

Professor Morris Halle to Professor Sylvain Bromberger

Mechanical Engineering

Professor Warren M. Rohsenow to Professor Ain A. Sonin

Political Science

Professor Myron Weiner to Professor Harvey M. Sapolsky.

Professors Bromberger, Sapolsky, and Seyferth are all former CGSP representatives.

FRANK E. PERKINS

GRADUATE WOMEN

The fall of 1983 saw the enrollment of women graduate degree candidates reach its highest percentage of the total graduate population--20 percent. Although the actual number of first-time enrolled women decreased from 267 to 258, their proportion remained at 20 percent. However, the increased number of continuing women students from 589 to 656 resulted in a 20 percent proportion of the total as compared with 19 percent in the fall of 1982. The total graduate student enrollment increased from 4,489 to 4,631, or 3 percent. This is a slightly higher increase than the national figures of 1.4 percent, and is not consistent with a slight decline of 0.9 percent in graduate enrollments at private Ph.D. institutions (Tables VII and VIII).

Nationally, figures indicate that the total enrollment of women in graduate schools showed little change (46 percent in 1982 to 47 percent in 1983). However, since MIT's graduate student population is concentrated in science and engineering it is not surprising that our graduate women do not reflect the national picture. If we take the national numbers (33 percent) for science and engineering only, however, MIT's percentage of women is more comparable.

In another anomalous comparison, the number of applicants increased 3.8 percent nationwide, while MIT's figures (Table IX) show an overall decrease of 4 percent (-1 percent for women; -4 percent for men). A large increase in the number of women applicants (+18 percent) in Engineering is encouraging, while a 16 percent decrease in Architecture and Planning is not surprising. The number of women applying to departments in the School of Science also increased 3 percent, while 7 percent fewer men applied. The Sloan School of Management showed an equal decrease of 10 percent in both male and female applicants.

Although women represented 20 percent of the total graduate enrollment, they received only 18 percent of the graduate degrees. This represents 19 percent of the Master's degrees and 15 percent of the doctoral degrees (Table X). In comparing enrollment totals with women degree recipients by schools, interesting variations are noted in Table XI. A further breakdown of the number of graduate degrees awarded to women by school over a ten-year period is indicated in Table XII. The number of Master's degrees awarded to women over this period has shown a steady increase with a dramatic 400 percent increase in the School of Engineering. At the doctoral level, however, an all-time high in the number of women recipients in 1982-1983 (71) sharply decreased this year to 61. As a matter of fact, the patterns for women doctoral recipients does not reflect their increasing numbers in the total

graduate population and varies greatly by department and school. Several women's groups at MIT are currently reviewing the academic environment for graduate women at MIT in an effort to determine whether women are encouraged to pursue doctoral work, or whether there are other reasons for the seemingly slower rate of increase of women doctoral candidates.

FINANCIAL AID

A constant and growing concern during recent years has been with financial support for graduate students. Tuition (as well as the cost of living) continues to rise. Women as well as men graduate students are affected. However, it is encouraging to note that more women are competing successfully in national fellowship competitions such as Hertz and the National Science Foundation (NSF). At MIT in 1983-84, 3 of 40 Hertz Fellows were women, while 22 percent (32/148) of the NSF Fellows were female. Although the total number of women who receive these awards is not equal to the number of men, it is partially due to the fact that women are still in the minority in the fields of study represented by these awards. We hope that as more women are encouraged to participate in traditionally male-dominated areas so will their proportion of the awards.

On the other hand, women pursuing graduate study at MIT are supported not only as Research Assistants and Teaching Assistants in growing numbers by their respective departments, but increasingly are being sponsored by industrial fellowships such as Hughes, Bell Labs Fellowships (for employees), IBM, Shell, and Chevron. Also, one of the five prestigious EXXON Teaching Fellowships at MIT is held by a woman. The few national scholarships programs specifically for women graduate students are also well represented at MIT, including American Association of University Women Dissertation Fellowships, Graduate Research Program for Women sponsored by the Bell Laboratories, Xerox Special Opportunities Fellowship Program, and the IBM Fellowship Program for Women and Minorities.

MIT's only financial aid program primarily for women--the Ida M. Green Fellowships--has recently selected five additional women who will be entering graduate programs this fall. This brings to 79 the number of women graduate students so honored. Many have completed their degree programs at MIT and have earned 17 doctoral degrees, 27 Master's degrees (including three Master of Architecture and two Master of City Planning degrees), and one Engineer's degree. Most are now pursuing lucrative careers in industry, academia, and government with a few who left MIT with Master's degrees continuing their graduate study at other universities. These women are representative of the truly outstanding caliber of women who attend MIT, and most of MIT's 21 graduate departments are represented by at least one Ida Green Fellow. Therefore, it is important that we continue to encourage an even larger number of women to matriculate in our graduate school by making sure financial, as well as academic, support is available to them.

JEANNE E. RICHARD

MINORITY GRADUATE STUDENT AFFAIRS

While other graduate institutions all across the country have been experiencing a steady decline in the number of minority graduate students enrolled in their institutions over the past few years, MIT witnessed a slight increase of 4.3 percent (see Table XIV) in its minority graduate student enrollment for the fall term 1983. The increase can be attributed primarily to the popularity and ongoing recruitment programs in engineering. Minority graduate student enrollment in the School of Engineering increased from 55 students in 1982 to 62 in 1983, a 13 percent increase (see Table XIII). This is the largest number of minority graduate students in the School of Engineering that we have ever had at the Institute.

We recruited minority graduate students in engineering from the six predominantly black engineering schools (Howard, North Carolina A&T, Prairie View A&M, Southern, Tennessee State, and Tuskegee). Other sources of students come from the University of Puerto Rico; MIT's Lincoln Laboratory Summer Program for Black Scientists and Engineers; participants in the National Consortium for Graduate Degrees for Minorities in Engineering; the U.S. Department of Education's Graduate and Professional Opportunities Program; the National Name Exchange Program involving 22 prestigious graduate schools; ETS' Minority Locator Service; and through several faculty members, graduate students, and administrators' recruitment trips to targeted undergraduate schools around the country. Trips were augmented with mass mailings, telephone calls, and a few campus visits by promising, prospective graduate students.

The above recruitment activities were conducted by Associate Dean John B. Turner out of the Graduate School Office in an attempt to supplement recruitment, admission, and financial aid activities and responsibilities of the 21 graduate departments at the Institute. We received a total of 170 applications from underrepresented minority group students. The academic departments admitted 73 of the 170 applicants, and

49 students actually enrolled as new minority graduate students for the fall term of 1983 (see Table XV), an increase of four percent over 1982.

During the course of the 1983-1984 academic year, the Graduate School Office sponsored a number of activities to help ease the transition of minority students from undergraduate school to graduate school and the adaptation to a new environment. Some of the activities were:

- Minority Graduate Student Orientation Program
- Weekend Retreat to Talbot House in Vermont
- Semiformal Dance and Cabaret (Ebony Affair)
- Informal Discussion Sessions on Contemporary Topics
- Distinguished Minority Guest Lecture Series
- Social Get-Togethers
- Annual Cookout at Dean Turner's Home
- Minority Awards Day Program
- Publication of the Minority Graduate Student Guide, 1983-1984
- Soul Food Sale
- Monthly Meetings of the Black Graduate Student Association
- Student Participation in Various Professional Meetings and Seminars
- Reception for Black Faculty and Staff
- Reception for the 1983-1984 Graduates and Their Parents.

Minority graduate students received a total of 51 advanced degrees for 1983-1984 with the following distribution: 40 Master's, 4 Engineer's, and 7 Doctor's degrees (see Table XVI). There was a slight decline in the number of advanced degrees awarded to minority graduate students for 1983-1984 versus the previous year. Numbers here usually fluctuate from one year to the next, depending on the progress of the students' rate of completion of their theses. Students seem to be making satisfactory progress toward their degrees much like majority students.

We had a good year in 1983-1984 with regard to minority graduate student affairs. The Graduate School Office will continue to work closely with the academic departments in helping to make MIT's goal of attracting and graduating more and more minority graduate students a true success story.

JOHN B. TURNER

TABLE I

For simple comparison with data for 1982-83, the following statistical information for 1983-84 is presented in the same format. Numbers in parentheses indicate the change from 1982-83 to 1983-84.

REGULAR GRADUATE STUDENT ENROLLMENT - FALL TERM 1983

| | Foreign ⁽¹⁾ | Women ⁽²⁾ | Minority ⁽³⁾ | Total | Non-Residents ⁽⁴⁾ |
|---|------------------------|----------------------|-------------------------|--------------------|------------------------------|
| School of Architecture and Planning | 125 (-21) | 171 (+19) | 35 (0) | 426 (+12) | 46 (+ 7) |
| School of Engineering | 775 (+13) | 240 (+22) | 60 (+4) | 2204 (+98) | 13 (- 3) |
| School of Humanities and Social Science | 95 (+ 2) | 96 (- 7) | 14 (+1) | 385 (+14) | 65 (+14) |
| Sloan School of Management | 151 (+25) | 129 (+15) | 7 (-5) | 507 (+26) | 12 (+ 6) |
| School of Science | 289 (+ 7) | 274 (+ 9) | 26 (-2) | 1079 (-19) | 23 (- 5) |
| Health Sciences and Technology | 4 (- 5) | 3 (- 1) | 1 (0) | 27 (+ 8) | 0 |
| Health Policy and Management | 0 | 1 (+ 1) | 0 | 3 (+ 3) | 0 |
| TOTAL | 1439 (+21) | 914 (+58) | 143 (-2) | 4631 (+142) | 159 (+19) |

(1) Includes Canadians

(2) See also Table IX

(3) Includes Black Americans, Puerto Ricans, Mexican Americans, and American Indians

(4) Included in Totals

TABLE II

GRADUATE DEGREES AWARDED - 1983-84

| Advanced Degrees Conferred | M.C.P., M.Arch., M.Arch. A.S. | S.M. | Engineer | Sc.D. | Ph.D. | Total |
|-------------------------------|----------------------------------|-------------------|-----------------|-----------------|------------------|-------------------|
| September 1983 | 7 (- 9) | 154 (-52) | 13 (+ 3) | 8 (- 6) | 79 (-10) | 266 (-73) |
| Woods Hole | | | 0 (0) | 2 (+ 2) | 3 (- 1) | |
| February 1984 | 11 (+ 3) | 255 (+18) | 21 (+ 8) | 15 (- 5) | 123 (+ 4) | 430 (+27) |
| Woods Hole | | | 0 (0) | 0 (- 2) | 5 (+ 1) | |
| June 1984 | 57 (+ 8) | 603 (- 5) | 38 (- 5) | 21 (+ 3) | 156 (-3) | 878 (-3) |
| Woods Hole | | | 0 (- 1) | 1 (0) | 2 (0) | |
| Total | 75 (+ 2) | 1012 (-39) | 72 (+ 5) | 47 (- 8) | 368 (- 9) | 1574 (-49) |

Numbers in parentheses indicate change from 1982-83.

TABLE III

DOCTORAL DEGREES AWARDED EACH YEAR BY SCHOOL AND CITIZENSHIP

Each number is the total of the doctoral degrees awarded in September, February, and June of the academic year indicated. The numbers in parentheses are the number of degrees awarded divided by the corresponding regular graduate student enrollment.

| Academic Year | | Arch. | Eng'g. | Hum. and Soc. Sci. | Sloan | Science | HST | Total |
|---------------|---------|-----------------|------------------|--------------------|------------------|------------------|-----------------|-------------------|
| 1974-75 | Citizen | 7 (.037) | 104 (.095) | 31 (.143) | 10 (.040) | 110 (.146) | | 262 (.105) |
| | Foreign | <u>2</u> (.033) | <u>56</u> (.107) | <u>10</u> (.154) | <u>8</u> (.080) | <u>24</u> (.110) | | <u>100</u> (.103) |
| | Total | 9 | 160 | 41 | 18 | 134 | | 362 |
| 1975-76 | Citizen | 1 (.005) | 83 (.073) | 49 (.232) | 12 (.055) | 126 (.162) | | 271 (.106) |
| | Foreign | <u>1</u> (.019) | <u>67</u> (.114) | <u>7</u> (.119) | <u>2</u> (.017) | <u>42</u> (.180) | | <u>119</u> (.113) |
| | Total | 2 | 150 | 56 | 14 | 168 | | 390 |
| 1976-77 | Citizen | 6 (.026) | 79 (.068) | 33 (.155) | 2 (.007) | 125 (.156) | | 245 (.090) |
| | Foreign | <u>4</u> (.071) | <u>64</u> (.106) | <u>19</u> (.264) | <u>1</u> (.010) | <u>46</u> (.199) | | <u>134</u> (.126) |
| | Total | 10 | 143 | 52 | 3 | 171 | | 379 |
| 1977-78 | Citizen | 5 (.023) | 111 (.096) | 50 (.240) | 8 (.029) | 119 (.146) | | 293 (.110) |
| | Foreign | <u>3</u> (.039) | <u>66</u> (.103) | <u>13</u> (.169) | <u>15</u> (.139) | <u>35</u> (.141) | | <u>132</u> (.115) |
| | Total | 8 | 177 | 63 | 23 | 154 | | 425 |
| 1978-79 | Citizen | 10 (.041) | 80 (.066) | 35 (.164) | 10 (.035) | 126 (.151) | | 261 (.093) |
| | Foreign | <u>3</u> (.033) | <u>64</u> (.101) | <u>11</u> (.130) | <u>9</u> (.088) | <u>33</u> (.142) | | <u>120</u> (.105) |
| | Total | 13 | 144 | 46 | 19 | 159 | | 381 |
| 1979-80 | Citizen | 8 (.031) | 96 (.074) | 40 (.156) | 5 (.017) | 127 (.153) | | 276 (.094) |
| | Foreign | <u>3</u> (.034) | <u>66</u> (.096) | <u>11</u> (.109) | <u>3</u> (.029) | <u>28</u> (.115) | | <u>111</u> (.091) |
| | Total | 11 | 162 | 51 | 8 | 155 | | 387 |
| 1980-81 | Citizen | 12 (.044) | 88 (.065) | 40 (.178) | 7 (.022) | 118 (.138) | | 265 (.088) |
| | Foreign | <u>7</u> (.078) | <u>75</u> (.103) | <u>12</u> (.153) | <u>2</u> (.020) | <u>35</u> (.130) | | <u>131</u> (.104) |
| | Total | 19 | 163 | 52 | 9 | 153 | | 396 |
| 1981-82 | Citizen | 7 (.023) | 94 (.066) | 35 (.128) | 4 (.012) | 124 (.148) | | 264 (.083) |
| | Foreign | <u>2</u> (.017) | <u>75</u> (.104) | <u>21</u> (.223) | <u>6</u> (.050) | <u>35</u> (.123) | | <u>139</u> (.103) |
| | Total | 9 | 169 | 56 | 10 | 159 | | 403 |
| 1982-83 | Citizen | 6 (.026) | 93 (.070) | 43 (.189) | 11 (.031) | 126 (.160) | 1 (.100) | 280 (.096) |
| | Foreign | <u>4</u> (.027) | <u>78</u> (.102) | <u>14</u> (.150) | <u>2</u> (.016) | <u>52</u> (.184) | <u>2</u> (.222) | <u>152</u> (.107) |
| | Total | 10 | 171 | 57 | 13 | 178 | 3 | 432 |
| 1983-84 | Citizen | 9 (.035) | 92 (.065) | 41 (.182) | 12 (.035) | 115 (.150) | 3 (.130) | 272 (.089) |
| | Foreign | <u>5</u> (.040) | <u>76</u> (.098) | <u>16</u> (.168) | <u>9</u> (.059) | <u>37</u> (.128) | <u>0</u> | <u>143</u> (.099) |
| | Total | 14 | 168 | 57 | 21 | 152 | 3 | 415 |

TABLE IV

A "SNAPSHOT" OF GRADUATE STUDENT SUPPORT "FULL AWARDS"

FALL TERM 1983

The following sources provided at least full tuition support for graduate students during the fall term 1983. Total regular graduate student enrollment, not including Non-Residents, was 4,472.

| | <u>Numbers of Students</u> | <u>Percent of Total Enrollment</u> | <u>Change from 81-82</u> |
|--|------------------------------------|--|----------------------------------|
| FELLOWSHIPS AND TRAINEESHIPS AWARDED BY MIT | | | |
| NIH and NIMH Traineeships | 104 | | - 9 |
| HEW Graduate and Professional Opportunities Program Fellowships | 5 | | + 5 |
| MIT Endowed and Other Fund Fellowships | 188 | | +13 |
| Industrial and Foundation Fellowships | <u>209</u> | | <u>+26</u> |
| | 506 | 11% | +35 |
| FELLOWSHIPS AWARDED BY SPONSORS TO MIT STUDENTS | | | |
| NSF Graduate Fellowships | 148 | | - 8 |
| NIMH Fellowships | 4 | | + 1 |
| Hertz Fellowships | 27 | | - 4 |
| ONR Fellowships | <u>8</u> | | <u>+ 3</u> |
| | 187 | 4% | - 8 |
| STUDENT ASSISTANTSHIPS | | | |
| Research Assistants | 1376 | | +86 |
| Teaching Assistants | 389 | | -32 |
| Instructor G | <u>13</u> | | <u>+ 7</u> |
| | 1778 | 40% | +61 |
| SPONSORED STUDENTS | | | |
| Many students receive support from employers and sponsors. The following reflect Student Accounts billing for tuition to employers and sponsors who presumably provide stipends to students by private arrangements: | | | |
| U.S. Government | 134 | | +30 |
| Foreign Countries and International Programs | 168 | | -66 |
| Industry and Foundation (U.S.) | <u>110</u> | | <u>-20</u> |
| | 412 | 9% | -56 |
| SUMMARY BY SOURCES - FULL AWARDS | | | |
| Federal Fellowships and Traineeships | 265 | 6% | -12 |
| Graduate Student Staff | 1778 | 40% | +61 |
| Industrial and Foundation Awards | 236 | 5% | +22 |
| MIT Endowed and Budgeted Funds | 188 | 4% | +13 |
| Students Sponsored by External Sources | <u>412</u> | <u>9%</u> | <u>-56</u> |
| | 2879 | 64% | +28 |

TABLE V

DISTRIBUTION OF FUNDING FOR GRADUATE STUDENT TUITION AND LIVING EXPENSES

FALL TERM 1983

Estimates of Required Funding

| | |
|--------------------------------------|-------------------|
| Tuition | 20,837,687 |
| Stipend (\$780/mo. for 4-1/2 months) | <u>16,080,372</u> |
| Total Estimated Required Funding | 36,918,059 |

Identified Support by Category

| | | |
|--|------------|---------|
| Research Assistantships | 11,832,922 | (32%) |
| Teaching Assistantships and Inst. G. | 3,966,331 | (10.7%) |
| Federal Fellowships and Traineeships | 2,042,621 | (5.5%) |
| General and Endowed Support (departmentally controlled) | 1,376,319 | (3.7%) |
| General and Endowed Support (Graduate School Office controlled) | 604,398 | (1.6%) |
| Outside Sources Administered by Departments | 1,315,205 | (3.5%) |
| Outside Sources Administered by Graduate School Office | 725,378 | (1.9%) |
| Outisde Sources, Direct Billing to Sponsor by Institute, Tuition Only | 1,918,584 | (5%) |
| Total Identified Support | 23,781,757 | (64%) |
| Loans | 3,948,191 | (10.5%) |

TABLE VI

TRENDS IN GRADUATE STUDENT SUPPORT
(\$000's)

| Academic Year | Fellowships Traineeships* Scholarships | Staff Tuition** Awards (TA & IG) | Staff Salaries (RA & TA) | Loans | |
|------------------|--|-------------------------------------|-----------------------------|--------------|----------------------------------|
| | | | | MIT Only | Including Outside Agencies |
| 1970-71 | 5,396 (.655) | 1,182 (.143) | 6,850 (.831) | 483 (.059) | 672 (.082) |
| 1971-72 | 5,076 (.589) | 1,294 (.150) | 7,086 (.823) | 696 (.080) | 827 (.096) |
| 1972-73 | 4,687 (.486) | 1,432 (.150) | 7,991 (.828) | 754 (.078) | 916 (.095) |
| 1973-74 | 3,930 (.378) | 1,453 (.140) | 8,781 (.844) | 852 (.082) | 1,014 (.097) |
| 1974-75 | 3,693 (.318) | 1,738 (.150) | 9,760 (.840) | 1,075 (.093) | 1,293 (.111) |
| 1975-76 | 3,447 (.259) | 1,878 (.141) | 10,878 (.816) | 1,141 (.086) | 1,407 (.106) |
| 1976-77 | 3,454 (.229) | 2,065 (.137) | 11,654 (.722) | 1,419 (.094) | 2,013 (.133) |
| 1977-78 | 3,418 (.205) | 1,978 (.118) | 12,479 (.750) | 1,391 (.084) | 2,201 (.132) |
| 1978-79 | 3,667 (.198) | 2,355 (.127) | 15,251 (.823) | 962 (.052) | 2,387 (.129) |
| 1979-80 | 3,733 (.172) | 3,079 (.142) | 16,610 (.766) | 976 (.045) | 3,575 (.165) |
| 1980-81 | 3,970 (.149) | 2,821 (.106) | 18,650 (.702) | 434 (.016) | 4,434 (.167) |
| 1981-82 | 4,194 (.128) | 3,362 (.102) | 21,258 (.648) | 662 (.020) | 5,412 (.165) |
| 1982-83 | 5,142 (.136) | 4,044 (.107) | 21,993 (.581) | 1,078 (.028) | 4,791 (.126) |
| 1983-84 | 5,561 (.130) | 19,094 (.445) | 12,671 (.295) | 1,602 (.037) | 4,576 (.106) |

* Administered by the Graduate School Office.

** Beginning with the academic year 1983-84, tuition awarded to Research Assistants is included under "Staff Tuition Awards".

To "normalize" these data, the total dollar values have been divided by the product (total regular graduate students registered for the fall term; tuition for the 9-month academic year).

TABLE VII

WOMEN GRADUATE STUDENT ENROLLMENT
Comparison of Fall Term Enrollments - 1982 & 1983

| | <u>Number of Women</u> | | <u>% of Women in Total Enrollment</u> | |
|---|------------------------|-------------|---------------------------------------|-------------|
| | <u>1982</u> | <u>1983</u> | <u>1982</u> | <u>1983</u> |
| <u>School of Architecture & Planning</u> | | | | |
| Architecture IV | 65 | 80 | 27% | 33% |
| Urban Studies & Planning XI | <u>87</u> | <u>91</u> | <u>49%</u> | <u>49%</u> |
| | 152 | 171 | 37% | 40% |
| <u>School of Engineering</u> | | | | |
| Aeronautics & Astronautics XVI | 11 | 14 | 6% | 7% |
| Chemical Engineering X | 35 | 32 | 17% | 15% |
| Civil Engineering I | 25 | 25 | 11% | 11% |
| Elec. Engineering & Comp. Science VI, A, W | 66 | 77 | 11.6% | 12.5% |
| Materials Science III, III-B, III-W | 36 | 43 | 17% | 18% |
| Mechanical Engineering II, II-T, II-W | 27 | 28 | 7% | 7% |
| Nuclear Engineering XXII | 12 | 13 | 7% | 8% |
| Ocean Engineering XIII, XIII-A, XIII-B | 6 | 6 | 3% | 3% |
| XIII-W | | <u>2</u> | | <u>22%</u> |
| | 218 | 240 | 10.4% | 11% |
| <u>School of Humanities & Social Sciences</u> | | | | |
| Economics XIV | 23 | 18 | 18% | 15% |
| Linguistics & Philosophy XXIV | 25 | 23 | 43% | 39% |
| Political Science XVII | 46 | 44 | 29% | 26% |
| Psychology IX | <u>9</u> | <u>11</u> | <u>33%</u> | <u>34%</u> |
| | 103 | 96 | 28% | 25% |
| <u>Sloan School of Management</u> | | | | |
| Management XV | 108 | 118 | 26% | 27% |
| XV-A (Fellows) | 5 | 8 | 9% | 14% |
| XV-B (Operations Research) | <u>1</u> | <u>3</u> | <u>17%</u> | <u>33%</u> |
| | 114 | 129 | 24% | 25% |
| <u>School of Science</u> | | | | |
| Biology VII | 39 | 45 | 29% | 34% |
| VII-W | 9 | 13 | 47% | 59% |
| Chemistry V | 50 | 49 | 25% | 28% |
| *Earth & Planetary Science XII | 16 | 22 | 19% | 17% |
| XII-W | 13 | 26 | 34% | 42% |
| Mathematics XVIII | 22 | 22 | 19% | 20% |
| Meteorology XIX | 6 | -- | 14% | -- |
| XIX-W | 7 | -- | 44% | -- |
| Nutrition & Food Science XX | 68 | 62 | 43% | 46% |
| Physics VIII | 34 | 35 | 11.5% | 12% |
| Interdisciplinary Science XXV | <u>1</u> | <u>--</u> | <u>50%</u> | <u>--</u> |
| | 265 | 274 | 24% | 25% |
| HST | 4 | 3 | 21% | 11% |
| HPM | -- | 1 | -- | 33% |
| TOTALS | 856 | 914** | 19% | 20% |

*1983 figures include former Crse XIX & XIX-W .

**Includes 58 non-resident.

TABLE VIII

WOMEN GRADUATE STUDENT ENROLLMENT
 (% of total 1973-83)

| <u>Fall Term</u> | <u>New</u> | | | <u>Continuing</u> | | | <u>Total</u> | | |
|------------------|--------------|--------------|-------------------|-------------------|--------------|-------------------|--------------|--------------|-------------------|
| | <u>Women</u> | <u>Total</u> | <u>% of Women</u> | <u>Women</u> | <u>Total</u> | <u>% of Women</u> | <u>Women</u> | <u>Total</u> | <u>% of Women</u> |
| 1973 | 105 | 1080 | 10% | 213 | 2278 | 9% | 318 | 3358 | 9% |
| 1974 | 140 | 1061 | 13% | 265 | 2407 | 11% | 405 | 3468 | 12% |
| 1975 | 175 | 1113 | 16% | 312 | 2490 | 12.5% | 487 | 3603 | 13.5% |
| 1976 | 185 | 1220 | 15% | 361 | 2554 | 14% | 546 | 3774 | 14% |
| 1977 | 192 | 1184 | 16% | 367 | 2640 | 14% | 559 | 3824 | 14.6% |
| 1978 | 218 | 1259 | 17% | 388 | 2685 | 14% | 606 | 3944 | 15.4% |
| 1979 | 193 | 1202 | 16% | 491 | 2944 | 16.6% | 684 | 4146 | 16.4% |
| 1980 | 254 | 1308 | 19% | 525 | 3076 | 17% | 779 | 4384 | 18% |
| 1981 | 243 | 1272 | 19% | 585 | 3269 | 18% | 828 | 4541 | 18% |
| 1982 | 267 | 1306 | 20% | 589 | 3183 | 19% | 856 | 4489 | 19% |
| 1983 | 258 | 1302 | 20% | 656 | 3329 | 20% | 914 | 4631 | 20% |

TABLE IX

COMPARISON OF ADMISSIONS STATISTICS FOR GRADUATE WOMEN AND GRADUATE MEN

Number of Applicants 1982/Number of Applicants 1983

Numbers in parentheses indicate the % change in number of applicants from 1982 to 1983.

| | <u>Women</u> | <u>Men</u> |
|---------------------------------------|------------------|------------------|
| School of Architecture & Planning | 310/260 (-16%) | 521/518 (N.C.) |
| School of Engineering | 293/345 (+18%) | 3136/3147 (N.C.) |
| School of Humanities & Social Science | 190/191 (N.C.) | 556/482 (-13%) |
| Sloan School of Management | 414/371 (-10%) | 1609/1452 (-10%) |
| School of Science | 424/437 (+ 3%) | 1343/1241 (- 7%) |
| HST | 5/8 | 35/38 |
| TOTALS | 1636/1612 (- 1%) | 7200/6878 (- 4%) |

TABLE X

COMPARISON, IN NUMBERS, OF DEGREES AWARDED TO MEN AND WOMEN
1973-74 to 1983-84

| | <u>Master's</u> | | | <u>Doctor's</u> | | | <u>Engineer's</u> | | | <u>All</u> | | |
|---------|-----------------|--------------|-------------------|-----------------|--------------|-------------------|-------------------|--------------|-------------------|--------------|--------------|-------------------|
| | <u>Women</u> | <u>Total</u> | <u>% of Women</u> | <u>Women</u> | <u>Total</u> | <u>% of Women</u> | <u>Women</u> | <u>Total</u> | <u>% of Women</u> | <u>Women</u> | <u>Total</u> | <u>% of Women</u> |
| 1973-74 | 58 | 832 | 7% | 34 | 378 | 9% | 3 | 102 | 3% | 92* | 1210* | 7.6%* |
| | | | | | | | | | | 95 | 1312 | 7% |
| 1974-75 | 80 | 856 | 9% | 32 | 362 | 9% | 0 | 107 | 0% | 112* | 1218* | 9%* |
| | | | | | | | | | | 112 | 1325 | 8.4% |
| 1975-76 | 93 | 862 | 11% | 33 | 390 | 8% | 2 | 94 | 2% | 126* | 1252* | 10%* |
| | | | | | | | | | | 128 | 1346 | 9.5% |
| 1976-77 | 145 | 971 | 15% | 50 | 379 | 13.2% | 2 | 91 | 2% | 195* | 1350* | 14.5%* |
| | | | | | | | | | | 197 | 1441 | 13.7% |
| 1977-78 | 135 | 934 | 14% | 48 | 425 | 11% | 5 | 108 | 5% | 183* | 1359* | 13.4%* |
| | | | | | | | | | | 188 | 1467 | 12.7% |
| 1978-79 | 145 | 968 | 15% | 29 | 387 | 7% | 2 | 65 | 3% | 174* | 1355* | 12.8%* |
| | | | | | | | | | | 176 | 1420 | 12.3% |
| 1979-80 | 156 | 984 | 16% | 47 | 386 | 12% | 3 | 77 | 4% | 203* | 1370* | 14.8%* |
| | | | | | | | | | | 206 | 1447 | 14% |
| 1980-81 | 184 | 1018 | 18% | 65 | 396 | 16% | 3 | 72 | 4% | 249* | 1414* | 17.6%* |
| | | | | | | | | | | 252 | 1486 | 16.9% |
| 1981-82 | 214 | 1118 | 19% | 49 | 403 | 12% | 5 | 64 | 8% | 263* | 1521* | 17.3%* |
| | | | | | | | | | | 268 | 1585 | 16.9% |
| 1982-83 | 198 | 1124 | 17.5% | 71 | 432 | 16.5% | 0 | 67 | 0% | 269* | 1556* | 17%* |
| | | | | | | | | | | 269 | 1623 | 16.5% |
| 1983-84 | 211 | 1084 | 19% | 61 | 415 | 15% | 9 | 73 | 12% | 272* | 1499* | 18%* |
| | | | | | | | | | | 281 | 1572 | 18% |

* Without Engineer's Degrees

TABLE XI

COMPARISON OF WOMEN ENROLLED WITH WOMEN DEGREE RECIPIENTS

| | <u>% of Women Enrolled</u> | <u>% of Degrees awarded to Women Master's</u> | <u>Doctoral</u> |
|-----------------------------|--------------------------------|---|-------------------|
| Architecture & Planning | 40% | 45% (50/121) | 14% (2/14) |
| Engineering | 11% | 12% (81/656) | 4% (7/166) |
| Humanities & Social Science | 25% | 9% (2/21) | 35% (20/57) |
| Sloan School of Management | 25% | 24.5% (55/221) | 19% (4/21) |
| Science | 25% | 35% (23/65) | 17% (28/154) |
| HST | 11% | | 0% (0/3) |
| <u>TOTAL</u> | 20% | 19% (211/1084) | 15% (61/157) |
| ALL DEGREES | | | 18% (272/1499) |

TABLE XII

DEGREES AWARDED TO WOMEN BY SCHOOL

| | 1974-75 | 1975-76 | 1976-77 | 1977-78 | 1978-79 | 1979-80 | 1980-81 | 1981-82 | 1982-83 | 1983-84 |
|---|---------|-----------|-----------|-----------|---------|-----------|-----------|-----------|-----------|----------|
| <u>Architecture & Planning</u> * | | | | | | | | | | |
| Master's | 23 | 23 | 34 | 23 | 33 | 41 | 48 | 51 | 48 | 50 |
| Doctor's | 2 | 0 | 2 | 4 | 3 | 5 | 6 | 2 | 6 | 2 |
| <u>Engineering</u> | | | | | | | | | | |
| Master's | 16 | 21 | 28 | 42 | 50 | 51 | 52 | 84 | 72 | 81 |
| Doctor's | 3 | 3 | 8 | 4 | 4 | 7 | 14 | 10 | 14 | 7 |
| <u>Humanities & Social Sciences</u> | | | | | | | | | | |
| Master's | 4 | 3 | 5 | 4 | 3 | 3 | 3 | 5 | 5 | 2 |
| Doctor's | 8 | 10 | 10 | 12 | 4 | 12 | 14 | 10 | 14 | 20 |
| <u>Sloan</u> | | | | | | | | | | |
| Master's | 21 | 26 | 46 | 40 | 45 | 34 | 49 | 47 | 47 | 54 |
| Doctor's | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 3 | 4 |
| <u>Science</u> | | | | | | | | | | |
| Master's | 16 | 19 | 32 | 25 | 14 | 27 | 21 | 25 | 25 | 23 |
| Doctor's | 19 | 19 | 28 | 23 | 18 | 20 | 26 | 23 | 29 | 25 |
| <u>Operations Research (XV-B)</u> | | | | | | | | | | |
| Master's | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 2 | 1 | 1 |
| Doctor's | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 1 | 0 |
| <u>WHOI</u> | | | | | | | | | | |
| Doctor's | 0 | 1 (VII-W) | 1 (VII-W) | 1 (VII-W) | 0 | 1 (VII-W) | 2 (XII-W) | 3 (XII-W) | 2 (XII-W) | 1 (VIIW) |
| | | | 1 (XII-W) | 1 (XII-W) | | 1 (XII-W) | 1 (XII-W) | 1 (XIX-W) | 1 (XIX-W) | 2 (XIIW) |
| <u>HST</u> | | | | | | | | | | |
| Doctor's | - | - | - | - | - | - | - | - | 1 | 0 |
| <u>TOTALS</u> | | | | | | | | | | |
| Master's | 80 | 93 | 145 | 135 | 145 | 156 | 184 | 214 | 198 | 211 |
| Doctor's | 32 | 33 | 50 | 48 | 29 | 47 | 65 | 49 | 71 | 61 |

* M.ARCH., MCP, SM

TABLE XIII

TOTAL AND MINORITY REGULAR GRADUATE ENROLLMENT

FALL 1983

| | <u>BA</u> | <u>PR</u> | <u>MA</u> | <u>AI</u> | <u>TOTAL MINORITY GRADUATE STUDENTS</u> | <u>TOTAL GRADUATE STUDENTS</u> | <u>% of TOTAL</u> |
|--|-----------|-----------|-----------|-----------|---|--|-----------------------|
| <u>ARCHITECTURE & PLANNING</u> | | | | | | | |
| Architecture (IV) | 9 (2) | 1 (1) | 1 | | 11 (3) | 242 | 4.5% |
| Urban Studies & Planning (XI) | 16 (6) | 2 (1) | 5 (2) | 1 | 24 (9) | 184 | 13.0% |
| Totals | 25 (8) | 3 (2) | 6 (2) | 1 | 35 (12) | 426 | 8.2% |
| <u>ENGINEERING</u> | | | | | | | |
| Aeronautics & Astronautics (XVI) | 5 (4) | 2 | | | 7 (4) | 187 | 3.7% |
| Chemical Engineering (X) | 8 (2) | | 1 | | 9 (2) | 208 | 4.3% |
| Civil Engineering (I,I-W) | 1 (1) | | 1 (1) | | 2 (2) | 227 | .8% |
| Electrical Engineering & Computer Science (VI) | 19 (5) | 6 (3) | 2 (1) | | 27 (9) | 614 | 4.3% |
| Materials Science & Engineering (III) | 1 (1) | 2 (1) | | | 3 (2) | 241 | 1.0% |
| Mechanical Engineering (II,II-T,II-W) | 6 (3) | 4 (1) | 2 | | 12 (4) | 379 | 3.1% |
| Nuclear Engineering (XXII) | 1 | | 1 | | 2 | 166 | 1.2% |
| Ocean Engineering (XIII, XIII-W, XIII-A, XIII-B) | | | | | | 182 | |
| Totals | 41 (16) | 14 (5) | 7 (2) | | 62 (23) | 2204 | 2.8% |
| <u>SLOAN SCHOOL OF MANAGEMENT</u> | | | | | | | |
| | 5 (1) | | 1 (1) | 1 (1) | 7 (3) | 507 | 1.3% |
| <u>HUMANITIES & SOCIAL SCIENCE</u> | | | | | | | |
| Economics (XIV) | 4 (2) | 1 | 1 | 1 | 7 (2) | 127 | 5.5% |
| Philosophy & Linguistics (XXIV) | | 1 (1) | | | 1 (1) | 59 | 1.6% |
| Political Science (XVII) | 4 (2) | | 1 | 1 | 6 (2) | 167 | 3.5% |
| Psychology | | | | | | 32 | |
| Totals | 8 (4) | 2 (1) | 2 | 2 | 14 (5) | 385 | 3.6% |
| <u>SCIENCE</u> | | | | | | | |
| Biology (VVI,VVI-W) | 3 | 1 | | | 4 | 164 | 2.4% |
| Chemistry (V) | 3 | | 1 | | 4 | 198 | 2.0% |
| Earth, Atmospheric & Planetary Sciences (XII, XII-W) | | | | | | 188 | |
| Mathematics (XVIII) | 1 | | 2 | | 3 | 112 | 2.6% |
| Nutrition & Food Science | 4 (1) | | | | 4 (1) | 135 | 2.9% |
| Physics (VIII) | 9 (4) | 2 (1) | 1 | | 12 (5) | 292 | 4.1% |
| Totals | 20 (5) | 3 (1) | 4 | | 27 (6) | 1079 | 2.5% |
| GRAND TOTALS | 99 (34) | 22 (9) | 20 (5) | 4 (1) | 145 (49) | 4631 | 3.1% |
| TOTALS % OF MINORITIES | 2.13% | .47% | .43% | .08% | 3.1% | | |

() = New Students

BA = Black Americans, PR = Puerto Ricans, MA = Mexican Americans, AI = American Indians.

TABLE XIV

Trends in Minority Graduate Enrollment at MIT*

| | <u>Minority Graduate Enrollment</u> | | | | | | | | | |
|------------------------------|-------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------------|-------------|
| | <u>1974</u> | <u>1975</u> | <u>1976</u> | <u>1977</u> | <u>1978</u> | <u>1979</u> | <u>1980</u> | <u>1981</u> | <u>1982</u> | <u>1983</u> |
| <u>SCHOOL</u> | | | | | | | | | | |
| Architecture & Planning | 41 | 50 | 59 | 44 | 46 | 45 | 57 | 41 | 31 | 35 |
| Engineering | 38 | 38 | 44 | 40 | 44 | 47 | 58 | 55 | 55 | 62 |
| Management | 10 | 9 | 17 | 20 | 13 | 9 | 16 | 10 | 12 | 7 |
| Humanities & Social Sciences | 34 | 30 | 27 | 21 | 16 | 9 | 15 | 9 | 12 | 14 |
| Science | <u>28</u> | <u>28</u> | <u>31</u> | <u>32</u> | <u>28</u> | <u>34</u> | <u>25</u> | <u>25</u> | <u>28</u> | <u>27</u> |
| Total Minority Enrollment | 151 | 155 | 178 | 157 | 147 | 144 | 171 | 140 | 139 ⁺ | 145 |
| Total Graduate Enrollment* | 3,468 | 3,603 | 3,744 | 3,824 | 3,944 | 4,146 | 4,327 | 4,435 | 4,349 | 4,631 |

| | <u>Black Graduate Enrollment</u> | | | | | | | | | |
|------------------------------|----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-----------------|-------------|
| | <u>1974</u> | <u>1975</u> | <u>1976</u> | <u>1977</u> | <u>1978</u> | <u>1979</u> | <u>1980</u> | <u>1981</u> | <u>1982</u> | <u>1983</u> |
| <u>SCHOOL</u> | | | | | | | | | | |
| Architecture & Planning | 34 | 39 | 45 | 34 | 32 | 34 | 40 | 30 | 23 | 25 |
| Engineering | 26 | 25 | 25 | 25 | 33 | 33 | 37 | 35 | 34 | 41 |
| Management | 10 | 8 | 13 | 17 | 12 | 8 | 16 | 10 | 12 | 5 |
| Humanities & Social Sciences | 31 | 26 | 23 | 17 | 14 | 9 | 12 | 5 | 5 | 8 |
| Science | <u>22</u> | <u>21</u> | <u>24</u> | <u>21</u> | <u>20</u> | <u>20</u> | <u>16</u> | <u>17</u> | <u>18</u> | <u>20</u> |
| Total Black Enrollment | 123 | 119 | 130 | 114 | 111 | 104 | 121 | 97 | 93 ⁺ | 99 |

⁺ Totals include one black graduate student registered in the HST Program.

* Does not include Special or Non-Resident Graduate Student Enrollment.

TABLE XV

MINORITY APPLICANTS, ADMITTED AND ENROLLED

1982-83 vs. 1983-84

| | <u>1982-83</u> | | | <u>1983-84</u> | | |
|--|----------------|----------|----------|----------------|----------|----------|
| | Applicants | Admitted | Enrolled | Applicants | Admitted | Enrolled |
| <u>Architecture & Planning</u> | | | | | | |
| Architecture | 13 | 5 | 4 | 10 | 3 | 3 |
| Urban Studies and Planning | 49 | 19 | 9 | 20 | 9 | 9 |
| Subtotal | 62 | 24 | 13 | 30 | 12 | 12 |
| <u>Engineering</u> | | | | | | |
| Aeronautics and Astronautics | 1 | 1 | 1 | 6 | 4 | 4 |
| Chemical Engineering | 8 | 3 | 3 | 7 | 2 | 2 |
| Civil Engineering | 3 | 2 | 0 | 3 | 2 | 2 |
| Electrical Engineering and Computer Science | 34 | 13 | 7 | 39 | 12 | 9 |
| Materials Science and Engineering | 3 | 2 | 1 | 2 | 2 | 2 |
| Mechanical Engineering | 19 | 13 | 5 | 5 | 4 | 4 |
| Nuclear Engineering | 1 | 1 | 1 | 1 | 0 | 0 |
| Ocean Engineering | 1 | 1 | 1 | 0 | 0 | 0 |
| Subtotal | 70 | 36 | 19 | 63 | 26 | 23 |
| <u>Sloan School of Management</u> | 63 | 17 | 3 | 43 | 19 | 3 |
| <u>Humanities and Social Sciences</u> | | | | | | |
| Economics | 11 | 4 | 3 | 11 | 2 | 2 |
| Linguistics and Philosophy | 2 | 1 | 0 | 1 | 1 | 1 |
| Political Science | 7 | 4 | 2 | 4 | 3 | 2 |
| Psychology | 2 | 0 | 0 | 1 | 0 | 0 |
| Subtotal | 22 | 9 | 5 | 17 | 6 | 5 |
| <u>Science</u> | | | | | | |
| Biology | 2 | 2 | 2 | 1 | 1 | 0 |
| Chemistry | 8 | 3 | 0 | 3 | 1 | 0 |
| Earth, Atmospheric and Planetary Sciences | 2 | 0 | 0 | 3 | 1 | 0 |
| Mathematics | 1 | 1 | 1 | 0 | 0 | 0 |
| Nutrition and Food Science | 3 | 3 | 2 | 2 | 1 | 1 |
| Physics | 10 | 6 | 2 | 8 | 6 | 5 |
| Subtotal | 26 | 15 | 7 | 17 | 10 | 6 |
| <u>GRAND TOTAL</u> | 243 | 101 | 47 | 170 | 73 | 49 |

TABLE XVI

Minority Graduate Degree Recipients1983-84

(September, February, June Degree Lists)

| | <u>Black</u> | <u>Hispanic*</u> | <u>NA</u> | <u>Total</u> |
|------------|--------------|------------------|-----------|--------------|
| Master's | 24 | 16 | 0 | 40 |
| Engineer's | 3 | 1 | 0 | 4 |
| Doctor's | <u>4</u> | <u>3</u> | <u>0</u> | <u>7</u> |
| Total | 31 | 20 | 0 | 51 |

| Degree List | <u>Master's</u> | | | <u>Engineer's</u> | | | <u>Doctor's</u> | | | <u>Total</u> |
|-------------|-----------------|----------|----------|-------------------|----------|----------|-----------------|----------|----------|--------------|
| | B | HS* | NA | B | HS* | NA | B | HS* | NA | |
| September | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 3 |
| February | 8 | 6 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 16 |
| June | <u>16</u> | <u>9</u> | <u>0</u> | <u>2</u> | <u>0</u> | <u>0</u> | <u>4</u> | <u>1</u> | <u>0</u> | <u>32</u> |
| Total | 24 | 16 | 0 | 3 | 1 | 0 | 4 | 3 | 0 | 51 |

B = Black Americans

*HS = Hispanic (Mexican American and Puerto Rican)

NA = Native American

Vice President in the Office of the President

In this preface of the departmental reports in my areas of responsibility, I would like to comment briefly on the results of our efforts to reduce costs; on the planning agenda; and, more significantly, on people and leadership.

As this report is written, our colleagues in the financial administration are putting the final touches on the closing of the books for the Fiscal Year 1983-84. Instead of the small budget deficit we had expected, this year will close with a relatively modest surplus.

The fact that we finished the year in the black is a very important piece of news. To be sure, the dollar swing from expected deficit to realized surplus (about \$1.5 million) is a relatively small difference between two very large numbers: The total operating expenses and the total operating revenues (about \$650 million). Seen another way, \$1.5 million is a very significant sum in that it represents about one-fifth of the annual flow of unrestricted funds, the only money over which MIT has complete discretionary control.

But beyond its dollar value, this year's outcome is a gratifying signal for MIT people throughout the campus. Over the past two years we took draconian measures to control costs, and we made extraordinary efforts -- and sacrifices -- to achieve a community-wide retrenchment program that has been very painful indeed.

Two years ago, 124 individuals across MIT received layoff notices; and, by last summer, no more than one-third of them had secured other employment at MIT. In the year just ended, the corresponding number of layoffs was 66, and the proportion of those who could find other jobs on campus was less than one-fourth. In fact, the total number of layoffs in both years masks a larger number of jobs that were eliminated by attrition. The current FY 1984-85 is the last in our three-year program of planned budget reductions in the administrative and support areas across MIT.

I said last year in my annual report that we faced a serious morale problem. Members of the support and administrative staffs feel pushed to do more with less, in a community whose standards of service are always very high and at a time when the demand for services to people is growing, in part because of the retrenchment program.

Against this background of tension and concern, we can say this summer, with some confidence, that the decisions and the actions we embarked upon two years ago have borne fruit. Our cost-cutting efforts are paying off. On behalf of MIT, we must express gratitude to all of the people responsible for a job well done. In my areas of responsibility, I especially wish to thank each one of the managers who worked individually and together to meet budget reduction targets. More importantly, I wish to thank them for providing the leadership in this difficult time to uphold and even to increase our commitment to delivering services of the highest quality to the campus community.

The road ahead for universities continues to be rocky and uphill. But our confidence is bolstered, our hold on the agenda is more firm, and our view of our priorities is clearer and realistic.

The focus on the view ahead -- call it planning, or vision, or just leadership -- has occupied our attention for the past three years. Working together in the Vice President's Staff Group, we developed our own strategic management model in 1981-82. We established mission and broad objectives for each department in 1982-83. Last year our model was adopted and further developed by Senior Vice President William R. Dickson into an MIT-wide five-year planning effort applicable to all support service areas. In the coming year, under the aegis of the Provost's Institute Planning Group, we hope to pull together all of the academic and support service plans into a comprehensive MIT five-year plan.

In preparation for the MIT-wide plan, senior officers are now aggregating the plans in their own areas. Exhibits A and B appended to this statement, summarize the organization and plans -- functions, mission, and broad strategic objectives -- of the Office of the Vice President. We will continue to iterate and refine our planning process. Our agenda for this year includes major studies and decisions in the management of health services, in news policy and public relations, and in personnel benefit programs. We will continue our efforts to enhance academic support for undergraduates and to assist in the development of strong student leadership in athletics, in residence programs, in activities, and in the complex management of scarce campus space resources.

Last year was, for me personally, a year of intensive immersion in the understanding of health care services, as I succeeded Professor Kenneth R. Wadleigh in the responsibilities of the MIT senior officer for the Medical Department. The Department provides extensive, vital services to the MIT community. It is a large and complex operation, justifiably proud of its achievements in providing consistently high quality care. It has experienced a remarkable growth in the past decade, including the establishment of a health maintenance organization and the design and execution of the move to consolidated new facilities on Carleton Street. Our current efforts to receive accreditation for the Department's hospital unit, to rationalize the Department's governance, and to study future health care options will continue to receive high priority on the agenda. We will have more to report next year.

In Admissions and in Personnel, this is a time of important turnover in senior leadership. Peter H. Richardson, after 12 years as Director of Admissions and 20 years on the MIT staff, decided to take early retirement as of September 1, 1984. He and his wife, Keenie, will make their home in Vermont. We know they will continue their active and productive lives. MIT will miss them. Peter has served with great distinction in one of higher education's most visible, most influential, and most demanding posts. He and his staff have dedicated themselves to serving generations of young people, men and women whose careers and lives are influenced by MIT and whose careers and lives, in turn, help to influence our future. Students, alumni, and colleagues -- all of us -- are in Peter Richardson's debt for his lasting contributions to MIT.

A national search is in place this summer to select a new Director. It will be, without question, one of MIT's most important appointments. In the meantime, beginning in September, Julia C. McLellan, Senior Associate Director, has agreed to set aside her own plans for retirement in order to provide the needed leadership and stability for the transition period until a new Director takes over. Significantly, before any of us knew about the changes, Julie received this spring the Gordon Y. Billard Award for special service of outstanding merit performed for the Institute during the past 39 years. In the next few months, she will have one more opportunity to match her talents and wisdom against the demanding tasks of heading the Office in the tension-filled climate of addressing the problems of enrollment imbalance at MIT.

Elsewhere in this Report, the Chairman of the Faculty will chronicle in detail the Faculty activities in response to this problem of imbalance and of crowded enrollments in the Department of Electrical Engineering and Computer Science. In many respects this problem represents the most vexing issue faced by MIT during the year. Its ramifications and its potential impact on future admissions and on the complexion of our undergraduate student body are enormous. This is not the right place to discuss this topic in depth. I simply wish to note here the quiet, creative, and extremely effective staff services provided to the Committee on Educational Policy and to the Chairman of the Faculty by David S. Wiley, Executive Officer of the Committee and Senior Associate in the Analytical Studies and Planning Group of the President's Office. In many senior staff roles throughout recent years, David has displayed superior skills in reporting on complex issues and in making sense out of endless controversy and debate. His patient persistence with multiple drafts and sensitive renditions of policy proposals is monumental. He is an invaluable member of our team.

On June 1, Joan F. Rice was promoted to succeed James J. Culliton as Director of Personnel. Joan's appointment enjoyed exceptional support throughout the MIT community. She is a leader of a strong department that she and her colleagues have helped to build. It is a sign of great health and promise for an organization to grow its own leaders. The announcement of Ms. Rice's appointment proudly noted that she joined MIT 12 years ago as a secretary.

The selection of James J. Culliton to succeed Stuart H. Cowen as MIT Vice President for Financial Operations on June 1 is another strong sign of institutional health. Jim is a superb manager and, in my view, a leader whose professional achievements and personal style fit MIT's needs and our times especially well. For a decade he has been a distinguished Director of Personnel who has insisted on the continuous development of people and of the highest standards of quality and performance in a department where there is a tradition of hard work but also a concern that personal effort can often go unrecognized in the community. Jim has been one of the best supporters of women and minorities in responsible jobs. For the past years he has also served as Assistant to the Vice President and in this capacity has been a close partner to me. I owe much to him for his unfailing support, wise counsel, and friendship. His cheerful sense of humor was often responsible for maintaining our perspective and sense of sanity through difficult situations. His appointment is for me the source of great confidence in MIT as a vital, human institution.

Exhibit A

ORGANIZATION AND PLANS

Functions: The Vice President in the Office of the President has staff and line responsibilities.

The line responsibilities include overview of nine departments which may be aggregated in three clusters:

- Academic/Student-Related Cluster
 1. Admissions
 2. Dean for Student Affairs
 3. Career Services and Preprofessional Advising
- Community-wide Services Cluster
 4. Athletics
 5. Medical
 6. Personnel
- Information Services Cluster
 7. News Office
 8. Campus Information
 9. MIT Press

The staff responsibilities include:

- Secretariat to the Executive Committee of the Corporation, staff to the Faculty structure and the CEP; and maintenance of the membership of Institute committees;
- Central responsibility for equal opportunity and affirmative action; for privacy; and for liaison with legal services;
- Advising the President and other senior officers on MIT organization, planning, and policy development;
- Administering the President's Office and the staff functions within it.

Exhibit B

Mission: (Stewardship of human resources)

The central goal of the office is to support the academic mission of MIT (in education and research) by developing and implementing effective policies and efficient services for all MIT people: students, faculty, and staff at all levels of employment.

Strategic

Objectives: The five-year plans of each of the nine departments reflect, in varying degrees, a set of broader strategic objectives which cut across administrative lines. These broader objectives include:

- A. Making progress in minority (especially black) recruiting and retention. Helping all MIT managers to become more successful.
- B. Making progress in long-range planning efforts, especially in relating central MIT mission and goals to departmental plans (including effective communication).
- C. Consolidating administrative organization and continuing to reduce costs, while striving to improve effectiveness of human services and alignment of these services to the academic mission of MIT (i.e., support of education and research).
- D. Enhancing productivity, sense of contribution, and growth potential of MIT people. Helping all managers to improve supervisory performance.
- E. Enhancing external image and communications, especially addressing narrow stereotypes of MIT.

CONSTANTINE B. SIMONIDES

Affirmative Action/Equal Opportunity

The 1983-84 academic year has been in many ways an echo of 1982-83. Federal dollars for research and education remain scarce, the nation's economic future continues to be unclear, and support for affirmative action and equal opportunity efforts is at an ebb. In fact, the situation presents a serious challenge to the MIT community as we know it and would like it to be. For this reason, a number of significant discussions around issues of Black faculty retention, minority student attrition and achievement, and minority staff development have taken place. These issues are both complex and interrelated; we expect the discussions and work on these issues to be ongoing.

As a community, MIT is predominantly white and male. The current workforce is 12 percent minority (five percent Black-American, five percent Asian-American, and two percent Hispanic-American) and 88 percent non-minority, 37 percent female and 63 percent male. The small number of Black and Hispanic faculty and administrative staff remains a serious concern.

The year was marked by the following encouraging highlights:

1. A successful compliance review by the Department of Labor.
2. The selection of Dr. Kenneth Manning, Associate Professor in the Program of Science, Technology, and Society, and Ms. Vera Ballard, Administrative Officer of the Whitaker College of Health Sciences, Technology, and Management, as MIT's representatives to the Black Achievers Program of the Greater Boston YMCA.
3. An encouraging progress report on affirmative action initiatives begun last year by the Dean of Science.
4. The appointment of a woman, Joan Rice, to succeed James Culliton as Director of Personnel; the naming of Ann Friedlaender, Professor of Economics and Civil Engineering and Head of the Department of Economics, to succeed Dean Hanham as Dean of the School of Humanities and Social Science, effective September 1; and the appointment of a minority woman, Janice Cooper, to the post of Assistant Dean in the Office of the Dean for Student Affairs.
5. The convening of the second National Conference on Black Administrators at White Institutions, June 21-24, 1984, sponsored by the MIT Black Administrators Association and co-chaired by Drs. Turner and Williams.
6. The inclusion of affirmative action goals in the Institute-wide strategic planning process, and the initiation of a computerized applicant flow system by Personnel.

In summary, the 1983-84 year has been one of challenge and hope. We are heartened by the breadth and depth of discussions around equal opportunity issues thus far. We expect these discussions and issues to be central items on the 1984-85 agenda.

PATRICIA BELL-SCOTT

Campus Information Services

This year we -- like offices and departments throughout the Institute -- spent considerable time assessing our own programs and working together to define the ways in which we can best serve the interests of MIT as an educational and research organization, and as a community of students, faculty, and supporting staff. The continued efforts to bring the Institute's budget into balance meant that much of our planning focussed on ways to economize, consolidate, or otherwise streamline our operations, while at the same time assessing the value of each of the services provided by the Campus Information Services.

The variety of services provided by the offices in the Campus Information Services created a challenge for us in defining a common mission to serve as the basis for our long-range planning, but the following statement does capture both the purpose and spirit of this organization: to provide services and information about MIT's programs, policies, and organization to internal, national, and international constituents in ways which best meet their interests and needs, which reinforce and enhance the quality of the Institute, and which promote a shared understanding of MIT's programs and policies among the people who are here.

This planning process has been a rigorous exercise, not without its rough spots, and I am most grateful for the dedication, energy, imagination, and goodwill demonstrated by all the participants in the planning process.

KATHRYN W. LOMBARDI

Communications Office

The Communications Office produced its nine annual publications and provided editorial/production assistance and advice to a wide variety of administrative and academic departments at MIT.

The policy changes implemented for the 1983-84 Courses and Degree Programs, detailed in this report last year, resulted in a catalogue which was 128 pages shorter than the previous edition. This was a significant accomplishment in several ways:

- the finished book contains more accessible information with less duplication;
- the level of detail is more appropriate for a book used by both current and prospective students; and
- with a print run of 65,000 copies, the elimination of those 128 pages translates into a total reduction of 8,320,000 pages.

A major change was also made this year in the distribution of the catalogue. The book was no longer provided free of charge to everyone who asked for it. Non-applicants requesting a catalogue were asked to purchase it for \$4. The dual purpose of the charge was to help offset production costs and to ensure that our supply of catalogues was available for the book's intended audience. Courses and Degree Programs was on sale at the Tech Coop and in the MIT Press Bookstore and also was distributed through the US mail.

We continued to provide one catalogue free of charge to the following: current MIT students, faculty, and staff; cross-registering Wellesley students; prospective undergraduates applying for 1984 and prospective graduate students applying for 1984 or 1985; Corporation members; Educational Counselors; and high school guidance counselors. Academic and certain administrative areas at MIT also could request two cartons of books for their own distribution to guests. Libraries throughout the country continued to receive a free microfiche copy of the book.

Although we did not generate as much income as we had predicted from the sale of Courses and Degrees, the charge was effective in curbing waste of the book. We believe that prior to the charge, many people requested a catalogue because it was available and free, not necessarily because they needed all the detailed information the book contains. The drop in use this year means that we will be able to reduce the print run of the 1984-85 edition of the book.

We decided that along with implementing a charge for the catalogue there was a need for a new visitors' publication for guests, especially for those who did not purchase a catalogue. With the excellent help of Betsy Hacker in Design Services, we developed and produced "Welcome to MIT," a brochure intended specifically for visitors. We were able to finance the new publication with the savings realized from the shorter page count of Courses and Degrees.

"Welcome to MIT" is available in the Admissions Office and the Information Center; and other administrative and academic areas also are distributing copies to their visitors.

The 1982-83 issue of MIT's large annual report was produced in a new manner, both to cut costs and to make the bound edition available sooner. The book was prepared like a set of conference proceedings, with authors submitting camera-ready material typed on special grid sheets. This process eliminated the editing, rekeyboarding, and subsequent proofreading that had been done in the past by the Communications Office staff (and part-time freelancers).

Given the nature of the book's use as an in-house reference and historical document, we no longer felt we could justify the time and expense required to publish the book in the usual manner. The new production process allowed us to save money and to publish the book two and one-half months sooner than it had been issued in the past without causing major additional work for departments. We also changed the name of the book from Report of the President to Reports to the President to more accurately reflect its unedited contents.

During the year, the Communications Office worked with academic and administrative areas plus several student groups on their publications. We provided editorial and production assistance and wrote copy for several new publications. This consulting role has been expanding in the last few years as our services become better known throughout the Institute.

The Office is currently conducting an Institute-wide survey of typesetting needs and capabilities for the Institute Planning Group. The results of this survey will be summarized here in next year's report.

In October we again offered our Publications Production class as part of MIT's Personnel Development Program. The class is planned for MIT employees who handle publications as an extra part of their jobs, and it provides a brief overview of the technical processes of typesetting and printing. The program also stresses efficient and cost-effective methods of producing publications. We plan to offer the course again next fall.

JANET L. SNOVER

Office of Design Services

The Office of Design Services continues to support the communications efforts of MIT by designing and managing the production of publications for departments and offices throughout the Institute. Among the areas receiving major assistance from the office during the past year were the Admissions Office; the Corporation; the Committee on the Visual Arts; Resource Development; a variety of programs in the School of Architecture and Planning, the School of Engineering, and the Sloan School of Management; the Special Summer Programs; and a wide range of special events and conferences coordinated by the Information Center. As in the past, the office provided major design and production support for the communications program of the Alumni Association. Overall, the office undertook 348 graphic design and publishing projects in 1983-84.

In January, Dorothea Black, Production Manager for Alumni Association publications, left to pursue personal interests. She was replaced by Celia Wilson, formerly of the MIT Press. Ms. Wilson will continue to provide design and production for the Alumni Association publications.

Professional recognition was accorded the design efforts of Jacqueline Casey, Ralph Coburn, and Betsy Hacker. Their work was included in the New York Type Directors Show, Print magazine Regional Design Annual 1983, and Graphis Annual.

Ms. Casey participated in the Illustrators and Designers Workshop in New York, and the CASE conference in Boston. Her work was featured in CA Magazine, as one of the people who have judged the 24 years of CA Annual Competitions. Her work will appear in the forthcoming publication: Print Case Books, The Best in Posters.

JACQUELINE S. CASEY

Information Center

Over the past year, the Information Center continued to provide 1) informational services to visitors and the MIT community; 2) assistance to faculty and staff in coordinating major Institute events and conferences; and 3) support and guidance to MIT's international faculty, staff, and visitors.

Public Relations and Information Services. This section offers information over the telephone, in person, and through publications -- this year answering some 30,000 telephone and 35,000 office inquiries about Institute programs and activities. The section conducted tours of the campus for over 6,000 visitors from all parts of the country and the globe. In addition to helping visitors and others find their way around campus, the office did the same for the enormous volume of mail (10,000 pieces this year) addressed generally to "MIT." Other activities of this section of the Center include maintaining the faculty mailing lists and the long-range planning calendar, maintaining and publishing membership records for over 60 Institute committees, providing support to the faculty Committee on Nominations, and arranging for MIT representation at major events of other colleges and universities.

During the past year the Admissions Office and Information Center discussed ways to improve the visitors guide service by means of expanding the guided tours, providing visitors with a lounge and informational materials, and a slide presentation. The guided tours, conducted primarily for prospective students and their families, serve an important public relations function for the Institute. The 26 student guides are an enthusiastic, candid, and motivated group, supervised under the very skillful and organized direction of Terri Priest. The head guide, Ellen Epstein '86, worked full-time during the past summer, the busiest time for visitors, both as a tour guide and public relations person in the Center. The following is a listing of guided tours during the past year:

| | |
|---------------------------|--------------|
| Prospective Students | 2,417 |
| International Visitors | 771 |
| General Visitors | <u>2,900</u> |
| TOTAL | 6,088 |
| Visitors on Special Tours | 548 |
| Visitors on General Tours | <u>5,540</u> |
| TOTAL | 6,088 |

Special Events and Conferences. During the past year, this section of the Information Center provided logistical support to 21 conferences held on campus. Examples of such meetings were: The American Society of Civil Engineers Hydraulics Division Specialty Conference, the Eighth International Vehicle Systems Dynamics Conference, the United Way Loaned Executives Program, the IEEE Computer-Aided Control Systems Design Symposium, the Whitehead Institute Symposium on "Forces Molding the Genome," the International Symposium on the Use and Development of Low and Medium Flux Research Reactors, the Enigma of Suicide Conference, the First National Conference of the Association of Collegiate Entrepreneurs, and the First National Logo Conference. The Special Events Office also provided coordination assistance to the "Women's Weekend" sponsored by the Admissions Office in April.

This office, which frees faculty and staff sponsors from the major logistical burdens required by large meetings and conferences, also facilitates the work of many of the other support operations by serving as the pivotal coordinator for all the logistical services needed by the conferences. In addition, the conferences (which brought 3,500 visitors to the campus this past year) generated income for a variety of Institute services, including Housing, Dining, Physical Plant, Audio Visual, Graphic Arts, and Design Services.

Planning is well under way for several international symposia and other conferences scheduled for 1985.

Also in the past year, the Special Events Office made arrangements for 76 presentations by companies visiting the campus in conjunction with the Office of Career Services and Preprofessional Advising.

The Director of the Center continues to coordinate many special events, including the Killian Lectures, building dedications, celebrations, and Commencement, which this year, despite drenching rain and cold the preceding week, turned out to be a glorious sunny day. Over 6,500 family members and friends watched as 1,674 students received 1,851 degrees. Shirley Chisholm, former congresswoman from Brooklyn, New York, and currently Purington Professor at Mount Holyoke College, was the Commencement guest speaker.

International Visitors Office. The International Visitors Office had a busy year serving the needs of international visitors, faculty, and staff on campus. There were 1,100 international faculty and staff this year. International visitors numbered 563.

The fall term focused on long-range planning activities, and we are already immersed in some of the FY85 priorities. We have been more aggressive about informing the community about immigration requirements, procedures, and problems through various workshops and instructions. These included a permanent residence workshop for administrative officers in the spring and participation in an Industrial Liaison Program seminar in the fall. The permanent residence workshop will be repeated twice a year under the auspices of the Personnel Office.

Professional staff development included attendance at and participation in various conferences and meetings. Terri Priest attended the conference of the National Council for International Visitors (NCIV); Lillian Whelpley, an NCIV workshop; Virginia Lyons, Virginia Silverman, and Lillian Whelpley, various NAFSA meetings; and Virginia Lyons, NAFSA conferences and the Practicing Law Institute.

The Simpson-Mazzoli bill continued to loom over and involve us but has yet to be enacted. The major immigration concerns of the year involved backlogs in the immigrant quota and increased delays in processing many applications.

Privacy of information about international visitors was an issue discussed by the President and the Provost with the Academic and Faculty Councils and described in a Tech Talk article. This office has had a longstanding practice of releasing only directory information when asked about foreign nationals. The Provost confirmed that this should be the practice Institute-wide, with unusual cases and circumstances referred to him.

Virginia Lyons served also as Executive Officer of the Committee on International Institutional Commitments, working closely with the Committee and the Office of Sponsored Programs in handling special projects and reviewing the proposals and material submitted for the Committee's review. A special meeting was held in March to review the first ten years of the Committee's work, identify the key issues which have emerged, and assess the Committee's current and future role.

Our dream of automating recordkeeping is now in reach with the recent arrival of a Decmate II. It is still new, and we are learning its intricacies, but we hope to report on real progress in this area next year.

This report would not be complete without a special salute to the entire Information Center staff: Kathleen Barrett, Sarah Clere, Donald Ferland, Gayle Fitzgerald, Virginia Lyons, Terri Priest, Virginia Silverman, and Lillian Whelpley, many of whom have assumed additional responsibilities and have carried out all their duties with a sense of caring and service to the Institute.

MARY L. MORRISSEY

Dean for Student Affairs

INTRODUCTION

The 1983-84 academic year was a challenging one for the staff as we struggled to provide quality service and assistance to students, organizations, and several faculty committees while functioning under the continued constraints of an ever decreasing budget and in the aftermath of a number of difficult situations. On a more positive note, the year provided many opportunities for the Office of the Dean for Student Affairs (ODSA) staff to work in a variety of areas with faculty, staff, and students as well as with a number of offices around the Institute. In addition, lines between the different sections of the Office blurred considerably as staff across sections stretched to support each other in numerous ways. Procedures were clarified in several areas and five-year plans were developed for the overall Office, for each of the sections, and for two of our long-standing programs.

Several community-wide forums were jointly sponsored by the ODSA and various offices, including those of the Provost, the President, and Independent Activities Period (IAP), as well as the Medical Department and the Student Committee on Educational Policy. The forums focused on a range of topics including the undergraduate enrollment imbalance problem, AIDS and Herpes, computers and education, and academic honesty. Special efforts involving faculty, staff, and students included the preparation of a quality of student life survey, an informational brochure on services available to handicapped students, and the development of guidelines for addressing harassment concerns. The Institute-wide awards convocation, the establishment of a working group to address a number of issues in the student activities area, and a series of discussions on community standards including issues related to pornography, substance abuse, and harassment also brought together individuals from various sectors of the community.

Major areas in which staff across sections within the Office worked closely together, in addition to those described above, include a successfully funded Athena project on academic and personal support programs for freshmen, discipline cases, drug and alcohol abuse, residence/orientation, and support to fraternities.

As a result of a series of complaints from within the community against individuals, offices, and organizations in connection with the showing of pornographic films, it became necessary to develop guidelines for the handling of such complaints. Following a series of meetings, alternative starting points for addressing harassment and other concerns involving faculty, staff, students, and student organizations were identified. A copy of the guidelines developed is appended to this report. Internal ODSA procedures for handling disciplinary cases were also developed.

Five-year plans for the Office and for each of the three sections were prepared and, for the first time, long-range plans were developed for the residence/orientation program. Though incomplete, major progress was also made in the discussion and preparation of a five-year plan for the Faculty/Graduate Resident Program. The planning process, while time-consuming, stimulated considerable discussion of existing ODSA programs and of possible new efforts to better enable us to support and complement the academic program of the Institute.

Additional highlights of the year included the renovation of the Cheney Room by three women graduate students from the Architecture Department, increased automation and computerization of the Office, visits by our staff to other offices and laboratories at the Institute along with several other staff development initiatives, closer working relationships with the Office of the Provost through a number of joint efforts, Institute support of a proposed two-year transition project to address pressing needs in the student activities area (that had the additional benefit of making the hiring of a full-time fraternity advisor possible), and our annual year-end review and planning meeting.

As discussed in the sectional reports that follow, the ODSA operated under unusual stress this year as a result of a number of developments including the departure of Dean Mary Hope, the tragic deaths of three students, the discovery of a major theft in the Student Center, increased concern over student use of nitrous oxide, a number of intense meetings on the showing of pornographic films by the Lecture Series Committee, and inadequate staff support, especially in the fraternity area. In addition, the knowledge that we would be losing Stephen Immerman and Anita Walton, both of whom have consistently made outstanding contributions to the work of the Office, did not improve staff morale. In spite of these constraints, we have managed to meet our numerous responsibilities because of the willingness of each member of the ODSA staff to make the extra effort to get our work done. We have been helped considerably in this regard by the efforts of Peter Brown and Katherine Cochrane to integrate computer usage into the work of the Office. My own work has been greatly enhanced by the addition of Dallas Slawter to the staff as my Administrative Secretary.

The Financial Aid Task Force required considerable time and effort this year. These meetings were productive, however, as were periodic meetings with Associate Provost Frank Perkins and Vice President Constantine Simonides, and biweekly meetings with the Undergraduate Academic Support (UAS) staff, the Director of the Office of Minority Education, and Associate Provost Perkins. The monthly meetings with the Committee on Student Affairs and with the Faculty Residents continued to serve as valuable sources of feedback and advice to the Office.

Michael Witt, this year's Undergraduate Association President (UAP), and Ray Samuels, Finance Board Chairman, were especially helpful in the very smooth transition this spring from their tenure in office to that of their newly elected replacements. David Libby (UAP), Stephanie Schiedler (UAVP), and Michael Vidaurri (Finance Board Chairman), are to be congratulated on a strong beginning in their new roles. We are extremely pleased with the fine caliber of leadership reflected in several key areas and committees within the student activities area and look forward to working closely with each of them to help bring about changes that we mutually identify as desirable. Developments in a number of areas are encouraging and we are hopeful that the 1984-85 academic year will be exciting and productive.

SHIRLEY M. MCBAY

UNDERGRADUATE ACADEMIC SUPPORT

Undergraduate Academic Support (UAS) coordinates the freshman and undesignated sophomore advising programs; the orientation programs for all new undergraduates; and serves as an academic information center for students, individual faculty members, and departments. The major UAS programs are described below.

Freshman Advising Program

The primary counseling of freshmen during 1983-84 was carried out by 269 advisors (145 faculty, 21 lecturers/instructors, 22 research staff members, 24 graduate students, and 57 members of the administrative staff), representing the ranks of the faculty. These advisors were supported by nearly 200 undergraduates who served as "associate advisors".

Seven freshmen withdrew for a variety of personal reasons during the academic year. Twelve additional freshmen were required to withdraw for at least one term because of unsatisfactory academic performance. The table below summarizes for the past four years the number of required withdrawals, the number of formal warnings of unsatisfactory performance given by the Committee on Academic Performance ("CAP Warnings"), and the number of the more informal letters from our office suggesting that the student review his or her performance.

| <u>Academic Year</u> | <u>Required Withdrawals</u> | <u>CAP Warnings</u> | <u>UAS Letters</u> | <u>Total Academic Actions</u> |
|----------------------|-----------------------------|---------------------|--------------------|-------------------------------|
| 1983-84 | 12 | 96 | 89 | 197 |
| 1982-83 | 17 | 109 | 73 | 199 |
| 1981-82 | 8 | 93 | 98 | 199 |
| 1980-81 | 11 | 104 | 121 | 236 |

Undesignated Sophomore Advising Program

The number of students choosing not to declare a major at the beginning of their sophomore year increased by about 20 percent this past year.

Thirty volunteer advisors drawn from faculty and staff were needed to provide a reasonable match of interests with 83 undesignated sophomores at the beginning of the fall semester and 28 in the spring. The respective student figures for 1982-83 were 69 and 32 for the fall and spring terms.

Administrative Support to the Committee on Academic Performance

The Committee on Academic Performance (CAP) was chaired again this year by Professor William Kaufmann; Stephen Patterson replaced Jane Dickson as staff support to the Committee. During the year, the CAP handled approximately 425 petitions from individual students requesting readmission and exceptions to certain regulations of the Faculty. A total of 126 Required Withdrawals (approximately 3 percent of the undergraduates) and 392 Warnings (approximately 9 percent of the undergraduates) were voted for the academic year. These figures are distributed by class as follows:

| | <u>Required Withdrawals</u> | <u>CAP Warnings</u> |
|---------------|-----------------------------|---------------------|
| Class of 1984 | 37 | 78 |
| Class of 1985 | 31 | 80 |
| Class of 1986 | 46 | 138 |
| Class of 1987 | 12 | 96 |

The CAP Support Office, with assistance from other UAS staff, continues to operate successfully as an information center for academically-related policies and procedures. The Committee's liason with the counseling resources of the ODSA is in frequent use, both as a referral service for counseling and for input on a particular student's background for the Committee's decisions.

The Undergraduate Seminar Program

The Undergraduate Seminar Program showed an increase in the number of offerings this past year (from 42 to 52 in the fall semester and from 38 to 39 in the spring). The large number of students who choose to participate in the program continues to underscore the importance of the seminars as a complement to the regular curriculum. Approximately 1,230 students (of whom 691 were freshmen) participated in seminars this year, continuing the upward trend of enrollment in seminars on the part of upperclass undergraduate students.

Professor Judah Schwartz found it necessary to resign after serving one term as Faculty Chairman of the seminar program. With assistance from the Office of the Provost, a search is currently underway for a new seminar program chairman.

Academic Support and Information Center

As we mentioned in last year's report, activities in this area are designed to encourage a strong undergraduate support system for both students and faculty, with the goal of improving the advising and teaching programs for undergraduates. We continued our involvement in most of the areas mentioned in the 1982-83 report. Examples of expanded or new efforts include the following:

- 1) Publication of a series of departmental "Roadmaps," outlining each undergraduate academic department's degree program and presenting one pathway through the program in graphic form. These "Roadmaps" were mailed to all freshman and undesignated sophomore advisors; individual copies of departmental programs are made available through our office.
- 2) Presentation of several series of academic skills seminars designed to assist students with problems associated with studying; e.g., time management and taking notes and exams.
- 3) Provision of administrative support to the re-formed freshman "Core Curriculum Group," formerly chaired by Dean Robert Alberty but now under the leadership of Associate Provost Frank Perkins.
- 4) Co-sponsoring, with the Office of the Provost, a faculty seminar on Teaching Assistant support and training. An Institute-wide orientation and workshop for new TA's is being planned for the fall of 1984.

Career and Course Orientation

As this past year was marked by increased discussion and concern about over-enrollment problems in the Department of Electrical Engineering and Computer Science, we participated in a number of efforts designed to improve information available to students about opportunities open to them. Some examples of our involvement are the following:

- 1) Providing the Committee on Educational Policy (CEP) with data from past years' freshman course selection questionnaires to form a baseline of information regarding how and why students select their majors, and working with a CEP subcommittee to develop a survey for all upperclass undergraduates regarding their freshman course selection experience.
- 2) Redesigning our course selection questionnaire and the procedure freshmen are asked to follow, so that students are given more opportunity to think about why and how they select their major while at the same time involving the freshman advisor in the process.
- 3) Publishing and distributing the departmental "Roadmaps" which, as well as serving as a tool for advisors, demonstrate the variety and flexibility of many degree programs.

- 4) Participating in the ODSA IAP luncheon series which brought together students and faculty to discuss ways to improve the information and advising available to students during the decision-making process.
- 5) Designing two new mailings to freshmen and their advisors (one from the Provost, one from the President) reminding everyone of the importance of active involvement in the selection process.
- 6) Beginning a new effort which will provide students with a brochure on course and career opportunities available in the many disciplines and departments at MIT.

We continue to work closely with departments in the planning and coordination of spring term departmental "open houses", and the UAS "Reading Room" is continuing to improve its stock of resource information about departments and disciplines. We have cut back on our programming efforts due to the disappointing attendance in past years at such major efforts as the "Trailblazing" programs and the all-day activities of the School of Science.

Supervision and Coordination of Residence/Orientation (R/O)

Our fall term residence/orientation program, designed to welcome all new undergraduates, is produced almost entirely by students under the leadership of an R/O coordinator, paid and supervised by the UAS. R/O '83, under the coordination of Lillian Chiang, Class of 1984, saw the incorporation of several new activities. Prior to the traditional Friday afternoon picnic, all new freshmen met in groups of 70 to 80 each under the leadership of an ODSA staff member and student "team". These "pre-picnic discussions" were designed to orient students to the activities during the four-day "rush" period, as well as to prepare them for what else to expect during R/O Week. In addition, the R/O Committee assisted in the preparation for the Registration Day Institute-wide welcome to all new students. Kathryn Chamberlain, Class of 1985, is coordinating the R/O efforts for the fall of 1984.

The UAS has assumed responsibility for the orientation of undergraduate transfer students; we have slightly altered the focus of transfer student R/O, particularly with respect to increasing the early involvement on the part of the new students' academic departments.

This year we have begun to develop a system designed to distribute responsibility for R/O Week more evenly among the members of the ODSA staff. Andrew Eisenmann of the Residence and Campus Activities Section (RCA) now has primary responsibility for supervision of the R/O '84 Coordinator, a responsibility previously assumed by Margaret Richardson. It is anticipated that, in the future, this responsibility will continue to be shared by the UAS and RCA sections.

Staff

Staff within the UAS served as *ex officio* members of the Committee on Curricula, the Committee on Undergraduate Admissions and Financial Aid, and the Committee on Academic Performance. We held membership on the Wellesley/MIT Exchange Committee, the IAP Administrative Committee, the Activities Development Board, the Committee on Privacy, and the Pre-Law Advisory Council.

Two major staff changes took place this year. E. Jane Dickson, who for 13 years had served as assistant to the chairman of the Committee on Academic Performance, left the Institute at the beginning of the academic year. The many people who attended a party to wish her well and who gave testimony to the value of her service underscore the appropriateness of Jane's receipt last year of a James M. Murphy Award. Jane's successor is Stephen Patterson, formerly of the Department of Electrical Engineering and Computer Science.

During the fall we welcomed Barbara Chuck, who has joined the UAS staff on a part-time basis after returning from maternity leave. Barbara worked formerly in the RCA section of the ODSA and is currently involved in projects related to the study skills series and to efforts at improving course orientation.

Finally, a record must have been set as we celebrated the marriages of three of our section members!

HOLLIDAY C. HEINE
 BARBARA S. CHUCK
 JEFFREY A. MELDMAN
 STEPHEN M. PATTERSON
 MARGARET S. RICHARDSON

STUDENT ASSISTANCE SERVICES

Counseling

The individual counseling load continued at a high level. We were down in the number of counseling deans for all but two months of the year, yet the number of appointments reached 2,500. The range of issues dealt with continued to be broad. Personal and academic concerns continued to dominate, and a litany of topics discussed reminds us that while our community is small, it mirrors society at large in its concerns, tensions, and priorities. A suicide in the fall, and the sudden death of two students within a month of each other in the spring, called forth a great deal of energy in support of both family and friends. In our community, services of this essential sort are very important and often overlooked. In all such cases there is follow-up with family and friends so that all loose ends can be tied.

International Students

This is the 40th anniversary of organized efforts to support international students studying at MIT. The function has never been more important and new initiatives are planned for next year. In September over 400 new students were welcomed to MIT; the fall enrollment included 2,094 students from 96 foreign countries. This number was larger by 110 than the previous year, and represents 22% of the total student body. There were 567 international undergraduates of whom 306 were women. In addition, there were 318 dependent spouses in residence during the year. Over the course of the year, all new students and a large number of returning students interact with this office as they deal with the varied demands placed upon them by the Institute and the government.

A major concern of the international community in the past year had to do with the changing climate perceived in interactions with the Immigration Service. In August, 1982, all educational institutions in the U.S. were asked by the Immigration Service to participate in a program of recertification in order to continue to issue U.S. visa documents to new or continuing foreign nationals on F-1 Student Visas.

Steps to inform all F-1 visa holders of the obligations they assume under the new regulations included a direct mailing to each F-1 student and informational meetings during both terms and IAP. Similar workshops will be held in the 1984-85 academic year. It will be several years before there is some degree of uniformity in the administration of these regulations.

Support to Special Groups

The departure of Dean Hope in November left a residue of difficulties for the office. The work we do with the minority community suffered because of public perceptions about what was going on. Dean Leo Osgood in a quiet and competent manner helped the programs we had under way continue. By the end of the year minority interaction with the office had improved markedly, and an extremely successful luncheon sponsored jointly with the Graduate School Office for graduating minority students ended the year. The coming of Janice Cooper in July, as Dean Hope's replacement, will strengthen our work with the minority community. Her experience at Brandeis University will allow her to quickly begin working with student groups.

Our efforts on behalf of handicapped students took a major step forward when we published a brochure for handicapped students describing the resources available for them here at MIT. With input from a number of individuals around the Institute, Dean Linda Vaughan coordinated the preparation of the brochure. The number of handicapped students remains small, but should grow as it becomes clear that we have a commitment to making the campus accessible to those who are handicapped.

The death of a student in the spring due to an overdose of nitrous oxide forced us once again to look carefully at what we do with regard to education about substance abuse. This year Dean Osgood continued to make education in this area a priority. An informal system of alcohol and drug referrals was established between Student Assistance Services (SAS) and the Residence and Campus Activities (RCA) Section of the ODSA. During the course of the year, Dean Osgood met individually with 10 students on specific referral after an incident of substance abuse; he also visited three independent living groups to discuss issues related to substance abuse.

As discussed in the RCA section of this report, there is a growing concern about substance abuse on the campus. Part of the concern is due to continued questions about community standards, but part is a growing awareness of the scope of the problem.

Other Initiatives/Concerns

The newly renovated Margaret Cheney Room was dedicated in September. The renovation was important because it increases the usability of the space but, more importantly, it is symbolic of the growing role of women at MIT. The room was restored by a group of women graduate students from the Architecture

Department with funding from the Cheney Room Endowment Fund. Use of the room in subsequent months has grown markedly. Building an MIT women's community network has been the intent of both the Cheney Room Papers and the Cheney Room Discussion Series. Ten monthly issues of the Cheney Room Papers were published and requests have poured in from all over the Institute from individuals and departments who wish to be added to the mailing list. It has become a major source of information for women. All of these activities have been conducted under the leadership of Sara Mae Berman.

Of major concern to many women on campus is The Lecture Series Committee's adherence to its tradition of showing pornographic films, despite the establishment of a community-wide committee which worked to develop guidelines for the showing of such films. The continued controversy has been an emotional drain on many members of the women's community as well as others at the Institute.

Other Personnel Changes

Dean Robert Halfman retires at the end of June. His long experience at MIT and his faculty standing will be difficult to replace. On the support staff side, Doreen Lauricella left in August and was replaced by Bonnie Fishman. Laura Herring chose not to return from maternity leave in May and Kathleen Lutfi, currently a Senior Secretary, filled the position of Administrative Assistant with primary responsibilities for International Students.

The year has not been an easy one but Student Assistance Services has come through it stronger than we were at the beginning of the year. We regret the retirement of Dean Halfman, but believe that our relationship with the academic community has never been stronger. The quality of student life survey has given us a great deal of data to digest and use in a variety of ways. There is a sense of building momentum as we move into next year.

ROBERT M. RANDOLPH
EUGENE R. CHAMBERLAIN
ROBERT L. HALFMAN
LEO OSGOOD
LINDA J. VAUGHAN

RESIDENCE AND CAMPUS ACTIVITIES

Institute Houses

The 138 crowded rooms in the Institute houses during the fall term represented the highest degree of crowding since 500 Memorial Drive opened for undergraduate housing in September, 1981. In addition, there were a number of college transfers, re-admits, and ninth-term seniors who remained on the waiting list and were unable to be accommodated in the houses. The return rates for residents continue to increase, as the popularity of the Institute Houses remains very high. Especially significant is the constant high demand for space in Green Hall, the Institute's only graduate dormitory for women.

Talbot House

Talbot House has continued to enjoy popularity with a variety of groups from the MIT community. During 1983-84, applications were received from 122 different groups, of which 54 were approved. As a result, Talbot House was occupied 41 weekends, with 13 groups making visits during the week. A total of 1,132 individuals stayed at the house, representing 15 academic groups, 13 living groups, 10 associations or clubs, five alumni groups, and 11 faculty/staff groups. As usual, IAP was the most active month with nine different groups taking advantage of the winter sports season.

Some minor improvements were made to the property this year including the addition of picnic tables and the landscaping of an adjacent field to increase the recreational area. A major renovation is planned for the Summer of 1984 which, among other improvements, will involve remodelling the kitchen and adding bathroom facilities on both levels. The House is expected to re-open before Labor Day.

Amherst Alley Renovation

Approval was granted for the renovation and landscaping of Amherst Alley, which is the main thoroughfare for residents who live in the dormitories and fraternities along Memorial Drive, on the west side of campus. Several meetings were held with representatives of groups affected by the change, in order to discuss the proposed plans and to get feedback and advice. The work is expected to start in June and to be completed early in the fall term.

Dining Program

There were a number of accomplishments this past year in the area of residential dining. We have seen the program evolve through the four-year transition phase to the point where all students living in Baker House, McCormick Hall, MacGregor House, and 500 Memorial Drive are required to purchase a meal plan. While students have accepted the inevitability of required meal plans, they are continually striving to find ways to make it suit their lifestyles and needs. For example, the dining room at 500 Memorial Drive was converted to an a la carte system, in response to strong student interest. The experiment at 500 Memorial Drive will be evaluated during the summer months as a group of students and administrators begin exploring the possibility of expanding a la carte to the other required meal plan houses.

Kitchens were installed last summer in East Campus and Senior House. After a year of operation, they have become important components of the residential program in those houses, and are being utilized to their capacity.

Fraternities and Independent Living Groups

Another strong Executive Committee of the Interfraternity Conference (IFC) provided the continuation of excellence in leadership, which has characterized the MIT Independent Residence System. In recognition of the strength and quality of its program, MIT's Interfraternity Conference was awarded the New England Interfraternity Conference Lunsford Award for excellence as the best fraternity system in the Northeast Region.

Improved relations with neighbors in the Back Bay were enhanced by representatives of the Neighborhood Association of the Back Bay, Condominium Associations, the IFC, and the ODSA meeting together with residents and fraternity members. Fraternity-sponsored crime watch and street clean-up programs also helped to demonstrate MIT fraternity commitment to the neighborhood area.

The newly founded chapter of Alpha Phi Sorority was officially chartered at MIT on February 11, 1984. Substantial efforts in securing a permanent home for the group have not been successful to date because of problems associated with local politics, zoning restrictions, and limited availability of suitable property. We recognize our responsibility to assist Alpha Phi in this regard and will continue until a satisfactory solution is found.

Efforts involving ODSA staff, the Alumni Interfraternity Conference (AIFC), and the IFC to provide support to the approximately 1,400 students in the 33 independent living groups without full-time staff assistance were not sufficient to meet their needs. Approval by the Institute of a plan to address concerns in the student activities areas will result in the hiring of a full-time fraternity advisor during the Summer of 1984.

While there were problems within the independent living group system, the most tragic incident of the year was the death of a senior resident of Tau Epsilon Phi who died of oxygen deprivation as a result of an accidental overdose of nitrous oxide. It has become increasingly clear that there is a campus-wide problem with the personal use of nitrous oxide by students. This problem persists despite many efforts to alert the community to the dangers of nitrous oxide use, as well as the possible legal and disciplinary ramifications. We plan to increase our educational efforts as well as to publicize widely any disciplinary actions that result from the personal use of nitrous oxide. Further efforts will also be made to develop an effective substance abuse program in conjunction with the Medical Department.

Campus Activities

The 1983-84 academic year focused on solidifying newly established directions and changes in activities management and philosophy. Staff responsibilities were clearly articulated, goals identified, and a real team effort was put forth in carrying the activities enterprise forward. Major accomplishments include the implementation of new scheduling procedures for the West Plaza Complex; the renovation of the East Lounge of the Stratton Student Center into an art gallery and lounge space named in honor of the past president of MIT, Jerome B. Wiesner; substantial progress by the Finance Board in standardizing and coordinating the financial support services to student organizations; and the successful resolution of the issue of applying the employee benefits rate to student organizations.

The Lecture Series Committee's decision to continue to show pornographic movies once again prompted campus-wide debate. While some progress has been made, including the development of criteria for acceptable erotic films by an administrative-student committee, much work remains to be done.

It was very shocking and disappointing to discover that approximately \$30,000 from the Student Center's 24-Hour Coffee House had been stolen over the past three years by a student who had served in several positions of trust. This development has resulted in a substantial review of the financial policies and

practices of the Student Center Committee, in particular, and other student organizations, in general. A review of student activity practices had actually begun a year earlier following the merger of the Residence Program and Student Activity sections of the Dean's Office. In fact, the November, 1982 meeting of the Student Affairs Visiting Committee was devoted entirely to issues related to student activities.

Needs and priorities for student activities were clarified throughout the year and, as a result, the functions of Activities Advising and of Operations Director are to be separated along the lines of the model in the housing/residence system. Through income generated within the Student Center and Walker the positions are to be self-supporting within two years. By establishing the West Plaza Complex (and Walker) as auxiliary services, the Institute should be able to increase services to the community, provide for the upkeep of the buildings, as well as eliminate the expense of the West Complex to the Institute's general budget. A student-faculty-staff working group chaired by Dean Robert Sherwood has been appointed to advise the ODSA on major policy changes as we work toward this transition to auxiliary status.

Community Standards

A great deal of time was spent during the past year discussing "community standards". Whether the issues were pornography, substance use/abuse, harassment, computer hacking, or academic honesty, it was repeatedly difficult and very frustrating to define which members of the community had the authority and/or responsibility to establish and/or enforce such standards. Despite the historical precedent of the Institute's seeming reluctance to establish community standards, the need for such standards is becoming more and more apparent, and will surely continue to be a source of discussion and debate for some time to come.

Discipline and Harassment Cases

A report outlining discipline cases involving students from living groups which were adjudicated by staff in the Residence and Campus Activities section is available in the ODSA. In summary, nine residents were suspended from their residences, two were declared *persona non grata*, 16 were placed on Dean's Office Disciplinary Probation, 10 were given Dean's Office Disciplinary Warnings, five were required to pay financial restitution, and one fraternity had its freshman rush privileges revoked. Offenses included such things as harassment, breaking and entering, assault and battery, stealing, obscene behavior, disturbing neighbors, throwing objects off roofs, alcohol and drug use/abuse, malicious destruction of property, and unacceptable "hacking".

This year the number of incidents of harassment reported to our Office increased substantially and a summary report on these is also available in the ODSA. Some cases were handled in a disciplinary manner, some referred for counseling, and at least one referred to Cambridge Court for criminal action. Several of the incidents were not particularly of a sexual nature, demonstrating the effectiveness of having a broadly written policy on harassment.

Institute Committees, Professional Conferences, and Associations

Various members of the Residence and Campus Activities section of the ODSA served on at least 32 standing or ad hoc committees of the Institute and served in an advisory capacity to at least 13 different student groups. In addition, various RCA staff hold memberships in six different professional associations and attended a total of five professional conferences during 1983-84.

Personnel Changes

The following personnel changes occurred in the RCA section during the year:

Departures

Sara Mae Berman to a part-time position in SAS
Barbara Chuck to a part-time position in UAS
Carolyn Harris to school for additional study
Stephen Immerman to the Resource Development Office
Deborah Morris to a position in the Mathematics Department
Anita Walton, relocation to another city

Additions

Ann Braden, Senior Secretary
Sharon P. Shea, Secretary/Receptionist

Promotions/Changes

Steve Burke to Senior Office Assistant
Andy Eisenmann to Staff Assistant for Campus Activities
Kathleen Haskell to Staff Assistant for Residence Programs

ROBERT A. SHERWOOD
PETER H. BROWN
ANDREW M. EISENMANN
KATHLEEN F. HASKELL
STEPHEN D. IMMERMANN
RETA M. LEE
ANITA T. WALTON

Attachments
to the ODSA
Report:

Guide to Alternative Starting Points and Sequences for Addressing
Harassment Concerns
Fall, 1983, Institute House Count
Fall, 1983, Regular Graduate Student Residential Distribution

A GUIDE TO ALTERNATIVE STARTING POINTS* AND SEQUENCES FOR ADDRESSING HARASSMENT CONCERNS
(Union employees have grievance procedures specified in union contracts)

PERSON WHOSE ACTIONS ARE QUESTIONED

| PERSON EXPRESSING CONCERN | STUDENT** | FACULTY | STAFF*** |
|---------------------------|---|--|---|
| STUDENT | <ul style="list-style-type: none"> - Office of the Dean for Student Affairs - Committee on Discipline - Department Head - Administrative Officer - Spec. Assts. to the President | <ul style="list-style-type: none"> - Office of the Dean for Student Affairs - Department Head → Dean → Provost - Administrative Officer - Spec. Assts. to the President | <ul style="list-style-type: none"> - Office of the Dean for Student Affairs - Immediate Supervisor → Dept. Head - Senior Officer - Personnel Officer → Manager of Personnel Services and Devel. → Director of Personnel → Senior Officer - Administrative Officer - Spec. Assts. to the President |
| FACULTY | <ul style="list-style-type: none"> - Office of the Dean for Student Affairs - Committee on Discipline - Spec. Assts. to the President | <ul style="list-style-type: none"> - Dept. Head → Dean → Provost - Spec. Assts. to the President | <ul style="list-style-type: none"> - Immediate Supervisor → Dept. Head → Senior Officer - Personnel Officer → Manager of Personnel Services and Devel. → Director of Personnel → Sr. Officer - Spec. Assts. to the President |
| STAFF | <ul style="list-style-type: none"> - Office of the Dean for Student Affairs - Committee on Discipline - Spec. Assts. to the President | <ul style="list-style-type: none"> - Department Head → Dean → Provost - Personnel Officer → Mangr. of Pers. Serv. and Devel. → Director of Personnel → Senior Officer - Spec. Assts. to the President | <ul style="list-style-type: none"> - Immediate Supervisor → Dept. Head → Senior Officer - Personnel Officer → Manager of Personnel Services and Devel. → Director of Personnel → Senior Officer - Spec. Assts. to the President |

Notes: A person expressing a concern should always first consider addressing the person whose actions are questioned. All formal complaints, except for those to COD, may be finally appealed to the President. The President may then ask a Special Assistant or other person to investigate and make a recommendation.

* Others with Possible Roles: Medical Dept., Campus Police, Faculty and Graduate Residents, Office of the Dean of the Graduate School, the Committee on Graduate School Policy, Chairman of the Faculty, Office of Equal Opportunity, and the Faculty Administration Committee.

** Other routes (e.g., academic or personnel) may be appropriate if the student whose actions are questioned is also an Institute employee.

*** For research staff, possible routes include Lab Director → VP for Research → Provost.

INSTITUTE UNDERGRADUATE HOUSE COUNT

Fall 1983

| <u>HOUSE</u> | <u>1</u> | | <u>2</u> | | <u>3</u> | | <u>4</u> | | <u>Other</u> | | <u>Total</u> | | <u>TOTAL</u> | <u>CAP</u> | <u>VACANCIES</u> | <u>CROWDS</u> |
|--------------|------------|----------|------------|----------|------------|----------|------------|----------|--------------|----------|--------------|----------|--------------|-------------|------------------|---------------|
| | <u>M</u> | <u>F</u> | <u>M</u> | <u>F</u> | <u>M</u> | <u>F</u> | <u>M</u> | <u>F</u> | <u>M</u> | <u>F</u> | <u>M</u> | <u>F</u> | | | | |
| Baker | 65 | 24 | 51 | 34 | 44 | 34 | 63 | 32 | 2 | | 225 | 124 | 349 | 337 | | 12 |
| Bexley | 25 | 4 | 21 | 4 | 19 | 7 | 34 | 4 | 2 | | 101 | 19 | 120 | 122 | 2 | |
| Burton | 83 | 49 | 60 | 22 | 37 | 31 | 52 | 40 | 3 | | 235 | 142 | 377 | 344 | | 33 |
| East Campus | 54 | 33 | 93 | 35 | 54 | 12 | 89 | 18 | 4 | | 294 | 98 | 392 | 367 | | 25 |
| MacGregor | 89 | | 113 | | 53 | | 70 | | 1 | | 326 | | 326 | 326 | | |
| McCormick | 62 | | 63 | | 46 | | 66 | | | | 237 | | 237 | 219 | | 18 |
| New House | 45 | 15 | 52 | 11 | 49 | 9 | 34 | 8 | 3 | | 183 | 43 | 226 | 208 | | 18 |
| French | 3 | 5 | 3 | 2 | 4 | 1 | 3 | 4 | | | 13 | 12 | 25 | 24 | | 1 |
| German | 2 | 2 | 5 | 2 | 3 | | 4 | 3 | | | 14 | 7 | 21 | 21 | | |
| Russian | 3 | 1 | 5 | 3 | 5 | | 2 | | | | 13 | 6 | 19 | 18 | | 1 |
| Spanish | 5 | 4 | 4 | | | 5 | 3 | 1 | | | 12 | 10 | 22 | 21 | | 1 |
| Random | 12 | 3 | 23 | 4 | 13 | 9 | 21 | 8 | | | 69 | 24 | 93 | 93 | | |
| Senior House | 44 | 5 | 35 | 10 | 28 | 13 | 36 | 8 | 1 | | 144 | 36 | 180 | 183 | 3 | |
| 500 Mem. Dr. | 53 | 25 | 60 | 44 | 108 | 44 | 40 | 7 | | | 261 | 120 | 381 | 352 | | 29 |
| TOTAL | 483 | 232 | 525 | 234 | 417 | 211 | 449 | 201 | 16 | | 1890 | 878 | | | | |
| | <u>715</u> | | <u>759</u> | | <u>628</u> | | <u>650</u> | | <u>16</u> | | <u>2768</u> | | <u>2768</u> | <u>2635</u> | <u>5</u> | <u>138</u> |

GRADUATE RESIDENTIAL DISTRIBUTION

Fall Term 1983

Regular Graduate Students

| <u>MIT HOUSING</u> | <u>Men</u> | <u>Women</u> | <u>Total</u> |
|--------------------------------------|--------------|--------------|--------------|
| Ashdown | 323 | 68 | 391 |
| Green | 0 | 46 | 46 |
| Tang | 351 | 53 | 404 |
| Graduate Residents (Single) | 24 | 16 | 40 |
| Total Single Graduates -- On Campus | 698 (19.2%) | 183 (21.4%) | 881 (19.6%) |
| Eastgate* | 179 | 18 | 197 |
| Westgate* | 197 | 12 | 209 |
| Graduate Residents (Married)* | 21 | 12 | 33 |
| Total Married Graduates -- On Campus | 397 (10.9%) | 42 (4.9%) | 439 (9.8%) |
| Total Graduates - On Campus | 1095 (30.2%) | 225 (26.3%) | 1320 (29.4%) |
| <u>OFF CAMPUS</u> | 2534 (69.8%) | 631 (73.7%) | 3165 (70.6%) |
| TOTAL REGULAR GRADUATES | 3629 (100%) | 856 (100%) | 4485 (100%) |

*There are fifteen couples in Eastgate where both members are students, eight in Westgate, and five Graduate Resident couples where both members are students.

Department of Athletics

I am pleased to submit my fourth annual report presenting a concise statistical review of our wide-ranging athletic and recreational programs.

GENERAL OVERVIEW

Broad-based student, faculty and staff participation continues the strong trend of the previous two years (see Exhibit I). All time highs were reached in Physical Education registrations (see Exhibit II) for graduate students and staff and Club Sports in number of programs and participants. Undergraduate Physical Education registrations, Intramurals and Intercollegiates are all holding at high participation levels. Athletic and Sailing Card purchases (see Exhibit XII) are up strongly across the board reflecting the increased popularity of the refurbished Class of 1974 Health Fitness Center and the great interest in the windsurfing program as a supplement to our always popular sailing activity.

MIT's men's and women's intercollegiate teams enjoyed outstanding success (see Exhibit V) with both showing overall winning records. The women's winning percentage was an impressive .691 (vs .613 last year).

Academic All-American honors were accorded to eight MIT students representing five sports including four members of the wrestling team named to the 1984 NCAA Division III Coaches Academic All-American team. The ability of so many MIT students to combine athletic and academic excellence confirms our belief that the MIT commitment to student-oriented amateur athletics is a soundly based philosophy that works for MIT.

The Academic-All American achievements plus the national 4th place finish of the women's volleyball team and the extraordinary trip to India by our men's basketball team were 1983-84 highlights that provided inspiration and pride for everyone associated with MIT Athletics.

A final highlight valued by our Department above all others is the decision by this year's 1984 Senior Class to provide a Senior Gift Fund to purchase figure and hockey skates for a Skate Rental Services available to all members of the MIT Community. In presenting the gift at Graduation, Class President Diane Peterson stated the gift was to "show our appreciation for the contributions the athletics program has made to our lives at MIT."

PHYSICAL EDUCATION

Professor Gordon Kelly's first year as Director of Physical Education has been one of innovation, achievement and sound management in the face of increasing registration demand and the net loss of three instructors. Total registrations held just below last year's record levels and well above two years ago with both graduate student and staff registrations at all time highs. Effective use of an increased number of part-time personnel has enhanced our course offerings and participation levels.

The Dance and Exercise Fitness programs both made successful transitions to new leadership with Reeva Gibley (Dance) and Maggie Lettvin (Exercise Fitness) ably replaced by Stephen Driscoll in Dance and a core of highly professional part-time instructors in Exercise Fitness.

The I.A.P. Physical Fitness experiments were highly successful with 110 people of all ages participating in the voluntary physical test program. One immediate result is the establishment of an advanced credit exam for physical fitness. Two senior students were able to receive credit by virtue of high scores. Our plan for next year is to make the test available for the full year with Sports Medicine playing an active role in the process.

The total I.A.P. Physical Education Program was again very successful with several course additions including Aerobic Dance, Rowing and an adaptive Swim Program for handicapped which we hope to expand. The number of I.A.P. participants increased almost 10% to 754.

The Physical Education summer program offerings have been reorganized and expanded to provide greater participation opportunities for the general community and P.E. credit for desirous students. Now summer programs include Weight Training, Advanced Swimming, Sculling, and Fencing.

CLUB ATHLETICS

Club Athletics continues to occupy an ever increasing position of importance in the athletic scheme of things at MIT (see Exhibit III). Growth during the past year continued to come from existing clubs rather than the formation of new clubs. Clubs are increasing the amount and levels of competition and strengthening club structures. Modest budget increases in the club area have been an important factor in this growth. The club program continues to be the vehicle for eventual development of varsity intercollegiate teams. This has been particularly important in the growth of women's athletics. Women's soccer is very likely in its final year as a club, as it moves towards the intercollegiate program. New clubs in dance are in very early stages and likely will become full-fledged clubs shortly if their leadership is energetic and creative enough.

INTRAMURALS

Under supervisor Dave Michael and Assistant Jean Heiney, the 1983-84 Intramural year has benefited from innovations in personnel, finances, operating guidelines and scheduling.

Looking ahead to 1984-85 decisions have been made to eliminate the unpopular activities of chess, backgammon, rifle and golf while adding IAP basketball foul shooting, archery and horseshoes.

Overall student participation (see Exhibit IV) continues to be very strong with particular attention focused on women's activities as the ratio of undergraduate women continues to rise. As Exhibit IV indicates total number of teams and student participants are equal to the high levels of two years ago and only slightly below last year's record levels despite four less program activities eliminated for lack of student interest.

INTERCOLLEGIATE ATHLETICS

MIT offers 34 intercollegiate athletic programs (including Club Varsity Football and men's Ice Hockey) enjoyed by 802 men and women students (17.5% of total undergraduate enrollment). There is a slight drop in intercollegiate participation over previous years partially explained by the decline in men students and partially by shifts in student interest to the diversity of the growing club programs.

Exhibit V indicates the intercollegiate year was highly successful for men and women with 14 of 21 men's programs enjoying winning seasons and 8 of 11 women's programs. Historically this is an extraordinary level of success for MIT teams as are the overall winning percentages for men (.564 vs .556 and .481 the previous two years) and women (.691 vs .631 and .441 the previous two years). This success reflects the tremendous enthusiasm and competitive instincts of our talented students and the outstanding leadership and coaching skills of our superior coaching staff.

Exhibits VI, VII, VIII and IX recap the impressive breadth of individual and team accomplishments among our men and women students during their respective 1983-84 intercollegiate seasons or post-season championship competition.

CHAMPIONSHIP COMPETITION HOSTED BY MIT

Continuing our philosophy to enhance the competitive environment for our students and for athletics in general, MIT had a busy championship event schedule (see Exhibit X) under the leadership of Special Events Coordinator Jack Barry, Director of Operations Jane Betts and Director of Sports Publicity Ken Cerino.

SPORTS PUBLICITY AND COMMUNICATIONS

Director Ken Cerino in coordination with student team managers, full-time and part-time coaches and the media both on and off campus had a particularly active and successful year in providing daily high quality support for the many Athletic Department components.

Ken Cerino's office must be singled out for special recognition with the announcement of eight MIT students on five different intercollegiate teams named to various Academic All-American teams. We believe this number to be the highest in the nation this year and a direct tribute to both our students and the dedication of Ken Cerino who initiates and coordinates all the student nominees support materials.

During the 1983-84 academic year, Sports Publicity assisted in the hosting of all championship tournaments and provided publicity and communication support for: 1) the christening and dedication of three MIT rowing shells, 2) the 1984 Community Service Road Race, 3) the MIT Activities Committee, 4) the 1983 Bay State Games and 5) various alumni groups.

Ongoing activities which remain a high priority include: hometown articles on individual accomplishments and coordination with the campus media (The Tech, Tech Talk, Technology Review, radio station WMBR) on athletic information for the campus community.

In 1984-85, the SI office along with the Admissions Office and Dean of Student Affairs Office will examine the possibility of publishing a general public relations flyer on the department which will be a handy reference guide for staff, coaches, athletes, alumni and prospective student athletes.

The department also plans to update the newly-renovated display cases in the du Pont/Rockwell Cage area. A lounge area for students in the Rockwell Cage lobby is also being discussed.

Finally, a sports awards committee was re-established last spring with its main objective to coordinate all students awards. One change which will take place in 1984-85 affects the Straight 'T' Award, the highest award to athletic excellence at MIT. A new award will be presented for outstanding team accomplishments in addition to individual achievements.

COMMUNITY RELATIONS AND PROGRAMS

The Institute's athletic facilities were used for many diverse community programs during the past year (see Exhibit XI). As always the policy was to be as helpful to the Cambridge community first, and other local areas also, where it was possible to do so without dislocating student activities.

ATHLETIC AND SAILING CARD SALES (see Exhibit XI)

Student, faculty, staff and alumni purchases and usage of the MIT Athletic and Sailing Card permits continues to rise reflecting increased interest in the recreational and instructional programs offered. Athletic Card sales are up over +10% with the largest increase from students. Students also show the largest increase in Sailing Cards as sailing and windsurfing popularity continues to grow.

MIT ATHLETIC FACILITIES AND OPERATIONS

Assistant Director of Athletics Jane Betts continues to provide outstanding leadership in this crucial area. Her report follows:

The following major projects were completed in 1983-84:

- The Class of 1974 IM Health Fitness Center - The traditional weight room was enlarged and renovated with a new ventilation system, additional lights, paint and a new floor. Thirteen Nautilus stations and numerous pieces of free weight equipment were installed, making the facility a modern and highly functional activity center.
- Rockwell Cage - A large section of telescoping bleachers was moved from the Athletic Center and installed on the east wall of Rockwell Cage. An opaque travelling curtain was installed from the north wall to the south wall, making the Cage into two semi-private activity centers.
- Public Address System at Pierce Boat House - Through gifts from Florence Smith and Cornelius Peterson, a system for public address and ship-to-shore radio contact was installed at the Boat House. This equipment will be used primarily for in-progress racing reports and public speaking at Boat House events and ceremonies.
- A new floor was installed in the T-Club Lounge. Essentially, the project was the direct result of a building maintenance problem; however, the new tile floor covering improved the ambiance and serviceability of the room.

Two projects are in progress with completion expected in 1984-85:

- A dressing/shower facility will be added to the east side of the J.B. Carr Tennis Bubble. The project is a gift from Harold Brown and should be completed by Fall 1984. It will have identical facilities for men and women: 16 lockers, 2 showers and 2 toilets. There will be a small storage area for supplies and equipment.
- Artificial outdoor playing surfaces: Plans are being made to select an appropriate product and to creatively finance the installation of artificial surfaces on Briggs Field Areas A, B and C. The following people comprise "The Jimmy Lester Fund for M.I.T. Athletic Field Improvement": Jane Betts, Robert Caldwell '36, Sara DeLeon '85, George Jaquette '85, James Lester, Phil Macneil '79, Chairman Dave Michael, Larry Pickard and Bruce Wrobel '79.

Four projects are under consideration in the discussion stage:

- Increasing the space in W32-235 (Dance Studio) by removing walls from adjoining small rooms. This anticipated space change would create a room better suited to teaching physical education activities and meetings for teams, groups, etc.
- Build an addition to W57 (Alumni Pool) on the southwest corner of the building. A two-story addition would provide additional space for the women's lockerroom on the second level and would provide space for an East Campus health fitness facility on the ground level. The project would also include a corridor for indoor access by women to the squash courts.
- Rockwell Cage Lobby Lounge is a project suggested by students at a recent Athletic Board meeting. This project is currently at the "brainstorming stage."
- There is some justification available to support a project that would involve resurfacing all the du Pont Tennis Courts and the Bubble Tennis Courts with a common synthetic surface. This project is currently at the "discussion stage" with surface suppliers and department personnel.

Physical Plant

The Athletic Department continues to work "hand in glove" with the Physical Plant Grounds Department on maintenance and use of outdoor athletic facilities. The liaison relationships with Jane Betts and Larry Pickard representing athletics and plant respectively seems to be effective in this delicate operation.

Athletic Department supervision of union labor: Boatmen, Boat House attendant, Lifeguards and Athletic Utility Personnel, is working effectively. Long-range plans include extending this supervision to Briggs Field grounds keeping as well.

Computer Component

One year ago two DECmate II machines, two letter-quality printers, and two word processing software packages were purchased. Six staff members each attended a six-hour user seminar. During the year the systems received limited use as word processors. The potential for increasing office efficiency with these systems is untapped. This year we hope to extend the use of word processing to all offices and begin keeping department records via data base management software. There are strong possibilities that a "Project Athena" project would be appropriate for this department in 1984-85.

SPORTS MEDICINE/TECHNOLOGY HEALTH FITNESS

Coordinator of Sports Medicine Paul Grace has provided strong and enthusiastic leadership as the Sports Medicine Unit continues to provide effective and efficient service to the MIT Community. This Department also oversees the staffing of the Class of 1974 IM Health Fitness Center.

- Staffing - In 1983, two new members joined the Sports Medicine staff, Ms. Kathy Davis and Mr. Gary Rizza. Each brought to our department varied interests and competencies, all of which can only additionally strengthen the existing quality of our program. Ms. Del Smith continued to provide excellent support and service during this past year as a part-time staff member. Ms. Smith will be returning next year in a similar capacity. On a sad note, Mr. Jimmy Lester, Senior Athletic Trainer retired due to health reasons. His valuable presence was missed by all.
- Service - The Sports Medicine Unit provides service to the eligible members of the MIT Community. Highlighting the past year of service is the following:
 1. Over 6,100 student athletes were provided service (treatments, etc.) by the sports medicine staff.
 2. Over 650 injuries were recorded as a result of precontest or contest participation by our varsity and junior varsity team members.
 3. The total numbers of MIT Medical Department Sports Medicine referrals totalled 303.
- Equipment - With the purchase and subsequent utilization of the Upper Body Ergometer, our capability to provide upper extremity muscular strengthening and training was enhanced. Additionally, for our non-ambulatory athletes the UBE was used to maintain cardiovascular strength.

Sloan School Health Fitness Instruction

In conjunction with the Sloan School's Executive Programs, over 225 participants have been provided instruction on varied health related topics. The first session began February 1982.

This past year a new component was added to the program: testing, evaluation and program recommendation. This component was received with enthusiasm and interest by the senior executive participants. The underlying goal of the entire program is to provide the participants with the background information on

exercise for effective decisions concerning their respective exercise programs in the future.

Eighty participants were screened for muscular strength, low-back flexibility and cardiovascular endurance.

Class of 1974 Intramural Health Fitness Center

Not yet in operation a full year the Center has become one of our Department's most popular facilities.

Excluding physical education class enrollments, approximately 300 community users (students, etc.) utilize the exercise equipment on a daily basis.

Thirteen Nautilus weight-lifting stations, varied free weight training equipment and a circuit weight training station provide the Center users with exceptional equipment to facilitate muscular and cardiovascular fitness opportunities.

The Center is staffed to provide encouragement, direction and instruction to the users of the facility at all times. Members of the sports medicine staff, part-time varsity team coaches, and most importantly students from Northeastern University Department of Physical Education provide this vital component --- instruction/supervision.

Health Fitness Research

During the past year the Sports Medicine Unit has been involved or assisted in the following studies or projects:

Undergraduate (MIT)

"Evaluation of Three Lateral Knee Braces
by Kinematic Analysis of Gait"

by Terry Felts - Professor Flower

"An Athletic Ankle Brace as an Alternative
To Present Ankle Stabilization Methods"

by Layne K. Xamada - Professor Mann

Graduate (Northeastern University)

"Cybex Evaluation of the Closed Gibney
Ankle Stabilization Pre and Post Exercise"

by Illeana Kalfas - Professor Christensen
(Northeastern University)

Ongoing communication with Dr. Bruns in the Center for Biomedical Instrumentation has provided the first stage of completion of ergometer interface with the Apple Computer.

STAFF ACCOMPLISHMENTS 1983-84

Karyn Altman, Head Coach of Women's Volleyball, named National Division III Coach of the Year by the Collegiate Volleyball Coaches Association.

Jack Barry, Assistant Director of Athletics, served as Director of the Greater Boston League Golf Tournament; Chairman of the NCAA District 1 Golf Committee; Vice President, New England Intercollegiate Golf Association; Division III ECAC Basketball Tournament Selection Committee.

Jane Betts, Assistant Director of Athletics, member of ECAC Council; Collegiate Council of Women Athletic Administrators; MIT Committee for Undergraduate Admissions and Financial Aid, and MIT ROTC Committee.

Ken Cerino, Sports Information Director, named Assistant Press Venue Chief for Fencing by the Los Angeles Olympic Organizing Committee for the 1984 Summer Games in Los Angeles.

Kathy Davis, Assistant Athletic Trainer, selected to serve as a two-week staff athletic trainer at the U.S. Olympic Training Center at Lake Placid.

Paul Grace, Coordinator of Sports Medicine, elected to the Executive Council of the National Commission for Health Agencies and appointed to the Board of Allied Health Professionals for the State of Massachusetts by Governor Dukakis.

Gordon Kelly, Head Coach of Track and Field, served as President of the New England Division III Track Coaches Association.

Gary Rizza, Assistant Athletic Trainer, selected as a staff athletic trainer for the Summer Olympic Soccer Games held at Harvard Stadium.

Dwight Smith, Head Coach of Club Football, named Coach of the Year in the New England Conference.

James Taylor, served as interim Head Coach of both the Squash and Men's Tennis teams during the 1983-84 season with winning records in both programs.

John Terwilliger, Head Coach of Men's Heavyweight Freshman Crew, named to the United States Olympic Rowing team.

STAFF CHANGES 1983-84

New Appointments (Effective 1983-84)

Bayliss, Robert, Assistant Professor and Head Coach of Men's Squash and Tennis (effective 1984-85).

Czuba, Greg, Junior Varsity Coach of Lacrosse - part-time

Davis, Kathy, Assistant Athletic Trainer and Physical Education Instructor.

Klein, Bruce, Assistant Coach of Men's Sailing - part-time.

Macneil, Philip, Assistant Coach of Lacrosse - part-time.

Rizza, Gary, Assistant Athletic Trainer and Physical Education Instructor.

Promotions

Alessi, Walter, to tenured Associate Professor effective 1984-85.

Benedick, John, to tenured Associate Professor effective 1984-85.

Houston, Sandra, to Administrative Secretary (promoted from Senior Secretary).

Retired or Relocation Outside MIT

Gianino, Rosemary, Administrative Assistant

Gilpatric, Jill, Administrative Assistant

Laatsch, Linda, Coach of Women's Gymnastics - part-time

Lester, Jimmy, Senior Athletic Trainer

ROYCE N. FLIPPIN, JR.

EXHIBIT I

M.I.T. ATHLETIC PROGRAM PARTICIPATION

| | Report Year <u>1983-84</u> | <u>1982-83</u> | <u>1981-82</u> |
|--|-------------------------------|----------------|----------------|
| STUDENT ENROLLMENT (October Figures - includes Specials) | | | |
| Undergrad Women | 1,090 | 1,048 | 977 |
| Undergrad Men | <u>3,512</u> | <u>3,571</u> | <u>3,585</u> |
| TOTAL | 4,602 | 4,619 | 4,562 |
| Graduate Women | 976 | 929 | 786 |
| Graduate Men | <u>3,999</u> | <u>3,927</u> | <u>3,649</u> |
| TOTAL | <u>4,975</u> | <u>4,856</u> | <u>4,435</u> |
| GRAND TOTAL STUDENTS | 9,577 | 9,475 | 8,997 |
| <hr/> | | | |
| STUDENT PARTICIPATIONS (Includes Multiple Activity Duplication) | | | |
| 1) <u>PHYSICAL EDUCATION</u> | | | |
| Total Registrations | <u>6,401</u> | <u>6,521</u> | <u>6,098</u> |
| (Undergrad) | (5,149) | (5,384) | (5,190) |
| (Grad) | (848) | (827) | (633) |
| (Staff) | (404) | (310) | (275) |
| 2) <u>INTRAMURALS (M/W & COED)</u> | | | |
| Programs | 25 | 29 | 27 |
| Teams | 1,180 | 1,229 | 1,151 |
| Students | 10,845 | 11,876 | 10,857 |
| 3) <u>CLUBS</u> | | | |
| Programs | 32 | 32 | 29 |
| Students | 857 | 812 | 740 |
| 4) <u>INTERCOLLEGIATES</u> | | | |
| <u>Women's Programs</u> | <u>11</u> | <u>11</u> | <u>11</u> |
| - Student Participants | 206 | 195 | 189 |
| - Varsity Letter Awards | 111 | 119 | 143 |
| <u>Men's Programs</u> | <u>23*</u> | <u>21</u> | <u>21</u> |
| - Student Participants | 596 | 609 | 645 |
| - Varsity Letter Awards | 267 | 259 | 271 |

* Increase from 21 to 23 reflects first time inclusion of Club Varsity Football and Men's Ice Hockey.

EXHIBIT II

PHYSICAL EDUCATION REGISTRATIONS 1983-84
(IN ORDER OF REGISTRATION PARTICIPATION)

| | | | |
|-----------------------------|------------|------------------------|--------------|
| Body Development (Wgt. Rm.) | 769 | Volleyball | 161 |
| Dance | 764 | Sculling | 131 |
| Partner Dance | 243 | Golf | 128 |
| Jazz I | 107 | Lacrosse | 108 |
| Beg. Ballet or (I) | 92 | Basketball Fund. | 96 |
| Inter. Ballet or (II) | 81 | Badminton | 88 |
| Tap Dance | 52 | Ultimate Frisbee | 73 |
| Jazz II | 55 | T'ai Chi | 70 |
| Ballet II-III | 47 | Softball | 65 |
| Exercise for Body | | Judo | 56 |
| Conditioning | 37 | Touch Football | 42 |
| Aerobic Dance | 30 | Karate | 37 |
| Move. for Body Cond. | <u>20</u> | Small Bore Rifle | 30 |
| TOTAL DANCE | <u>764</u> | Rugby | 19 |
| Sailing | 415 | Table Tennis | 19 |
| Skating | 402 | Bicycling | 16 |
| Beginning | 297 | Basketball Officiating | 12 |
| Hockey | 75 | Precision Air Rifle | <u>11</u> |
| Figure | <u>30</u> | | <u>5,647</u> |
| TOTAL SKATING | <u>402</u> | Independent Activities | |
| Exercise Fitness | 391 | Period | <u>754</u> |
| Swimming | 375 | TOTAL | 6,401 |
| Beginning | 180 | | |
| Advanced Beginning | 56 | | |
| Intermediate | 31 | | |
| Advanced Techniques | 24 | | |
| Scuba | 26 | | |
| Skin Diving | 21 | | |
| Red Cross W.S.I. | 20 | | |
| Diving | 9 | | |
| Advanced Life Saving | <u>8</u> | | |
| TOTAL SWIMMING | <u>375</u> | | |
| Tennis | 315 | | |
| Beginning | 189 | | |
| Intermediate | <u>126</u> | | |
| TOTAL TENNIS | <u>315</u> | | |
| Pistol | 290 | | |
| Fencing | 221 | | |
| Squash | 194 | | |
| Archery | 187 | | |
| Yoga | 162 | | |

EXHIBIT III

CLUB PROGRAMS

| | <u>1981-82</u> | <u>1982-83</u> | <u>1983-84</u> |
|-------------------------------------|----------------|----------------|----------------|
| (1) Aikido | 15 | 17 | 18 |
| Archery | 11 | 12 | 14 |
| Badminton | 20 | 27 | 28 |
| (1) Bowling | 11 | 12 | 14 |
| Cheerleading | 12 | 11 | 12 |
| Cricket | 24 | 26 | 26 |
| Fencing | 25 | 30 | 32 |
| Figure Skating | 55 | 50 | 52 |
| Football | 45 | 48 | 50 |
| Folk Dance | 40 | 33 | 33 |
| Frisbee | 60 | 53 | 60 |
| Hockey, Men | 25 | 24 | 26 |
| Hockey, Women | 26 | 27 | 27 |
| (1) Ice Dance | 30 | 34 | 35 |
| Judo | -- | 6 | 11 |
| Karate, Shotokan | 30 | 26 | 26 |
| (1) Lacrosse, Womwn | 12 | 23 | 30 |
| Rifle & Pistol | 45 | 40 | 40 |
| Rugby, Men | 47 | 44 | 48 |
| Rugby, Women | 17 | 18 | 12 |
| Scuba | 25 | 26 | 26 |
| Society for Creative Anachronism | 20 | 19 | 19 |
| Soccer, Grad Men | 24 | 28 | 29 |
| (2) Soccer, Women | -- | 30 | 33 |
| Square Dance | -- | 14 | 14 |
| Table Tennis | 14 | 20 | 26 |
| Tae Kwon-Do | 24 | 22 | 24 |
| Volleyball, Men | 20 | 24 | 24 |
| Water Polo, Women | 13 | 14 | 14 |
| White Water | 20 | 22 | 22 |
| (1) Wu-Tang Boston | 15 | 15 | 16 |
| (1) Wu-Tang MIT | <u>15</u> | <u>17</u> | <u>16</u> |
| TOTAL PARTICIPANTS | 740 | 812 | 857 |
| TOTAL PROGRAMS | 29 | 32 | 32 |

(1) New Clubs 1981-82

(2) New Clubs 1982-83

EXHIBIT IV

INTRAMURAL PARTICIPATION

| | 1983-84 | | 1982-83 | | 1981-82 | |
|------------------|-----------------------|--------------------------|-----------------------|--------------------------|-----------------------|--------------------------|
| | <u>Teams</u> | <u>Approx. No. Part.</u> | <u>Teams</u> | <u>Approx. No. Part.</u> | <u>Teams</u> | <u>Approx. No. Part.</u> |
| Backgammon | 24 | 108 | 39 | 176 | 43 | 194 |
| Badminton | 35 | 175 | 43 | 215 | 52 | 124 |
| Basketball | 130 | 1040 | 134 | 1072 | 138 | 1104 |
| Bowling | 56 | 280 | 75 | 225 | 108 | 124 |
| Chess | Inactive | | Inactive | | 12 | 72 |
| Cross Country | 8 | 51 | 4 | 45 | 4 | 35 |
| Cycling | 5 | 27 | 3 | 29 | 9 | 40 |
| Fencing | Inactive | | 7 | 48 | 9 | 41 |
| Football | 78 | 1170 | 84 | 1260 | 80 | 1200 |
| Frisbee | 59 | 590 | 46 | 460 | 53 | 530 |
| Foosball | Inactive | | 21 | 126 | Inactive | |
| Hockey | 95 | 1140 | 80 | 960 | 78 | 936 |
| Octathlon | 18 | 234 | 18 | 234 | 16 | 192 |
| Pentathlon | 6 | 90 | 6 | 90 | 6 | 90 |
| Pool & Billiards | 22 | 110 | 20 | 100 | 30 | 150 |
| Rifle | Inactive | | Inactive | | Inactive | |
| Rugby | 12 | 118 | 16 | 144 | 8 | 72 |
| Sailing | 4 | 16 | 8 | 32 | 12 | 48 |
| Soccer | 86 | 1452 | 88 | 1496 | 84 | 1428 |
| Softball | 137 | 1918 | 148 | 2072 | 160 | 2240 |
| Squash | 47 | 235 | 54 | 270 | 32 | 160 |
| Swimming | 13 | 93 | 6 | 75 | 8 | 81 |
| Table Tennis | 40 | 280 | 56 | 392 | Inactive | |
| Team Tennis | 32 | 144 | 32 | 144 | Inactive | |
| Tennis | Inactive | | | 128 | 9 | 140 |
| Track, Indoor | 12 | 102 | 9 | 86 | | 110 |
| Track, Outdoor | 6 | 56 | 6 | 64 | | 38 |
| Volleyball | 160 | 1280 | 166 | 1328 | 144 | 1152 |
| Water Polo | 46 | 460 | 46 | 460 | 42 | 420 |
| Weight Lifting | Inactive | | 5 | 51 | 3 | 24 |
| Wrestling | <u>8</u> | <u>90</u> | <u>9</u> | <u>94</u> | <u>11</u> | <u>112</u> |
| TOTALS | 25 Programs | | 29 Programs | | 27 Programs | |
| | 1,180 Teams | | 1,229 Teams | | 1,151 Teams | |
| | 10,845 Participations | | 11,876 Participations | | 10,857 Participations | |

EXHIBIT V

MIT INTERCOLLEGIATE ATHLETIC COMPETITION 1983-84

MEN'S SPORTS (19) (vs. Actual 21)*

| <u>1983 FALL</u> | <u>WON</u> | <u>LOST</u> | <u>TIED</u> |
|------------------|------------|-------------|-------------|
| Cross Country | 4 | 1 | |
| Golf + | 2 | 4 | |
| Soccer | 3 | 9 | 1 |
| Water Polo | 10 | 16 | |

1983-84 WINTER

| <u>WON</u> | <u>LOST</u> | <u>TIED</u> | |
|---------------|-------------|-------------|--|
| Basketball | 2 | 20 | |
| Fencing | 8 | 6 | |
| Gymnastics | 7 | 3 | |
| Pistol | 9 | 1 | |
| Rifle | 46 | 5 | |
| Squash | 10 | 10 | |
| Swimming | 5 | 3 | |
| Track, Indoor | 8 | 0 | |
| Wrestling | 16 | 3 | |

1984 SPRING

| <u>WON</u> | <u>LOST</u> | <u>TIED</u> | |
|----------------|-------------|-------------|--|
| Baseball | 7 | 11 | |
| Crew, Hwt. | 0 | 7 | |
| Crew, Lwt. | 0 | 8 | |
| Golf + | 9 | 4 | |
| Lacrosse | 5 | 9 | |
| Tennis | 8 | 6 | |
| Track, Outdoor | 5 | 0 | |

1983-84 TOTALS 164 127 1
(.564)

1982-83 TOTALS 144 115 1
(.556)

WOMEN'S SPORTS (10) (vs. Actual 11)*

| <u>1983 FALL</u> | <u>WON</u> | <u>LOST</u> | <u>TIED</u> |
|------------------|------------|-------------|-------------|
| Cross Country | 6 | 9 | |
| Field Hockey | 7 | 6 | 1 |
| Tennis ++ | 8 | 4 | |
| Volleyball | 41 | 2 | |

1983 WINTER

| <u>WON</u> | <u>LOST</u> | <u>TIED</u> | |
|------------|-------------|-------------|--|
| Basketball | 11 | 9 | |
| Fencing | 12 | 4 | |
| Gymnastics | 5 | 6 | |
| Swimming | 4 | 5 | |

1984 SPRING

| <u>WON</u> | <u>LOST</u> | <u>TIED</u> | |
|------------|-------------|-------------|--|
| Crew | 6 | 4 | |
| Softball | 19 | 5 | |
| Tennis ++ | 4 | 1 | |

1983 TOTALS 123 55 1
(.691)

1982 TOTALS 98 62
(.613)

* no won-lost record for sailing, skiing
+ golf plays a combined fall/spring season

** no won lost record for sailing
++ tennis plays a combined fall/spring schedule

1983-84 CLUB VARSITY SPORTS

| | <u>WON</u> | <u>LOST</u> |
|------------|------------|-------------|
| Football | 5 | 4 |
| Ice Hockey | 11 | 7 |

EXHIBIT VI

MEN'S INTERCOLLEGIATE ATHLETICS - INDIVIDUAL ACHIEVEMENTS 1983-84

I. STRAIGHT 'T' AWARD WINNERS

FENCING

Russell D. Holtz, Class of 1985 (Tulsa, OK) - Intercollegiate Fencing Association foil champion for the second consecutive year. (Repeat winner)

PISTOL

Larry M. Deschaine, Class of 1984 (Plymouth, CT) - Named to All-America air pistol team. (Repeat winner)

Roberto L. Landrae, Class of 1985 (Carolina, Puerto Rico) - Named Honorable Mention All-America in air pistol. (Repeat winner)

David W. Martin, Class of 1984 (Melrose, MA) - Finished third in standard pistol at the national championships and was named to the All-America team in both free and standard pistol. (Repeat winner)

Jerry L. Martin, Class of 1986 (North Little Rock, AR) - Named Honorable Mention All-America in air pistol.

Jon M. Williams, Class of 1984 (Woodbury, NJ) - Named to All-America team in standard pistol.

RIFLE

Clifford J. Eskey, Class of 1985 (Bethesda, MD) - Named to the NCAA All-America smallbore 1st team, was the New England College League sectional champion in air and smallbore, and had the high average in league competition. (Repeat winner)

SAILING

Albert H. Pleus, Class of 1984 (Plandome, NY) - Was the Division "A" champion at the New England Dinghy Championships held at the U.S. Coast Guard Academy in New London, CT.

SWIMMING

Clark E. Dorman, Class of 1987 (Arlington, VA) - Received All-America recognition after finishing 4th in the 3-meter and 5th in the 1-meter diving events at the NCAA Division III Championships.

Andrew A. Renshaw, Class of 1985 (Albany, NY) - Named to the All-America team for the third straight year after placing 2nd in the 100-yard butterfly and 5th in the 200 butterfly at the NCAA Division III Championships. (Repeat winner)

Robert W. Schoenlein, Class of 1984 (Petaluma, CA) - Received All-America honors for the fourth consecutive year after finishing 6th in the 100-yard breaststroke and 10th in the 200 breaststroke at the NCAA Division III Championships. (Repeat winner)

TRACK AND FIELD

Patrice M. Parris, Class of 1985 (Georgetown, Guyana) - Finished 5th in the 35-lb. weight throw at the prestigious Intercollegiate Association of Amateur Athletes of America (IC4A) Championships. (Repeat winner)

WATER POLO

George W. Jaquette, Class of 1985 (San Rafael, CA) - Named to the American Coaches Association Division III All-America 1st-team.

WRESTLING

Kenneth R. Shull, Class of 1984 (Cogan Station, PA) - New England Division III champion at 134 pounds for the third consecutive year. (Repeat winner)

Straight 'T' Award Winners from the Spring of 1983:

SAILING

Bruce F. Klein, Class of 1983 (Sea Cliff, NY) - Named Honorable Mention All-America by the Inter-collegiate Yacht Racing Association.

TRACK AND FIELD

Patrice M. Parris, Class of 1985 (Georgetown, Guyana) - Named to All-America team after finishing 5th in the hammer throw at the NCAA Division III Championships.

II. ATHLETIC AWARD CONVOCATION WINNERS

The Class of 1948 Award is presented annually to the male senior athlete of the year.

Robert W. Schoenlein, Class of 1984, was a four-year performer on the men's swimming team. He finished 6th in the 100-yard breaststroke and 10th in the 200 breaststroke at the NCAA Division III Championships to become the first MIT swimmer ever to achieve All-America honors four consecutive years. He also placed in the top 12 nationally in both events four straight years.

Schoenlein, a native of Petaluma, CA., also established varsity records in the 100 and 200 breaststroke, and was a member of the 400-yard medley relay team which set another school mark. His efforts helped MIT to a 5-3 record this year and a 7th-place finish at the New England Championships.

The Admiral Edward L. Cochrane Award is given annually to a male senior who has shown highest qualities of humility, leadership, and scholarship in intercollegiate athletics.

John M. Taylor, Class of 1984, was a member of both the indoor and outdoor track teams.

The Malcolm G. Kispert Awards are presented annually to the male and female senior scholar-athlete of the year.

Kenneth R. Shull, Class of 1984, was a member of the wrestling team.

The Burton R. Anderson, Jr. Awards are presented to the outstanding manager of the year for a men's and women's intercollegiate team.

James W. Bishop, Jr., Class of 1984, was a four-year manager of both the baseball and men's basketball squads.

The Varsity Club Award is given to the outstanding freshman athlete.

Clark E. Dorman, Class of 1987, was a member of the men's swimming team while Gordon C. Holterman, Class of 1987, was a member of both the indoor and outdoor track squads.

III. OTHER INDIVIDUAL HIGHLIGHTS

Baseball - Vincent P. Martinelli, Class of 1985 (Orange, MA) was named to the College Sports Information Directors of America College Division Academic All-America first-team. He hit .426 (a school record) and had a cumulative grade-point-average of 4.7 (on a 5.0 scale) in materials science and engineering. Martinelli also was named to the Greater Boston League All-Star team.

Crew (Heavyweight) - The team of Andrew C. Ziegler, Class of 1985 (Menlo Park, CA) at stroke; Ronald G. Wilkes, Class of 1984 (Oceanside, CA); James R. Nugent, Class of 1986 (Poway, CA); Geoffrey R. Kelsch, Class of 1987 (Flushing, MI) at bow, and Steve Meszaros, Class of 1985 (Oakville, Canada) at coxswain won the Intercollegiate Rowing Association National Championship Open Four-oared with Coxswain title.

Fencing - Russell D. Holtz, Class of 1984 (Tulsa, OK) finished seventh in foil competition at the NCAA Championships. Charles H. Kwon, Class of 1984 (St. Cloud, FL) also competed in the national meet.

Football - John K. Einhorn, Class of 1984 (Chatham, MA) was lineman of the year in the National Collegiate Football Association (NCFA) and New England Conference. Einhorn and Fred D. Allen, Jr., Class of 1984 (Washington, DC) were both named to the NCFA first-team All-America squad while Thomas W. Hastings, Graduate (Boston, MA) was selected to the second-team. Einhorn, Allen, Hastings, Scott A. Berceci, Class of 1985 (Pittsburg, PA) and Larry S. Monrow, Graduate (Arab, AL) also were

named to the conference all-star first-team.

Golf - Eric D. Asel, Class of 1987 (Brookville, PA) tied for 29th (among 129 players) at the NCAA Division III Championships to receive All-America recognition. He also was the medalist with a 150 (76-74) at the Greater Boston Championships (GBC) to become the first MIT player to win the GBC title in the 25-year history of the tournament.

Gymnastics - Richard J. Campione, Class of 1985 (Champaign, IL) participated in the NCAA Division II Championships.

Lacrosse - John M. (Mark) Johnston, Class of 1984 (Rye, NY); John A. Laplante, Graduate (Foxboro, MA), and William T. Larkins, Class of 1984 (West Hartford, CT) were selected to play in the East-West All-Star game at Trinity College. Laplante also was named to the All-Colonial League All-Star first-team. He finished his career with 120 points (91 goals, 29 assists) which is third on the all-time MIT list. Johnston received the "Ben Martin Award" for dedication, determination, and spirit.

Rifle - Clifford J. Eskey, Class of 1985 (Bethesda, MD); Mark A. Foringer, Class of 1987 (Fairfax, VA); Felixa Goldenberg, Class of 1985 (Rego Park, NY); Robert B. Cooley, Class of 1985 (Wilbraham, MA); and Pamela C. Sullivan, Class of 1986 (Dover, NH) were named to the New England College Rifle League All-Star team.

Soccer - William T. Mayweather III, Class of 1986 (Stone Mountain, GA) was named to the Greater Boston League All-Star team.

Squash - Ronald S. Reuss, Class of 1986 (Pearl River, NY) won 12 of 20 matches against some of the nation's top players.

Swimming - Clark E. Dorman, Class of 1987 (Arlington, VA) won the one-meter diving event at the New England Championships.

Tennis - John C. Chen, Class of 1984 (Morris Plains, NJ) won the number four singles title at the New England Championships while Robert T. Craig, Class of 1986 (Pepper Pike, OH) and Thomas C. Ransohoff, Class of 1984 (Bethesda, MD) were New England runners-up at number one and number three singles, respectively. Ransohoff and Willard L. Sauer, Class of 1985 (Naperville, IL) finished second in number two doubles competition at the New England.

Indoor Track - Patrice M. Parris, Class of 1985 (Georgetown, Guyana) won the 35-lb. weight throw at the New England Division III Championships with a toss of 59' 1 1/4 ", a meet record. Other winners: Joseph F. Presing, Class of 1984 (Westwood, NJ), 55-meter hurdles, and Ronald E. Smith, Class of 1985 (Darby, MT), 800-meter run. The 1600-meter relay team of John E. DeRubeis, Graduate (Sayville, NY), Daniel Lin, Class of 1986 (Lafayette, CA), John M. Taylor, Class of 1984 (Clifton, NJ), and David M. Richards, Class of 1986 (East Greenwich, RI) also finished first.

Outdoor Track - John M. Taylor, Class of 1984 (Clifton, NJ) won the 400-meter hurdles at the New England Division III Championships after finishing second the previous three years. Taylor, Patrice M. Parris, Class of 1985 (Georgetown, Guyana), and Gregory M. Procopio, Class of 1985 (W. Collingswood, NJ) participated in the NCAA Division III Championships.

Water Polo - Brett A. Hildebrand, Class of 1984 (Saratoga, CA) was named to the American Water Polo Coaches Association All-America second-team.

Wrestling - Kenneth R. Shull, Class of 1984 (Cogan Station, PA); Patrick J. Peters, Class of 1985 (Saline, MI); Timothy P. Skelton, Class of 1985 (Manitowoc, WI); and Stephen C. Ikeda, Class of 1985 (Valparaiso, IN) were named to the NCAA Division III Coaches Academic All-America team. Shull finished his career with an 82-7 records and 24 pins.

EXHIBIT VII

MEN'S INTERCOLLEGIATE ATHLETICS - TEAM ACHIEVEMENTS 1983-84

Basketball - took historic trip to India the first two weeks of January playing nine exhibition games as part of a goodwill mission to further international basketball competition between the two nations. MIT spent 97 1/2 hours travelling 20,500 miles to play the nine games (winning three) in 12 days.

Cross Country - Posted a 4-1 record for its sixth consecutive winning season.

Fencing - Won the New England Championships and had an 8-6 record. Since 1969, the team's record in dual matches is a sparkling 156-53 (74.6%).

Football - Finished with a 504 record for its first winning season in three years. Highlight of season was an 18-13 win over Bentley College, the two-time national club football champion.

Golf - Had a combined fall/spring record of 11-8 for its third straight winning season. Since 1973, the team has a record of 127-71-3.

Ice Hockey - Combined an 11-7 record for its fourth straight winning season under the direction of Coach Joe Quinn.

Pistol - Was first in air, free, and standard pistol at the NRA Sectional. Tech was second in free pistol, fourth in standard pistol, and seventh in air pistol at the nationals.

Rifle - Had a remarkable 46-5 record with a perfect 36-0 mark in winning the league title.

Sailing - Placed second at the Greater Boston's and seventh (among 35 teams) at the New England Dinghy Championships, the team's most traditional and most important regatta.

Squash - Had a 10-10 record playing some of the nation's top teams. One highlight was a 5-4 victory over Columbia which was MIT's first win over an Ivy League opponent in three years.

Swimming - Finished seventh at the New England's and 10th at the NCAA Division III Championships while winning five of eight dual meets.

Tennis - Posted an 8-6 record and finished second among 10 schools at the New England Championships.

Indoor Track - Had an 8-0 record for its second unbeaten season in three years and finished second unbeaten season in three years and finished second at the New England Division III Championships.

Outdoor Track - Continued its fine showing with a 5-0 record while again finishing second at the New England Division III Championships.

Wrestling - Compiled an impressive 16-3 record which was the squad's best mark since 1969 and which also was a school record for most wins in a season.

EXHIBIT VIII

WOMEN'S INTERCOLLEGIATE ATHLETICS - INDIVIDUAL ACHIEVEMENTS 1983-84

I. STRAIGHT 'T' AWARD WINNERS

BASKETBALL/SOFTBALL

Louise Jandura, Class of 1984 (Clifton, NJ) - Named to the College Sports Information Directors of America (CoSIDA) Women's Softball Academic All-America 1st-team and CoSIDA Women's Basketball Academic All-America 2nd-team.

FENCING

Anne J. Huber, Class of 1986 (Carisle, MA) - New England Collegiate foil champion.

SOFTBALL

Cynthia C. Robinson, Class of 1984 (Los Angeles, CA) - Named to the New England Intercollegiate Association All-Star team for the third straight year. (Repeat winner)

SWIMMING AND DIVING

Lori A. Blackwelder, Class of 1986 (Cincinnati, OH) - Finished 3rd in the 3-meter diving event at the NCAA Division III Championships to receive All-America honors.

VOLLEYBALL

Team Award. MIT finished 4th at the NCAA Division III Championships and posted a 41-2 record for its best mark in nine years of competition. The Engineers also won the Eastern College Athletic Conference New England Regional Tournament and the Massachusetts AIAW state title. Team members receiving the Straight 'T': Michele M. Heng, Class of 1984 (Lincoln, NE); Amy B. Smith, Class of 1984 (Lexington, MA); Barbara E. Wesslund, Class of 1984 (St. Paul, MN); Lori A. Cantu, Class of 1985 (San Antonio, TX); Janette M. Kauth, Class of 1985 (Columbus, OH); Julie A. Koster, Class of 1985 (Santa Ana, CA); Anella E. Minro, Class of 1985 (Vancouver, British Columbia); Akiko Kodaka, Class of 1985 (Closter, NJ); Jennifer A. Smith, Class of 1986 (Georgetown, Ontario); Lo-Ping Yeh, Class of 1986 (Jackson Heights, NY); Rachel Chin, Class of 1987 (New York, NY); Carol D. Morris, Class of 1987 (Washington, DC). Everyone is a repeat winner except Chin, Morris and Yeh.

Straight 'T' Award winner from the Spring of 1983

SOFTBALL

Cynthia C. Robinson, Class of 1984 (Los Angeles, CA) - Named to the New England Intercollegiate Association All-Star team for the second consecutive year. (Repeat winner)

II. ATHLETIC AWARD CONVOCATION WINNERS

The Betsy Schumacker Award for excellence in athletic competition by an undergraduate woman.

Cynthia C. Robinson, Class of 1984, was a four-year starter on both the women's basketball and softball teams. In softball, she pitched and compiled a career record of 43-16 with an impressive 1.97 earned-run-average. Robinson was named to the New England All-Star team three straight years. In basketball, Robinson was the team's third leading scorer and second top rebounder. Robinson led the women's basketball to an 11-9 record and the women's softball squad to a 19-5 mark this year which were the best performances ever by those respective teams.

The Pewter Bowl Award is given annually to a female senior who has shown highest qualities of inspiration and leadership in contributing to women's athletics.

Amy B. Smith, Class of 1984, was a member of the women's volleyball team.

The Malcolm G. Kispert Awards are presented annually to the male and female senior scholar-athletes of the year.

Louise Jandura, Class of 1984, was a member of the women's basketball, field hockey, and softball squads.

The Burton R. Anderson, Jr. Awards are presented to the outstanding manager of the year for men's and women's intercollegiate teams.

Karen E. Welch, Class of 1984, was the manager of the women's volleyball team.

The Varsity Club Award is given to the outstanding freshman athlete.

Martha R. Beverage, Class of 1987, was a member of both the women's basketball and field hockey teams.

III OTHER INDIVIDUAL HIGHLIGHTS

Basketball - Julie A. Koster, Class of 1985 (Santa Ana, CA) became the first MIT woman to be named to a weekly Eastern College Athletic Conference Division III All-Star team.

Crew - Elizabeth Bradley, Graduate (Cliffside Park, NJ) was invited to the Olympic trials camp at Princeton University.

Fencing - Anne J. Huber, Class of 1986 (Carisle, MA) won the New England Holiday foil title and was selected to the New England Women's Intercollegiate Fencing Association All-Star first-team. Vivian L. Wang, Class of 1984 (Fair Lawn, NJ) and Ann I. Zabludoff, Class of 1986 (Glenside, PA) were named to the second-team. Wang also competed at the NCAA Northeast Regional Championships in New York City.

Field Hockey - Martha R. Beverage, Class of 1987 (Pittsfield, ME) set a school record for most goals in a game, with four against Simmons College.

Gymnastics - Michelle (Missy) Maxfield, Class of 1986 (Houston, TX) took first-place honors in the balance beam event at the New England Division III Championships while finishing third in the all-around competition. She also competed in the NCAA Division II Regional Championships.

Sailing - Michelle M. Bagdis, Class of 1984 (Northboro, MA) and Margaret A. Norris, Class of 1985 (Greenville, NC) finished seventh and eighth, respectively, at the New England Single-Handed Championships.

Softball - Elizabeth J. Anderson, Class of 1984 (Montclair, NJ) completed her career by playing her fourth season on the varsity softball team. She received 12 varsity letters in four years (four each in basketball, field hockey, softball). Terry J. Felts, Class of 1984 (Huntington Beach, CA) also played four years of softball and earned 11 varsity letters during her career.

Swimming - Lori A. Blackwelder, Class of 1986 (Cincinnati, OH) won both the 1- and 3-meter diving events at the New England Division 'B' Championships setting meet and school records in the process.

Volleyball - Lori A. Cantu, Class of 1985 (San Antonio, TX) was among six players named to the Collegiate Volleyball Coaches Association Division III All-America team. Anella E. Munro, Class of 1985 (Vancouver, British Columbia) and Barbara E. Wesslund, Class of 1984 (St. Paul, MN) were named to the second and third Academic All-America team, respectively, by the nation's college sports publicists. Cantu, Munro, Julie A. Koster, Class of 1985 (Santa Ana, CA), and Michelle M. Heng, Class of 1984 (Lincoln, NE) were named to the NCAA Division III Eastern Regional All-Star team.

EXHIBIT IX

WOMEN'S INTERCOLLEGIATE ATHLETICS - TEAM ACHIEVEMENTS 1983-84

Basketball - Posted an 11-9 record for its first winning season in ten years of competition.

Crew - Finished with a 6-4 record winning three of five regattas including the Smith Cup (for the first time since 1980) over Boston University and Northeastern.

Fencing - Compiled a fine 12-4 record against strong competition while finishing second among 10 teams at the New England Championships.

Field Hockey - Had a 7-6-1 record for its first winning season since 1980.

Softball - Had its best season ever finishing with a 19-5 record while winning both the Massachusetts AIAW Class 'C' and Northeast Intercollegiate Athletic Conference Tournament titles.

Tennis - Had a combined fall/spring record of 12-5 which was its first winning season since 1975.

Volleyball - One of best team performances in MIT history. MIT finished fourth at the NCAA Division III Tournament and posted a 41-2 record for its best mark in nine years of competition. MIT hosted and won the NCAA Division III Regional Tournament. Tech also captured the Eastern College Athletic Conference Regional Tournament, the Massachusetts AIAW Class 'A' title, and the Northeast Intercollegiate Athletic Conference championships.

EXHIBIT X

MAJOR TOURNAMENTS AT MIT 1983-84 (CLUB & INTERCOLLEGIATE)

IFA Fencing Championships - March 9-11, 1984
MAIAW Volleyball Championships - November 5, 1983
New England Division III Women's Gymnastics Championships - March 3, 1984
NCAA Regional Women's Volleyball Championships - December 2-3, 1983
MIT Table Tennis Club Tournaments - October 30, 1983; January 29, 1984
MAIAW Tennis Tournament - October 15-16, 1983
GBCAA Women's Tennis Championships - October 1, 1983
Chinese Students Volleyball Tournaments - October 1-2, 1983; February 18, April 21, 1984
Korean Students Volleyball Tournament - November 12, 1983
Graduate Volleyball Club Tournaments - December 11, 1983; March 24, 1984
ECAC Women's Softball Tournament - May 11-12, 1984

EXHIBIT XI

GREATER BOSTON AND OTHER COMMUNITY USAGE OF MIT FACILITIES
1983-84

Alumni Pool

New England Master's Swim Meet
Child Care Office Pre-School Swim Program
Moray Wheels (Disabled Scuba Divers)
Alpha Phi Omega (Cambridge Scouts)

Briggs Field

Westgate Children's Soccer
Middlesex County Courthouse Softball League
Stride Rite Retail Corporation
New England Prep School Track Association
Harvard Varsity Softball
Varsity Baseball (Northeastern vs. Suffolk)
Cambridge Boy Scouts

du Pont Gymnasium

Bay State Games
New England Juniors Volleyball
"That's Incredible" TV Program
New England Independent School Wrestling
Tournament
SAElor Party for Muscular Dystrophy
Walter Sullivan Party

MIT Athletics Center

Mass. State Science Fair
MIT Association of Black Administrators
Conference
White Head Institute Conference
1984 National Logo Conference
Real Estate & Management Conference Luncheon
Mass. State Police Junior Olympics
Mass. Dept. of Civil Service & Registration
Medical Licensing Exam
Suburban League Athletic Association
New England Prep School Track Association
Liberty Athletic Club
N.E. Paralyzed Veterans Wheelchair Sports Team

Fencing Room

U.S. Wrestling Federation
U.S. Fencing Association

Pierce Boathouse

U.S. Rowing Team

Rockwell Cage

Cambridge Police
Niles Company, Inc.
USA vs. Japan Women's Volleyball
Cambridge-Belmont Merchants Softball
Bay State Games

Steinbrenner Stadium

Mount St. Joseph's Academy Girls Track Team
Farr Academy
Cambridge Rindge & Latin Girls Track
Cambridge Sports Union
Bay State Games
Cambridge Police
Kendall Games

Varsity Club Lounge

Walter Sullivan Party

Wrestling Room

U.S. Wrestling Federation

EXHIBIT XII

ATHLETIC CARD SALES

| | <u>1983-84</u> | <u>1982-83</u> |
|---------------------------------|----------------|----------------|
| Students | 6,636 | 6,234 |
| Staff | 1,534 | 1,548 |
| Draper | 248 | 235 |
| Faculty | 392 | 386 |
| Alumni | 467 | 385 |
| <u>Family Cards</u> | | |
| Student (charge beginning 1983) | 493 | -- |
| Staff | 394 | 377 |
| Alumni | <u>110</u> | <u>93</u> |
| TOTAL | 10,274 | 9,258 |

SAILING PROGRAM PARTICIPATION

| | <u>Calendar 1983</u> | <u>Calendar 1982</u> |
|---------------------|----------------------|----------------------|
| Total Students | 1,473 | 1,300 |
| - Card Sales | (1,030) | (925) |
| - Phys. Ed. Classes | (443) | (375) |
| Faculty/Staff | 218 | 193 |
| Alumni | 92 | 93 |
| Special Family | <u>182</u> | <u>147</u> |
| TOTAL | 1,965 | 1,733 |

Medical Department

Even though the surveyors from the Joint Commission on Accreditation of Hospitals (JCAH) commented on the high quality of the care we provide patients, they warned that we were guilty of some mortal sins of omission. We had not delineated privileges for each of our physicians, nor could we document that we reassessed those physicians "in depth" at the time of reappointment. The JCAH, then, following the April 29 visit, offered us the option of considering it to be a consultation and educational experience rather than an official survey. We accepted the offer.

We have now delineated privileges, and have conducted and documented a thorough reassessment of our staff in the course of making recommendations about reappointment. Application for a formal survey for accreditation has been submitted. Although we are quite different from the prototypical hospital, our concern with quality of patient care makes it most appropriate for us to apply for and, we trust, receive accreditation as a hospital.

A major preoccupation for many of us this year has been a re-examination of the governance of the Medical Department. Preparation for the accreditation survey as well as some recent events have crystallized concerns about the current structure of departmental governance. The role, authority, responsibility and accountability of the Medical Administrative Board, the Vice President to whom the Director reports administratively, and the medical staff all need sorting out, as does the general question of the over-all relationships among the Department, the MIT Health Plan, and MIT.

A small group, working with Vice President Constantine B. Simonides, has been looking at these questions. We anticipate bringing some recommendations to the Medical Administrative Board and the Corporation by the end of this calendar year.

As anticipated, this has been an active and important year for our Information Systems Group. Severance of the umbilical cord to MIT's Information Processing Service is all but complete, the manual systems for processing patient registration and visit-connected information are in use, the patient data-base has been updated and substantially corrected. With input from all sections of the Department, the new system is being described and defined. Cables and wiring have been installed and the arrival of the first shipment of hardware to support our computer-based system is excitingly imminent.

The burgeoning Pharmacy Service has again met or exceeded its goals. A sharp increase in volume of business was experienced as the new MIT Health Plan prepaid drug benefit went into effect.

We have continued to participate in the Mount Auburn Hospital Primary Care Internal Medicine Residency Program. Drs. J. Christian Kryder and Gail Clinton have finished their tours of duty; Dr. A. Modest will join the Department in this capacity for the next two years. In addition, for the first time, the Department offered an Introduction to Clinic course (in cooperation with the Mount Auburn Hospital). Three students in the MIT Medical Engineering program participated. Preceptors included Drs. Biller, Kane, Ruth and Shiang.

Staff Changes

Several members of the Department with many years of service have left this year - Florence Dingle, Joseph Leahy, Samuel Stein and Kenneth MacAskill. In addition, our first full-time Surgeon-in-Chief, John V. Pikula, has decided to retire after over 25 years of association with MIT. It is hard to say too much in his praise.

-- APPOINTMENTS --

Barbara J. Bidstrup
Mary R. Connolly
Robert W. Edwards
Deborah J. Friscino
Pamela Greenley
Michael Hatton
Sharon B. Manus
Kathyrn N. Post
Jeffrey Rimpas
Andrew Thomson

In-patient Nurse
Nurse Practitioner
Industrial Hygienist (EMS)
Pharmacist
Industrial Hygiene Engineer (EMS)
Dentist
Nurse Coordinator; OB/GYN
Audiologist
Marketing Coordinator; Health Plans
Technical Director; Health Information
Systems Project

-- RESIGNATIONS --

| | |
|-------------------|---|
| Florence Dingle | Nurse Coordinator; OB/GYN |
| Michael Hatton | Dentist |
| Susan Hudson | Dental Hygienist |
| Jean Inge | Nurse Practitioner |
| Sharon Jackson | Administrator; Dental Service |
| Joseph Leahy | Industrial Hygiene Engineer (EMS) |
| Kenneth MacAskill | Maintenance and Safety Coordinator |
| John V. Pikula | Surgeon-in-Chief |
| Kathleen Reid | Administrator; Psychiatry/Social Work Service |
| Linda Ronis-Kass | Audiologist |
| Clare Sellig | In-patient Nurse |
| Samuel Stein | Physician |
| Andrew Thomson | Technical Director; Health Information Systems Project |

-- CHANGES --

| | |
|-----------------|---|
| Bruce Biller | Physician Coordinator; Quality Assurance Programs |
| George Boylen | Promotion: Industrial Hygiene Officer (EMS) |
| Mark Goldstein | Promotion: Chief, Student Health Programs |
| H. Walter Jones | Promotion: Physician, Chief of Inpatient Services |
| Gioia Morongell | Promotion: Manager for Marketing & Member Services, MIT Health Plans |

Level of Activity

Because we have used a different (manual) method to keep statistics this year, and since the available data cover only ten months, comparisons with previous years will not be attempted in any detail. It is clear that the total number of visits is about the same as has been the case for the two prior years.

An interesting spin-off of the new registration procedure has been the identification of many people who have been coming to the Department for care, even though they are ineligible to do so. In some instances, this perseveration of a well-established pattern of activity has occurred in all innocence (remarriage of a divorced spouse); in some case, a certain ingenuity has been exerted. In any case, the improved patient registration procedure will soon become part of our new computer-based information system, offering this kind of information accurately and quickly.

Environmental Medical Service (EMS)

Despite continuing increases in the demand for services, it has been possible through stabilization of working schedules and restructuring of the Industrial Hygiene staff to reduce the number of technicians by two. Further call upon all EMS services is expected to be quite high as the Whitehead Institute moves into its new facility and brings it up to speed.

The final version of MIT's guidelines for Video Display Terminal Users will soon be distributed. EMS played an important role in the development of the guide and is listed in it as one of the major resources for information and assistance for VDT users.

A major concern has been Massachusetts' new "Right-to-Know" law. The Institute will apply for exemption-status as a research laboratory. Preparation of the application has involved EMS, working with many others. The outcome of this effort will have a profound effect on the Institute and on EMS within it.

Training and teaching activities increased significantly this year. Students from the Harvard School of Public Health and University of Massachusetts Medical School were provided on-site training. Special training seminars were also conducted for Campus Police, electricians and carpenter shop personnel.

Concerns dealt with by the Service have also included asbestos exposure, noise, reentry of effluents, and the "tight building" syndrome. The reentry of effluents containing possible toxic contaminants has been enhanced by the reduced ventilation rates associated with energy saving programs. The tight building syndrome, primarily seen in office areas, is usually associated with low general ventilation rates as well.

A major strength of EMS has been its acceptance by faculty and investigators as a friendly source of help, expert advice, and recommendations. Pressures from outside sources and governmental regulations continue to increase. Great care must be taken to protect this precious asset lest it become - or be seen as - a police force.

Social Work Service

Ronald Fleming, Chief of this Service, offers this:

"The Social Work Service continues to operate at virtual 'capacity' experiencing a heavy sustained demand for services. While the number of individual clients remained virtually unchanged (1984 - 536 cases; 1983 - 534 cases) the number of clinical visits rose nearly ten percent to 3,580.

"The Service continues as well to be active in the MIT community. Staff members this year have been involved with minority students, Nightline staff, Tech Child Care Committee, personnel officers, supervisors at Campus, Lincoln and Draper, and the Black Administrators Group. In addition, our staff have been involved in two work/study groups within the Institute, one examining policies on the use of alcohol by students on Campus, and the other investigating attitudes about and conditions of work at MIT.

"The effects of MIT's financial retrenchment were relatively less noticeable this year in its effects on the employees to whom we provided services. A possible clinical trend noticed this year was the increased demand for discharge planning services for older or very infirm patients who require either supportive home care services or extended care placements. We are attempting to ascertain if in fact this is a trend because we need to be very concerned about the availability of the needed services.

"The Institute Personal Assistance Program (IPAP) continues to play an active role in the work life of persons at MIT, Lincoln and Draper. Total referrals are now approaching five hundred persons (since IPAP's inception). Recovery rates continue to be at the level of approximately two of every three referrals recovering sufficiently to improve both quality of life and work. Alcoholism remains the single most frequent problem in the IPAP. This year also saw the first meeting of IPAP advisory committee, now a presidentially appointed committee."

Psychiatry Service

For poorly understood reasons, admissions of students to psychiatric hospitals continue to rise. Health Plan member hospitalizations are also significantly increased over last year. The same trends are noted nationally.

Our experience suggests that a core group of patients and families accounts for the lion's share of total admissions and total days of hospitalization. Further study of this phenomenon is needed, as is an increase in our ability to influence the course of treatment once our patients are admitted to outside hospitals.

MIT Health Plan

Laurence H. Bishoff, Chief Administrative Officer of the MIT Health Plan offers the following:

"Membership in the MIT Health Plan crept upward this year from 8,023 people on June 1, 1983 to 8,376 members as of May 31, 1984. Relatively flat growth during the year had been forecasted, due to saturation of the market, increasing competition from existing plans, and the offering of a new competing plan at MIT. These figures, however, do not reflect the activity in the MIT Health Plan office, as turnover this year averaged 30 percent, virtually all due to members leaving MIT.

"In the first three quarters of this year, the MIT Health Plan remains the most popular choice among new MIT employees. Fifty-two percent (52%) of the new employees on the Cambridge campus joined the Plan. Fewer than 100 employees transferred to other health care programs in the first nine months of the year.

"Utilization of outpatient services continues to be very high. Members visited providers at the Medical Department an average 6.2 times per year, the highest rate of any health care plan in the nation. Hospital utilization rose over last year, from 348 days per 1,000 members in acute hospitals to 408 days per 1,000 members. The major driving force continues to be psychiatric utilization accounting for 154 days per 1,000 members, about 5 times the national average, and more days than either medical or surgical admissions.

"A prepaid drug benefit was added in January of this year, which increases service to members, decreases the forms and filing requirements, and increases the volume in the MIT Pharmacy. Also, the competitive position of the Plan's benefit package is enhanced. Initial reception from members and staff is positive. Following introduction of the benefit, service to Lincoln Laboratory staff members was improved via a prescription delivery service using the Lincoln Laboratory shuttle.

"The Effectiveness of the MIT Health Plan administrative service was enhanced with the appointment of Gioia Morongell as Manager for Marketing & Members Services. Members have benefited from an integrated

"approach to services from the Plan. This spring, Jeffrey Rimpas joined the staff as Marketing Cordinator, increasing our ability to respond to the increasing competition in Boston for consumers' health care dollars, and to respond to the specific needs of our community."

MELVIN H. RODMAN, M. D.

MIT Press

Last year we published one of our best and most successful book lists, launched three new journals, and achieved strong financial results. We published 145 titles: 109 were original publications and 36 were paperbacks reprinted from our own hardcover backlist. Nine of the original publications were issued simultaneously in hardcover and paperback; and 13 were original paperbacks. We sold a total of 435,000 copies of our books for a net sales of \$5,360,000, up 8.8 percent from the previous year. Domestic sales were up 11 percent, foreign sales up six percent. Sales for U.K. and the Continent were flat due to the booming buck and there was significant improvement in sales to Canada and Japan. In Journals, paid subscribers were 35,500 and sales were \$2,537,000, up 18 percent from the previous year.

Some of our best sellers were:

| | |
|-----------------------------|--|
| Winston & Prendergast | <i>The AI Business: Commercial Uses of Artificial Intelligence</i> |
| Brady, et al | <i>Robot Motion: Planning and Control</i> |
| Bhagwati & Srinivasan | <i>Lectures on International Trade</i> |
| Pearce | <i>Dictionary of Modern Economics</i> |
| Lynch & Hack | <i>Site Planning, 3rd Edition</i> |
| Pulos | <i>American Design Ethic: A History of Industrial Design</i> |
| Herdeg | <i>The Decorated Diagram: The Bauhaus Legacy</i> |
| Pacey | <i>The Culture of Technology</i> |
| Cornell & Gorenstein | <i>Astronomy From Space: Sputnik to Space Telescope</i> |
| Thompson, Coldrey & Bernard | <i>The Pond</i> |
| Akmajian, Demers, & Harnish | <i>Linguistics: An Introduction to Language and Communication, 2nd Ed.</i> |
| Jackendoff | <i>Semantics and Cognition</i> |
| Barwise & Perry | <i>Situations and Attitudes</i> |
| Churchland | <i>Matter and Consciousness</i> |
| Harre & Lamb | <i>The Encyclopedic Dictionary of Psychology</i> |
| Sterba | <i>The Aquarium Encyclopedia</i> |

Books written by MIT faculty:

| | |
|--------------------------|--|
| Kindleberger & Audretsch | <i>The Multinational Corporation in the 1980s</i> |
| Joskow & Schmalensee | <i>Markets for Power: An Analysis of Electric Utility Deregulation</i> |
| Dornbusch & Simonsen | <i>Inflation, Debt, and Indexation</i> |
| Wilson | <i>The Design of High-Efficiency Turbomachinery and Gas Turbines</i> |
| Hildreth | <i>The Measurement of Visual Motion</i> |
| Leighton | <i>Complexity Issues in VLSI</i> |
| Lynch & Hack | <i>Site Planning, 3rd Edition</i> |
| Berwick & Weinberg | <i>The Grammatical Basis of Linguistic Performance</i> |
| Winston & Prendergast | <i>The AI Business: Commercial Uses of Artificial Intelligence</i> |
| Abelson & Sussman | <i>Structure and Interpretation of Computer Programs</i> |

Abelson & Sussman/ *Structure and Interpretation of Computer Programs* was the first publication in the Electrical Engineering & Computer Science Department Series which will be followed by Seibert/ *Circuits, Signals, and Systems*; Horne/ *Machine Vision*; and Liskov & Guttag/ *Software Design* to be published during the coming year.

Changes in personnel include new managers in our Design, Computergraphics and Journals Departments, two of whom were promoted from within. In addition to expanding our Acquisition Department to support the development of our computer science and economics programs, we also welcomed a new text sales manager, a new designer and additional personnel in circulation and production in our growing Journals Department. Our London operation, responsible for marketing in the U.K. and Europe was completely reorganized and expanded during this past year. There were many changes. The Press lost some long-term valued employees. On balance the enthusiasm and commitment evident from the addition of "new blood" and successful recruiting from within will serve the Press well in the coming years.

Financial results were satisfying. The Press closed its fiscal year with a \$56K net gain from operations, as compared to a (\$50K) deficit in 1983. Sales volume achieved was 8.8 percent above 1983 and total operating expense grew 3.5 percent. Net cash flow was \$370K, on \$7.8 million cash receipts, compared to \$172K, on \$7.2 million, in 1983. One result was that the Press was able to reduce its working capital advances from the Institute to an historic low.

The Journals Division continued to expand, showing a significant profit for the third year in a row. Last year marked the first full year of publication for three journals acquired during the previous year, all of which show promise of operating in the black during the coming year. The Journals operating surplus of \$157K was lower than that of the previous year and the current plan. The decline is attributed to the deferral of more subscription revenues than anticipated on newer journals and to the decision to absorb larger writedowns of back issue stock on a number of annuals in the program.

The MIT Press Bookstore exceeded expectations once again. Total sales of MIT Press books in Kendall Square were in excess of \$160,000. The reason: ambience and good books.

COMPARATIVE OPERATING RESULTS

(in thousands)

| | Fiscal Year 1984 <u>Actual</u> | Fiscal Year 1983 <u>Actual</u> | Fiscal Year 1982 <u>Actual</u> |
|-----------------------|--------------------------------------|--------------------------------------|--------------------------------------|
| Total Net Book Sales | \$5,353 | \$4,919 | \$4,535 |
| Cost of Sales | <u>2,423</u> | <u>2,233</u> | <u>2,154</u> |
| Gross Margin on Sales | 2,930 | 2,686 | 2,381 |
| Other Pub. Income | 31 | 28 | 35 |
| Bookstore Net | <u>30</u> | <u>21</u> | <u>-</u> |
| Total Income | 2,991 | 2,735 | 2,416 |
| Operating Expense | <u>3,092</u> | <u>2,987</u> | <u>2,961</u> |
| Net Books Division | (101) | (252) | (545) |
| Journals Surplus | <u>157</u> | <u>202</u> | <u>146</u> |
| NET | \$ 56 | \$(50) | \$(399) |

The Press received approximately \$120,000 towards the subvention of the publication of 10 of its titles during the past year. Its sources of subvention were the J. Paul Getty Trust; the Millard Miess Fund; AEG, Frankfurt; NEH; NEA; Ford Foundation; Sloan Foundation; General Research Board of the University of Maryland; Bei Shan Tang Foundation; and Xerox. These grants made possible the publication of the following titles:

| | |
|-----------------------------------|--|
| Stafford | <i>Voyage Into Substance</i> |
| Buddensieg, White, & Rogge | <i>Industriekultur: Peter Behrens and the AEG</i> |
| Etlin | <i>The Architecture of Death</i> |
| Craig | <i>The Federal Presence</i> |
| Schrank | <i>Industrial Democracy at Sea</i> |
| Gossen | <i>The Laws of Human Relations</i> |
| Pechman | <i>Economics for Policymaking: Selected Essays of Arthur M. Okun</i> |
| Maxwell, Brush, Everitt, & Garber | <i>Maxwell on Saturn's Rings</i> |
| Liang | <i>A Pictorial History of Chinese Architecture</i> |

Architecture and the Crisis of Modern Science by Alberto Perez-Gomez, won the Alice Davis Hitchcock Award of the Society of Architectural Historians.

Faculty serving on The MIT Press editorial board in 1983-84 were Professors Peter Elias, Kurt Forster, Loren R. Graham, James T. Higginbotham, Robert L. Jaffe, Carl Kaysen, John P. Longwell, and Richard Wurtman. Jay Lucker, Constantine Simonides, and Frank Urbanowski served as ex-officio members. Professor Ascher Shapiro served as chairman of the editorial board.

The MIT Press management board met twice during the year. Members of the board are John M. Deutch, Dean, School of Science; Ann F. Friedlaender, Dean, School of Social Science & Humanities; Alvin J. Silk, Associate Dean of the Sloan School; Jeremiah Kaplan, President, Macmillan Publishing Co., Inc.; Norman Pomerance, Vice President, General Books Group, Harper & Row; Jack Schulman; and W. Bradford Wiley, Chairman, John Wiley & Sons, Inc. Professor Shapiro, chairman of the editorial board, and Mr. Urbanowski, director of The MIT Press, are ex-officio members. Mr. Simonides, vice president in the Office of the President, is chairman of the management board.

BOOK PROGRAM

The complexion of last year's list and the current one in production continues to reflect our intention to devote most of our resources to build depth in our programs in architecture and design arts; computer science and artificial intelligence; cognitive science and linguistics; economics; with the balance of our efforts devoted to publication of important works in philosophy; science technology and society; and science and engineering. During the coming year we will plan and implement the development of another core publishing program in science and/or engineering.

Noteworthy books in our scholarly and professional program included:

| | |
|----------------------------|---|
| Studdert-Kennedy | <i>Psychobiology of Language</i> |
| Boyer | <i>Dreaming the Rational City: The Myth of American City Planning</i> |
| Perez-Gomez | <i>Architecture and the Crisis of Modern Science</i> |
| Pechman | <i>Economics for Policymaking: Selected Essays of Arthur M. Okun</i> |
| Ljung & Soderstrom | <i>Theory and Practice of Recursive Identification</i> |
| Adams & Hickman | <i>Global Econometrics: Essays in Honor of Lawrence R. Klein</i> |
| Etlin | <i>The Architecture of Death</i> |
| Blauert | <i>Spatial Hearing: The Psychophysics of Human Sound Localization</i> |
| Reps | <i>Generating Language-Based Environments</i> |
| Ericsson & Simon | <i>Protocol Analysis: Verbal Reports as Data</i> |
| Johnson | <i>Synthesis of Digital Designs From Recursion Equations</i> |
| Farmer | <i>Modularity in Syntax: A Study of Japanese and English</i> |
| Hildreth | <i>The Measurement of Visual Motion</i> |
| Buddensieg, White, & Rogge | <i>Industriekultur: Peter Behrens and the AEG</i> |
| Stafford | <i>Voyage Into Substance</i> |
| Wussing & Shenitzer | <i>The Genesis of the Abstract Group Concept</i> |
| Hornstein | <i>Logic as Grammar: An Approach to Meaning in Natural Language</i> |
| Aronoff & Oehrle | <i>Language Sound and Structure</i> |
| Liang | <i>A Pictorial History of Chinese Architecture</i> |
| Rock | <i>The Logic of Perception</i> |

New hardcover books for trade and general audiences included:

| | |
|-----------------------------|--|
| Hayes | <i>The Genius of Arab Civilization</i> |
| Muschamp | <i>Man About Town: Frank Lloyd Wright in New York City</i> |
| Cornell & Gorenstein | <i>Astronomy From Space: Sputnik to Space Telescope</i> |
| Pacey | <i>The Culture of Technology</i> |
| Thompson, Coldrey & Bernard | <i>The Pond</i> |
| Rigutti & Giacconi | <i>A Hundred Billion Stars</i> |
| Spear | <i>Presidents and the Press: The Nixon Legacy</i> |
| Diamond | <i>The Spot: The Rise of Political Advertising on Television</i> |
| Reeves | <i>Atoms of Silence: An Exploration of Cosmic Evolution</i> |
| Winston & Prendergast | <i>The AI Business: Commercial Uses of Artificial Intelligence</i> |
| Hennessey | <i>Russel Wright: American Designer</i> |

The American Monograph Series, published for the Architectural History Foundation in New York included three new volumes: Oliver/ *Bertram Grosvenor Goodhue*; Longstreth/ *On the Edge of the World: Four Architects in San Francisco at the Turn of the Century*; Curl/ *Mizner's Florida: American Resort Architecture*; Turner/ *Campus: An American Planning Tradition*.

We published 12 new titles in the inaugural year in our series with the Institute for International Economics including the highly successful titles: Cline/ *International Debt and the Stability of the World Economy*; Williamson/ *IMF Conditionality*.

Our series in German Social Thought included the publication of Offe & Keane/ *Contradictions of The Welfare State*; Peukert & Bohman/ *Science, Action, and Fundamental Theology: Toward a Theology of Communicative Action*; Habermas/ *Observations on "The Spiritual Situation of the Age"*; Theunissen & Macann/ *The Other: Studies in the Social Ontology of Husserl, Heidegger, Sartre, and Buber*; Habermas/ *Philosophical-Political Profiles*.

Our Bradford imprint included the publication of Brandon & Burian/ *Genes, Organisms, Populations: Controversies over the Units of Selection*; Brand/ *Intending and Acting: Toward a Naturalized Action Theory*; Hornstein/ *Logic as Grammar: An Approach to Meaning in Natural Language*; Millikan/ *Language, Thought, and Other Biological Categories: New Foundations for Realism*; Miller/ *Husserl, Perception, and Temporal Awareness*; Stich/ *From Folk Psychology to Cognitive Science: The Case Against Belief*; Barwise & Perry/ *Situations and Attitudes*; Rock/ *The Logic of Perception*; Churchland/ *Matter and Consciousness*; Flanagan/ *The Science of the Mind*; Sober/ *Conceptual Issues in Evolutionary Biology: An Anthology*; Pylyshyn/ *Computation and Cognition: Toward a Foundation for Cognitive Science*.

New Series in our Bradford imprint include:

LEARNING, DEVELOPMENT AND CONCEPTUAL CHANGE: Lila Gleitman, Susan Carey, Elizabeth Spelke, and Elissa Newport; COGNITIVE NEUROSCIENCE: Michael Gazzaniga; COMPUTATIONAL MODELS OF COGNITION AND PERCEPTION: Jerome Feldman, Patrick Hayes, and David Rumelhart.

Books published and directed primarily at the textbook market included:

| | |
|-----------------------------|--|
| Chick | <i>Macroeconomics after Keynes</i> |
| Nigam | <i>Introduction to Random Vibrations</i> |
| Wilson | <i>The Design of High-Efficiency Turbomachinery and Gas Turbines</i> |
| Bhagwati & Srinivasan | <i>Lectures on International Trade</i> |
| Sober | <i>Conceptual Issues in Evolutionary Biology: An Anthology</i> |
| Churchland | <i>Matter and Consciousness</i> |
| Flanagan | <i>The Science of the Mind</i> |
| Akmajian, Demers, & Harnish | <i>Linguistics: An Introduction to Language and Communication, 2nd Ed.</i> |
| Lynch & Hack | <i>Site Planning, 3rd Edition</i> |
| Whiffen | <i>American Architecture</i> |

New reference books this year included: Pearce/ *Dictionary of Modern Economics*; Harre & Lamb/ *The Encyclopedic Dictionary of Psychology*; The Boston Area Music Libraries/ *The Boston Composers Project: A Bibliography of Contemporary Music*.

The ACM Doctoral Dissertation Series, launched in fiscal year 1983, included three new publications this year. Reps/ *Generating Language-Based Environments*; Hildreth/ *The Measurement of Visual Motion*; Johnson/ *Synthesis of Digital Designs From Recursion Equations*.

The Press also launched two new series in the History of Computer Science which included the publication of four books in the Charles Babbage Institute Reprint Series for the History of Computing under the general editorship of Martin Campbell-Kelly; and two new books in the MIT Press Series in the History of Computing under the general editorship of I. Bernard Cohen and William Aspray.

The Press launched four new series in computer science during this past year under the general editorship of Peter Denning, currently director of the Research Institute for Advanced Computer Science.

FOUNDATIONS OF COMPUTING, edited by Michael Carey, AT&T Bell Laboratories; INFORMATION SYSTEMS, edited by Michael Lesk, Bell Communications Research; SCIENTIFIC COMPUTATION, edited by Dennis Gannon, Purdue University; COMPUTER SYSTEMS, edited by Herb Schwetman, Purdue University.

Acquisition editors at the MIT Press include Frank Satlow (Engineering & Computer Science); Laurence Cohen (Sciences, Engineering & Philosophy); Roger Conover (Architecture & Design Arts); Robert Bolick (Economics, Management & Linguistics); Harry & Betty Stanton (Cognitive Sciences, Bradford Books); Terry Ehling (Computer Science & Economics).

BOOK PRODUCTION

Under the direction of Helen Osborne, managing editor, and Dick Woelflein, production manager, the editorial and production departments produced many fine books. Computergraphics, under the new management of Miriam Palmerola, produced over 12,000 pages of type at competitive rates. Turnaround continues to be faster and work more error free than with outside compositors. The Design Department, under the new management of Diane Jaroch, continued to produce fine book and jacket designs, winning multiple awards from the Boston Art Directors Club, the Association of American University Presses, the New England Book Show, and the American Institute of Graphic Arts Show, and Print Magazine Design Annual.

BOOK SALES

Under the direction of Tom McCorkle, marketing manager, domestic sales increased 11 percent over last year. Sales in the United States and Canada by distribution channel were as follows:

| <u>Customer Type</u> | <u>Fiscal Year 1984</u> | <u>Fiscal Year 1983</u> | <u>Fiscal Year 1982</u> |
|----------------------|-------------------------|-------------------------|-------------------------|
| | (in thousands) | | |
| College Bookstore | \$1,105 | \$ 885 | \$ 755 |
| Retail Bookstore | 1,159 | 1,108 | 1,123 |
| Wholesale/Jobber | 1,163 | 1,042 | 848 |
| College/Univ. Lib. | 136 | 123 | 107 |
| Direct Mail | 412 | 388 | 341 |
| Other | <u>357</u> | <u>346</u> | <u>341</u> |
| Totals | \$4,332 | \$3,892 | \$3,515 |

This has been a satisfying and encouraging year. Sales in the United States and Canada are up about 11 percent; sales to college bookstores, the bulk of which are text adoptions, are up 15 percent over last year and are 31 percent greater than they were two years ago.

International Sales and Subsidiary Rights

International sales increased six percent over last fiscal year, representing approximately 23 percent. Substantial sales increases in Canada, Japan, and Latin America more than compensated for decreased sales in Australasia, Continental Europe, and Mainland China.

International Sales, FY 1982-1984

| | <u>FY 1984</u> | <u>FY 1983</u> | <u>FY 1982</u> |
|------------------------------|----------------|----------------|----------------|
| Australasia | \$ 35,000 | \$ 36,000 | \$ 42,000 |
| Canada | 229,000 | 206,000 | 187,000 |
| Japan | 251,000 | 194,000 | 238,000 |
| Rest of Asia/Other | 109,100 | 119,000 | 94,000 |
| Latin America | 47,500 | 27,000 | 64,000 |
| UK/Europe/Africa/Middle East | <u>560,600</u> | <u>580,000</u> | <u>543,000</u> |
| Totals | \$1,232,200 | \$1,162,000 | \$1,168,000 |

There was a very modest 1.7 percent increase in subsidiary rights sales this year. Time was spent in the development and implementation of a streamlined system for handling permission requests (shown as "reprint rights" in the table below). This new system has freed time for concentration on boosting translation rights sales during fiscal 1985.

Subsidiary Rights Income, FY 1982-1984

| | <u>FY 1984</u> | <u>FY 1983</u> | <u>FY 1982</u> |
|------------------|----------------|----------------|----------------|
| Trans. rights | \$26,592 | \$28,335 | \$34,240 |
| Book Club rights | 11,224 | 12,647 | 18,332 |
| Reprint rights | <u>19,979</u> | <u>15,844</u> | <u>28,330</u> |
| Totals | \$57,795 | \$56,826 | \$80,902 |

Direct Mail and Promotion

Under the direction of Brooke Stevens, promotion manager, direct mail income was \$412,000, up six percent from last year. After an 18-month start-up period, the economics backlist began making a large contribution toward mail-order sales. A new computer science catalogue mailed this spring broke even after just one month. And *The Encyclopedic Dictionary of Psychology* was the most successful single-book mailing, producing sales of \$26,000.

In addition to about 1500 reviews and notices, vigorous publicity efforts produced major reviews of architecture and design titles in The New York Times Book Review, The New York Review of Books, House & Garden, Vanity Fair, and The Los Angeles Times. A major review of Arnold Pacey's *The Culture of Technology* appeared in February 1984 in the New York Times Book Review.

Journals Department

MIT Press Journals has steadily expanded over the last five years, and now publishes 18 scholarly and professional journals in a wide range of disciplines.

PLACES, a new journal of environmental design co-edited by William Porter and Donlyn Lyndon, was launched in the fall of 1983 with seed money from the National Endowment for the Arts. In just over nine months the journal has built a paid subscriber base of 1,484. A promotion mailing for DESIGN QUARTERLY, a publication of the Walker Art Center, landed it over 1,000 subscribers. and CELL increased its subscriber level by 1,000.

Journals continued to win many prestigious awards. THE INTERNATIONAL JOURNAL OF ROBOTICS RESEARCH, edited by Richard Paul and Michael Brady, received the 1983 Association of American Publishers/Professional and Scholarly Publications Division Award for Best New Journal in the category of technology. PERSPECTA 21: The Yale Architectural Journal won the Boston Art Director's Association silver medal. Mildred Friedman, editor of DESIGN QUARTERLY, won an award for general excellence in design by the American Institute of Architects. ROBOTICS RESEARCH was reviewed in Nature, October 1983, and an article appeared in the March 1984 issue of HARPERS on "The Sexuality of Christ in Renaissance Art and in Modern Oblivion," The Summer 1983 Special Issue of OCTOBER, edited by Annette Michelson and Rosalind Krauss.

Other journals in the program are CELL, edited by Benjamin Lewin; COMPUTER MUSIC JOURNAL, edited by Curtis Roads; DESIGN QUARTERLY, a publication of the Walker Art Center focusing on contemporary design; THE DRAMA REVIEW, edited by Michael Kirby; JOURNAL OF INTERDISCIPLINARY HISTORY, edited by Robert Rotberg and Theodore Rabb; INTERNATIONAL SECURITY, edited by Albert Carnesale and Michael Nacht; LINGUISTIC INQUIRY, edited by Jay Keyser; MILBANK MEMORIAL FUND QUARTERLY, edited by David Willis; OCTOBER, edited by Annette Michelson and Rosalind Krauss; PLACES, coedited by William Porter (MIT) and Donlyn Lyndon (UC/Berkeley); HARVARD ARCHITECTURE REVIEW, sponsored by the Graduate School of Design at Harvard University; PERSPECTA: Yale Papers in Architecture, sponsored by the School of Art and Architecture at Yale University; VIA, sponsored by the Department of Architecture, University of Pennsylvania; INTERNATIONAL JOURNAL OF ROBOTICS RESEARCH, edited by Richard Paul and Michael Brady; MIMAR/Architecture in Development, edited by Hasan Uddin-Khan; INTERNATIONAL ORGANIZATION, edited by Peter Katzenstein, and THE WASHINGTON QUARTERLY, edited by Richard Bissell.

Ann Reinke Strong has resigned after heading the Journals division for six years. Christine Lamb, Journals Production Manager since 1981, will succeed her as Journals Manager.

FRANK URBANOWSKI

News Office

MIT continued in 1983-84 as one of America's most publicized universities.

During the year, the News Office issued a total of 267 press releases, plus monthly calendar of events listings.

Thirty-nine releases dealt with art, music, drama, dance, etc., cultural activities for which MIT is becoming celebrated not only regionally, but also nationally. Assistant Director China Altman, in her second year with us, has been in charge of publicizing art, music, and related activities, and has enjoyed uncommon success, particularly at the level of national publications. Her successes have been due, in no small part, to the outstanding job of organization and management that she has brought to the task. She has trained and organized people within MIT cultural organizations into a working publicity network, used the News Office's so-far rudimentary word processing equipment to bring sense and logic to our release lists and calendar mailing lists, and has made effective contacts with important news media people.

Twenty-four of our releases dealt with the results of research at MIT and were written principally by Assistant Directors Robert C. Di Iorio (most particularly in areas of engineering and science) and Charles H. Ball (in areas of management, social science, architecture, planning and humanities). In addition, they have facilitated the reporting of numerous other stories out of MIT stemming from the University's expertise and research programs and pursued by the nation's press. As respondents to media requests for assistance, MIT's News Office continued during the year to live up to its reputation among news media people as one of the most effective and responsive university news operations in the country.

Tech Talk, the University's campus tabloid newspaper edited by Joanne Miller, was published 37 times during the year aggregating 300 pages of news, pictures, calendar items, notices, positions available and classified ads. In addition, there were three supplements to Tech Talk: Arts In The News, Report Of The President, and Committees Of The Institute. Judging from spoken and written comments from throughout the University, Tech Talk continues to be a popular and much-sought-after medium of communications for the University's diverse populations. A nagging Tech Talk problem, perhaps the result of its popularity, continues to be the week-to-week accumulation of more news than there is room in the newspaper. The plain fact is that, in the steady state, MIT and its people generate more news than the newspaper as presently constituted can accommodate.

Calvin Campbell's photographs for the News Office continued to win attention for the University in the outside news media, and to form an important part of Tech Talk. Outside, his photographs this year of the TARA tandem mirror machine at the Plasma Fusion Center, of students setting speed record for pedal powered airplanes with the vehicle they call Monarch, and of two women students working with a space suit in the MIT wind tunnel all captured news attention throughout America and in several foreign countries.

All of us are grateful for the support we have received from support staff members Lynn Heinemann (Tech Talk), Lisa Hirsh (press releases) and Leova Wolf (administrative secretary). We are equally grateful to our student employees: Dora Lee, Norman Chen, Jennifer Wiseman, Steven Hunter, John Phillips and Todd Weber.

During the second half of the year, the News Office initiated for principal officers of administration a weekly summary of stories involving MIT and appearing in the nation's press. The news digest was intended as an experiment. It was suspended at the end of the year to permit a period of evaluation and comment before a decision is made to continue it on a permanent basis.

ROBERT M. BYERS

Office of Admissions

This year a significant effort was devoted to seeking a solution to the dilemma caused by the continued growth of interest in the Department of Electrical Engineering and Computer Science (EE/CS) among our applicants and our students. On campus this was called the Course VI Enrollment problem but the impact is being observed wherever engineering or computer science is taught. At this time we also face the integration of computer technology, through Project Athena, into the entire curriculum and our ways of learning and teaching. To maintain our historic thrust toward intellectual diversity and programmatic flexibility is no small challenge in the face of these trends.

This is a moment to reflect on longer-term issues. Professor B. Alden Thresher in his last annual report (1961) as Director of Admissions forecast that admissions officers' "basic preoccupation will continue to be with educational guidance in the broadest sense, and that they will find themselves at a hinge point upon which will inevitably converge many of the social stresses generated in a world for which higher education has become a major concern." This is true even as we write.

By the time Professor Roland B. Greeley wrote his last report (1972) as Director of Admissions, the concerns were of special recruiting efforts for minority students, women, and even engineers. Today the concern is too many electrical engineers and still not enough minority and women students at MIT.

Both Professor Thresher and Professor Greeley were frequently heard to say that the character of MIT's student body is dictated by who applies and who decides to enroll. In other words, self-selection controls our future and the admissions process. Our success or failure to develop the student body we want is dependent on our skill in communicating to the high schools and their students the reality of student life (intellectual, social, and emotional) on this campus. In addition, we must provide adequate financial resources for student support, and respond to the challenge of caring for each individual who has made an inquiry about the opportunities here.

Some changes in the past twenty years are shown in the table below. We all can be encouraged by the increase in enrollment among women, but must face with renewed vigor the task of enrolling more students from minority groups.

| | <u>1964</u> | <u>1974</u> | <u>1984</u> |
|------------------------|-------------|-------------|-------------|
| Applications | 3846 | 4421 | 6049 |
| Freshmen | 869 | 825 | 752 |
| Freshwomen | 39 | 211 | 307 |
| Minority Students | unknown | 62 | 110 |
| College Transfers | 68 | 115 | 91 |
| New Graduate Students | 1506 | 1290 | 1290 |
| Educational Counselors | 790 | 1050 | 1550 |

The challenge ahead is to seek out the very best talent wherever it is to be found and bring to MIT this ever renewing energy. Once here individuals must be encouraged, not only to stretch themselves, but to accept responsibility for stewardship of this world and its people. Whatever course of action is chosen in response to the over enrollment in EE/CS, we must not lose sight of these larger goals and must be sensitive to the lifelong search of MIT students and graduates for intellectual challenge in a world where change is a dominant characteristic.

The success of this office is, as it has been for many decades, the result of the efforts of the men and women who have served here. It is only through their dedication that the tasks have been completed and for their efforts MIT can be justly proud.

PETER H. RICHARDSON

ADMISSIONS TRENDS 1975 - 84

| | <u>1975</u> | <u>1976</u> | <u>1977</u> | <u>1978</u> | <u>1979</u> | <u>1980</u> | <u>1981</u> | <u>1982</u> | <u>1983</u> | <u>1984</u> |
|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <u>Entrants from Secondary Schools</u> | | | | | | | | | | |
| Preliminary applications | 8,166 | 8,104 | 7,853 | 9,320 | 10,274 | 11,223 | 12,526 | 12,525 | 12,653 | 12,465 |
| Final applications | 4,726 | 5,194 | 4,838 | 4,870 | 5,368 | 5,677 | 5,922 | 5,921 | 5,959 | 6,055 |
| Admissions offered | 2,106 | 2,277 | 1,939 | 1,865 | 1,813 | 1,809 | 1,909 | 1,898 | 1,817 | 1,854 |
| Actual registration | 1,154 | 1,044 | 1,073 | 1,059 | 1,059 | 1,081 | 1,031 | 1,050 | 1,109 | 1,059 |
| Registrations as percent of admissions | 54.7% | 45.8% | 55.3% | 56.7% | 58.4% | 59.7% | 54.0% | 55.3% | 61.1% | 57.1% |
| Number of secondary schools represented | 918 | 866 | 859 | 877 | 893 | 894 | 835 | 842 | 891 | 722 |
| Percent of students from 9 northeastern states | 50.8% | 48.0% | 52.0% | 50.6% | 49.0% | 47.8% | 51.9% | 51.0% | 50.5% | 50.5% |
| <u>College Transfers</u> | | | | | | | | | | |
| Total applications | 879 | 941 | 1,079 | 1,074 | 1,143 | 1,131 | 818 | 1,378 | 1,024 | 1,048 |
| Applications completed | 499 | 536 | 591 | 535 | 486 | 471 | 399 | 425 | 400 | 304 |
| Admissions offered | 200 | 203 | 175 | 172 | 152 | 167 | 93 | 118 | 128 | 124 |
| Actual registrations | 155 | 162 | 141 | 123 | 124 | 119 | 76 | 82 | 91 | 91 |
| Registrations as percent of admissions | 78% | 80% | 81% | 72% | 82% | 71% | 82% | 69% | 71% | 73% |
| <u>Graduate Students</u> | | | | | | | | | | |
| Total applications | 6,447 | 7,511 | 7,740 | 7,454 | 7,849 | 7,832 | 9,075 | 9,342 | 8,836 | 7,922 |
| Admissions offered | 2,119 | 2,676 | 2,644 | 2,724 | 2,636 | 2,380 | 2,926 | 2,920 | 3,007 | 2,223 |
| Actual registrations | 1,015 | 1,441 | 1,369 | 1,461 | 1,362 | 1,212 | 1,465 | 1,476 | 1,542 | 1,290 |
| Registrations as percent of admissions | 48% | 54% | 52% | 54% | 52% | 51% | 50% | 51% | 51% | 58% |

Office of Career Services and Preprofessional Advising

The economic recovery, which has not benefited all industries equally, was reflected in a mixed bag of indicators in the Office. One welcome sign that things were picking up was that the line of students waiting to sign up for employer interviews seldom was as long as a year ago. Also, at year's end we had information on far more employment offers than the year before. Many companies went out of their way to ensure they had full interview schedules. Seventy-six made arrangements with the Office of Special Events to hold information meetings, compared with 50 in 1982-83. In October 150 company representatives attended a symposium we organized under the auspices of the Industrial Liaison Office on "Technical Recruiting in Changing Times".

On the other hand the number of employers making recruiting visits rose hardly at all, from 405 in 1982-83 to 407 in 1983-84. The number of student interviews also changed very little, hovering near 9,700. Salary offers in electrical engineering and computer science, the two fields in which recruiting was easily the busiest, hardly kept pace with inflation for bachelor's and master's students. By contrast, seniors in chemical engineering, who continued to be worried about the job market after the trying time chemical engineers experienced in 1982-83, were offered salaries up to six percent higher than in 1982-83. The highest salary increases were at the doctorate level - eight percent or more in electrical engineering and in chemistry, up to nine percent in physics.

The demand for graduates in electrical engineering and computer sciences was pervasive, like a prevailing wind. In the spring term alone nearly 300 separate employers asked to see electrical engineers; over 200 asked for students in computer science. By comparison, about 150 firms listed mechanical engineers, and about 60 asked for chemical engineers. The firms looking for electrical engineers and computer scientists were in almost every sort of industry, from computers and communications to aerospace, chemicals, oil, paper, railroads, and banking. They ranged in size from conglomerates to start-ups. They came from all over the country. A student in Course 6 had a wealth of opportunities to choose from. It is little wonder that students are attracted to the department.

There are also other factors, it has to be said, that make electrical engineering and computer science appealing. In both fields innovation is the name of the game. Many of the firms doing the most exciting work are new enterprises and are as youthful in spirit as they are in years. There is the lure, not necessarily very distant, of getting a piece of the action oneself. No other technology buzzes with so many entrepreneurs. Napoleon said that every corporal in the French army carried a field marshal's baton in his knapsack. It sometimes seems as if every MIT student has the draft of a business plan and of a stock prospectus in his.

But for all its glitter Course 6 is not the only route to a rewarding career and the Office, along with the rest of the Institute, devoted considerable effort during the year to pointing out to students the opportunities in other fields.

It helps that the department boundaries at MIT overlap as they do, so that a student does not need to be in Course 6 to learn an appreciable amount about electronics or computers. A student who would prefer to major in physics or mathematics out of love for the subject need not forfeit the chance to work for a computer company if he or she wants to pursue that option. Similarly, much that a student learns in any of the engineering disciplines is highly transferable. The Wall Street Journal gave a good illustration in an article which described the opportunities at investment firms for students with a background in computer science. It mentioned two MIT seniors who accepted jobs during the last twelve months at Morgan Stanley: one was actually a mechanical engineer, the other an ocean engineer.

The ferment in the electronics and computer industries has also created a demand for other disciplines in their own right. Examples are the need for people to develop new manufacturing systems and to develop and process new electronic materials. In 1981-82 over a third of the Institute's graduates in mechanical engineering joined electronics firms. In 1982-83 the electronics industry was the destination of a quarter of the Institute's chemical engineers. For that matter, electronics firms and software houses also took a third of the master's graduates at Sloan. Figures are not yet available for the year just past but it is likely that they will tell the same story, probably even more emphatically.

To help remind students that there continue to be a multitude of paths one can take after MIT and that each of the major fields at the Institute has something to offer, the Office brought out in December the first issue of a publication in magazine format entitled How To Get There From MIT. Alumni representing each of the undergraduate degree programs and a number of fields which a student can enter from any department (e.g. law, banking, medicine, journalism) were asked to write in a personal vein how their careers developed. They did so very engagingly, prompting the News Office to reprint their articles in

successive issues of Tech Talk during the spring term. We printed eight thousand copies of the magazine. They were distributed through the Undergraduate Academic Support section of the Office of the Dean for Student Affairs as well as through the Office of Career Services. Employer advertising in the magazine just about covered the printing bill. Warm thanks are due to the alumni contributors and to the advertisers for their spirited support of this new venture.

Preprofessional Advising

There was a small increase in the number of MIT applicants to medical school, which was largely accounted for by an increase in the number of alumni applicants. A total of 109 candidates filed applications, compared with 101 in 1982-83. They included 70 seniors, four graduate students, and 35 alumni.

Thirty-seven MIT candidates are known to have applied to law school. As in previous years the majority were alumni (21 out of the 37). It is a measure of their ability that 11 out of the total of 37 were accepted at Harvard. Unfortunately it is still too early for complete information on how all the applicants to medical school and law school fared.

Study Abroad

A year ago we took over from the Office of the Dean for Student Affairs responsibility for advising undergraduate students wishing to spend a term or a year studying abroad or at another institution in the United States. The number of undergraduate students going abroad to study has generally run between twenty and thirty a year, far fewer than at many sister institutions. MIT students are held back by their perception that they should complete most, if not all, of their technical work at MIT. As a first step towards identifying foreign institutions at which our students could get credit for technical subjects we arranged a meeting in June between key faculty from mathematics, physics, and mechanical engineering and a representative from Queen Mary College in the University of London. The discussion was promising. If students knew that departments in science and engineering were prepared to give credit for work done abroad it could influence their choice of department, and indeed contribute to their choosing MIT in the first place.

Gifts to the Office

We acknowledge with gratitude significant gifts from the Goodyear Tire and Rubber Company Fund, the Norton Company Foundation, the Procter & Gamble Company, and AT&T Bell Laboratories which allowed us to take a long step forward in the use of computers in the Office, as well as strengthening our services in other ways.

ROBERT K. WEATHERALL

Personnel Office

The reports which follow highlight the past year in the four sections that now comprise the MIT Personnel Office. The present structure and staffing of these sections appears to be particularly effective in meeting the needs of the MIT community in personnel services during a period of restrictive budgets.

The Personnel Office staff have also experienced the difficulty of counseling and assisting many individuals undergoing the hardship of layoff and attrition while experiencing significant reductions in their own office. This year the office achieved its budget reduction goal of a complement of 41 individuals; this compares with 61 individuals in 1975. The ability to continue to meet the goal of service to the community reflects the hard work and competence of all members of the office.

The year ended on a note of change. This will be my last report as Director of Personnel since I was appointed Vice President for Financial Operations effective June 1, 1984. Joan F. Rice, the Manager of Personnel Services and Development for the past three years and a member of the Personnel Office since 1972, succeeds me as Director. I know Joan will bring the same dynamic leadership and skills to this position that she exhibited in her previous positions in Personnel. I wish her and the office well.

A number of other staffing changes occurred during the year. Anne P. Starr left MIT to pursue a career in industry and L. Muriel Birchette was appointed as the Personnel Officer for the School of Science.

I will miss the daily contact with my friends and colleagues in Personnel; but, fortunately, I will not be too far away.

JAMES J. CULLITON

COMPENSATION AND EMPLOYMENT

Benefits Administration

The Compensation Office is nearing completion of development of a benefits database, and is finalizing plans for data entry in FY 1985. When completed, the database will sharply reduce the time currently needed to research employee inquiries, and will also make possible more sophisticated analysis of enrollment and usage of the 22 benefits plans currently offered.

Following the recommendation of an ad hoc committee, pension benefits were increased as of July 1, 1983, for active and retired members of the Retirement Plan for Employees, to help offset some of the effects of recent high inflation. The Compensation Office also completed a yearly calendar of retirement planning communication to individuals eligible for retirement.

In compliance with new, complex federal regulations, in September nearly 150 employees age 65-69 were required to make new choices of health insurance plans. In a cost containment move late in the year the Compensation Office introduced a new enrollment policy for the Blue Cross/Blue Shield Master Medical Plan. New employees can enroll during their first 31 days of employment, and current employees can enroll only during an annual open enrollment period. In addition, the Tufts Associated Health Plan was offered for the first time at MIT as a fifth health insurance plan. Finally, the Affiliate Health Insurance program was implemented for certain persons who are affiliated with MIT but not eligible for employee health insurance.

In January nearly all employees received increases in take-home pay as a result of a new Health and Life Insurance Payment Plan. This plan enables employees to pay their share of health and life insurance premiums with before-tax dollars. All but 29 employees chose to participate in the plan. The Compensation Office also began to explore ways of expanding this plan to include certain other expenses, as federal regulations permit.

A decision was made to improve the long-term disability coverage for faculty, staff, and support staff by providing coverage immediately upon employment for disabilities resulting from accidents. In addition, the service requirement for support staff will be reduced from three to two years for

disabilities from other causes, and the support staff payment formula will be improved. These changes will take effect July 1, 1984.

During the past year the Compensation Office conducted 71 workshop sessions on benefits for current employees, including pre-retirement seminars, tax-deferred annuity workshops, and health insurance open enrollment meetings. Pre-retirement seminars were revised, and tax deferred annuity and health insurance meetings were regularly held at Bates Linear Accelerator and at the Haystack Observatory for the first time. We also held 115 orientation sessions for new faculty, staff, and employees.

The Benefits Editorial Committee continued its work of revising all of the ERISA Summary Plan Descriptions, and began issuing the revised booklets in a new format suitable for inclusion in a Benefits Handbook.

Wage and Salary Administration

The Compensation Office continued its work to provide fair and equitable salary administration across the Institute during the annual reviews, and in studies of individual salary and promotion recommendations submitted by departments throughout the year. The annual review cycle begins with preparation for the Sponsored Research Review early in October, and proceeds through the academic year to encompass the reviews of Faculty, Support Staff, Academic Staff, and Administrative Staff, concluding with year-end reports to the Executive Committee of the Corporation in early June. Through these annual merit reviews, approximately 8,000 individuals received consideration for salary adjustment this year, based on conditions as they exist for the appropriate marketplace, the Institute's economic outlook, and the relationship of the Institute's salary structure to these conditions. Participation in 32 salary surveys during the year, and particularly in the MIT Faculty Salary Survey, the R & D Survey, and MIT's Administrative Survey, enables us to assess the Institute's position to these appropriate markets, and to make informed recommendations to the Executive Committee for adjustments to the Institute's existing salary structures and pay ranges.

Twenty-two universities participated in MIT's 1983 nationwide Faculty Salary Survey. For each of MIT's three faculty ranks, the Institute's average salaries exceeded the overall averages for the 22 universities. Special emphasis at selected ranks in the Schools of Engineering, Management, and Science during this year's Faculty review should help to maintain the Institute's market position in the coming year. Refinements in programs in our tabulation of the survey data have provided participants with information displayed by individual school, and by professorial and institutional rankings. These improvements will also enable our office to provide more detailed analysis to our Deans for the 1985 survey.

A major increase in activity occurred in the classification of new positions in the Staff Salary Administration Program, with the influx of 188 reappointments to the Administrative, Academic Administrative, and Library Staffs from the Exempt payroll. (An additional 65 individuals were reappointed to the Sponsored Research Staff.) A total of 177 requests for reclassification on the Administrative Staff were received during the year: 108 assessments of positions reappointed from Exempt; 25 requests to assess new positions on the Administrative Staff; 9 promotional requests from Support Staff (and one from Service Staff); and 33 requests to reevaluate existing Administrative Staff positions and their salary ranges. The coming summer months should provide the time and concentration of effort necessary to complete these position assessments, and to solicit position descriptions for the remaining 80 reappointments from Exempt. A recent revamping of our database for the Staff Salary Administration Program will enable us to make more efficient use of the information already in the system in analyzing those positions still outstanding.

Salaries paid to members of the Support Staff continue to compare favorably to the local market of major Boston area employers. Salary ranges, and the position standards developed several years ago by the Working Group on Office/Clerical Issues, continue to be useful, fair, and workable guidelines for reaching equitable decisions regarding individual support staff positions, and in particular for assessing requests for promotion within the Support Staff. The position standards contribute substantially to the use of all ranges within the Support Staff Structure.

Employment Activity

The non-academic population on campus as of June 1, 1984 was 4,772. Cutbacks in payrolls continued through the year resulting in a 1.2 percent decrease from last year in the overall campus population.

A total of 951 positions were posted during the year, 11 percent more than the previous year. Personnel Officers interviewed 1,163 applicants, a 7 percent decrease in the number of interviews granted last year. Qualified applicants were referred to one or more supervisors generating 1,620 departmental interviews. Additionally, 5,255 resumes were received, reviewed, and acknowledged by mail. Of these, approximately 80 percent were referred to departments to be considered for available positions. From

this applicant pool of 6,418, 603 were hired. In addition, 174 employees successfully transferred into new positions within the Institute.

KERRY B. WILSON

FACULTY AND STAFF INFORMATION SERVICES

A major effort of the past year centered on organizational and physical consolidation of the two records sections; i.e., the Faculty and Academic Staff Records Office and the Personnel Information Services Office. In the physical consolidation, the sections were combined into a single office area, now located at E19-284. The move permitted a modest expansion of word processing facilities and provided a number of attractive, accessible, and decentralized work stations for this activity. In bringing together in a single work space the activities of the two records sections, the consolidation has begun to enhance coordination of records management methods and procedures.

A principal accomplishment of the past year has been the successful implementation of information systems in support of benefits management and applicant tracking. Prototype systems were tested and evaluated in the spring, and final design modifications were suggested by departmental users. The implementation schedule for these modifications will allow regular, daily on-line access to both systems by mid-summer. The completion of these two systems marks the end of an important phase in the modernization of information systems for the Personnel Office.

Initial steps toward the next phases of system development have been taken through the introduction of microcomputers and associated equipment. The integration of these devices into existing systems should enhance the ability of FASIS to generate specialized reports and analyses, should provide additional information management capabilities to other sections of the Personnel Office, and should point toward the enhancement of decision support in the senior offices outside of Personnel. Plans are already under way to work with a team of systems analysts and programmers from the Administrative Information Services to develop specific microcomputer applications and to overcome some initial technical problems associated with the introduction of these devices.

ISAAC M. COLBERT

LABOR RELATIONS

Early in Fiscal 1984, new two-year Labor/Management Agreements were signed covering 1,650 Service Staff employees in six separate bargaining units represented by one independent and three international unions. James J. Culliton, Director of Personnel, served as the Institute's spokesman and chief negotiator for four of the bargaining units (the Service Employees' International Union-Campus and -Lincoln Laboratory; the Hotel, Restaurant, Institutional Employees' and Bartenders' Union-Student Dining Halls and -Faculty Club). The Institute successfully negotiated the elimination of the fixed percentage employees have been paying for their health benefits. In its place the Unions agreed to share the increased cost of Blue Cross/Blue Shield on a fifty/fifty basis during the term of the Agreement and the Institute offered to tax shield employees' contributions for health benefits and life insurance. All Agreements provided for 6 percent wage increases in the first and second years of the contracts plus certain changes in the Retirement Plan for Employees, Sick Leave, Tuition Assistance, one Personal Day, and other local union/management provisions.

James J. Fandel, Manager of Labor Relations, served as negotiator for the bargaining with the Independent Union of Plant Protection Employees and the Research, Development, and Technical Employees' Union. The Institute's committee, working with a receptive group of RDTEU officials, successfully negotiated new wage structure changes that govern employee merit increases, promotions, and the application of negotiated wage increases. These new provisions replace a system that has been in place for 25 years which had become burdensome to managers and employees alike and obsolete for the purposes it was intended. In addition, new classifications, adjusted rate inequities, and benefits for part-time employees were agreed upon by the parties. The Campus Police Association gave notice in April, 1984, of termination of their current Agreement; and negotiations have reached the final stages, with both sides hopeful of an early settlement.

The grievances have been fewer in number than in past years; but several were directed at basic management rights, such as the right to make job assignments and discharge after completing due process procedures. Two arbitration cases were lost, and four were won without the loss of any management rights. In fact, the Institute's position that the Union does not have a right to simply demand any and all related documents on an issue was upheld by the arbitrator. This award strengthens the

Institute's right to reasonable privacy in labor relations matters. More important, perhaps 18 pending arbitrations were dropped by the Union or resolved by the parties without loss of any contractual rights of the parties. The most significant resolves were reached on pending arbitrations that struck at the basic relationship of the parties on the conditions of work under which management and employees must operate when radiation is present in the workplace.

Labor relations orientation and training sessions are still in demand by managers who continue to request lectures, programs, and general meetings to clarify contract interpretations and the administration of labor Agreements. Working with Personnel Development and independently with departments and laboratories, this Office has had an opportunity to communicate with the managers on a wide variety of personnel/labor relations matters. We plan to continue this effort in Fiscal 1985.

JAMES J. FANDEL

PERSONNEL SERVICES AND DEVELOPMENT

Personnel Services and Development has responsibility for development and interpretation of personnel policies and procedures, service to departments and employees, screening and referral of candidates for positions, and development and direction of training programs.

Eight Personnel Officers, with defined organizational unit responsibilities, continue to work closely with supervisors and employees on organizational needs and issues. Personnel Officers increased their participation in the development and presentation of training programs.

Seven new programs were added in the training area in response to needs expressed by employees. Three of the new programs addressed computer-related skills. Programs continue to be well received, with over 3,000 employees taking advantage of Personnel sponsored programs. In the Perspectives series, sponsored by Personnel in conjunction with the Provost's Office and the Sloan School of Management, four separate presentations by faculty members were well attended.

The large majority of presenters in programs are members of the MIT community, who continue to provide their time and expertise to the training effort.

JOAN F. RICE

Quarter Century Club

The MIT Quarter Century Club was founded in 1950 and became an Institute administrative department in 1978, reporting to the Vice President in the Office of the President.

The membership of the Club totals approximately 1800, with each member having served the Institute for more than 25 years. The annual meeting, at which new members are inducted into the Club, takes place in the spring. Other annual functions include a picnic in the summer and a holiday gathering in December. The Club also provides administrative and logistical support to the Institute's annual charitable campaign and to its retirement dinner in June, as well as special functions when requested by the Administration. The Club also administers the MIT Activities Committee (MITAC) which organizes recreational and cultural activities for the employees.

An extensive travel program is organized for the alumni, retirees, and the Institute community offering approximately 100 departures to various destinations annually. Some of these include lectures or other educational aspects.

There are five officers and nine directors on the board. The staff of the Club consists of Ann P. Brazier, manager, and three assistants, M. Frances Daly, Nanci Drago and Diane Schowalter.

DANIEL H. GOULD

Secondary Technical Education Project

The Secondary Technical Education Project (STEP), which was created in 1974 in response to Judge Arthur Garrity's request that Boston area colleges and businesses assist Boston schools during the period of court-ordered desegregation, has recently completed a year of change and refocus.

The energies of the STEP Ad Hoc Committee and project personnel centered on providing more direct-services to students at Mario Umana High School of Science and Technology, in addition to assisting the Cambridge Public Schools design a model School of the Future for five-to twelve-year-olds.

Under the direction of the Ad Hoc Committee, Alan Dyson, the STEP Director, now spends 80 percent of his time with the Boston involvement (funded through Chapter 636 Massachusetts Desegregation) and 20 percent assisting with the development of the School of the Future (funded through MIT, President's Fund for Community Affairs).

STEP's focus in both Cambridge and Boston is to assist schools integrate computer-based technology into all phases of the curriculum, using the computer as a tool rather than as an object of study.

As we refocus our energies and broaden our interest in Boston from one high school to two high schools, we also are acutely aware of the need for strong collaborative efforts with representatives from the business world.

At the present time, we are working with Digital and Boston Edison in concert with Tufts University, to design small model schools within schools at Boston Tech and Mario Umana High Schools. Our focus will be on tool-based uses of computers.

1983-1984 HIGHLIGHTS

Model Programs

Technology Insights Program - Collaboration, STEP/MIT Museum/Masspep.

MIT/Umana Pilot Writing Program - STEP/Umana English Department/MIT faculty and staff.

Science Mentors Program - MIT fraternity brothers serve as mentors to Umana students.

SAT Prep - Financial Aid Preparation, STEP/MIT Financial Aid Office.

Industry Contribution

Control Data Corporation - A 10 station Plato Basic Skills Lab to Mario Umana High School.

Apple Computer Foundation - 25 Apple IIe's to School of the Future in Cambridge.

ALAN DYSON
DOROTHY MAC DOUGALL

Committee on the Visual Arts

A presidentially appointed group composed of members of the faculty, administration, and student body, the Committee on the Visual Arts (CVA) oversees policy for an ambitious program in the visual arts which is administered by a professional staff. The CVA is charged with a broad spectrum of responsibilities: to foster and present, through its nationally recognized exhibition program, the most challenging contemporary art and design; to provide the MIT community and general public with educational activities which increase visual literacy and explain how the visual arts reflect ideas governing contemporary society; to enhance the quality of the Institute's visual environment and to encourage daily experience with original works of art through three publicly sited collections of contemporary art in all mediums; and to contribute to the cultural vitality of the region.

The CVA met six times during the 1983-84 academic year. A primary concern was drafting a mission statement and five-year plan to reflect both the increased opportunities and pressures associated with the projected March 1985 move to and administration of the Albert and Vera List Visual Arts Center in the new Arts and Media Technology Facility. The Committee agreed its two most pressing initiatives would be to increase external support for its programs and to bolster such educational activities as publications, lectures, inter-disciplinary seminars, and artist-in-residencies. In order to achieve these goals, the Committee, with guidance from the President's Office, hopes to establish in the coming year a board of professional advisors; to strengthen its ties with existing MIT organizations and programs such as the Council for the Arts and Science, Technology and Society; and to increase its range of relationships with regional and national arts institutions.

Other topics of discussion included working with the Bursar to assure the prompt return of art in the two student loan collections; the advisability of replacing posters with postcards for exhibition announcements due to budget constraints; and the desirability of continuing to oversee the Hayden Corridor Gallery after the move to the new Facility. In order to prepare appropriate grant proposals and loan requests, exhibitions planned and proposed for the 1984-85 and 1985-86 schedules were discussed at two meetings; upon the request of the United States Information Agency, two of these exhibitions were developed as proposals for the American Pavillion at the 1986 Venice Biennale.

EXHIBITION PROGRAM

The 10 exhibitions in the 1983-84 season continued to demonstrate the CVA's commitment to exploring and explicating the most pressing issues in contemporary art by both promising and internationally known practitioners. All exhibitions were conceived, organized, and installed by CVA staff; five were supported by generous grants from the National Endowment for the Arts. Attendance is estimated at 30,000, continuing the upward trend of the past several years. Each exhibition opened with a public preview; frequently the participating artists were in attendance.

1983-84 Exhibition Schedule

List and Stratton Student Loan Collections, Hayden Gallery, September 6 - 25, 1983. The annual exhibition and lottery of prints and artist-designed posters, including works by Barry LaVa, William Bailey, and Robert Motherwell.

CVA Poster Archives, Hayden Corridor Gallery, September 6 - 25, 1983. A survey of the outstanding graphic design of CVA exhibition posters from the past decade, made available for purchase.

Peter Campus, Photographs/ David Deutsch, Paintings and Drawings, Hayden Gallery, October 8 - November 13, 1983. Although divergent in medium and scale, these works shared an interest in psychologically charged landscapes, real and imagined, which reflect the effect of man's intervention. (Supported by NEA Museum Program; 28-page illustrated exhibition catalogue published.)

Beyond the Monument, Hayden Corridor Gallery, October 8 - November 13, 1983. This exhibition surveyed, through photographs, plans, and drawings, recent public art projects around the country which fuse form with function. (Supported by the New England Foundation for the Arts, which circulated the exhibition in New England and nationally; exhibition brochure published.)

Jackie Winsor/Barry Ledoux, Hayden Gallery, December 3 - January 15, 1984. Winsor showed five sculptures completed since the 1979 Museum of Modern Art survey of her work; she selected Ledoux, whose five elaborate and allusive sculptures provided an effective foil to her abstract geometry. (Supported by NEA Museum Program; 40-page color illustrated catalogue prepared.)

Local Visions III: Architectural Photography, Hayden Corridor Gallery, December 3, 1983 - January 15, 1984. Seven local architectural photographers showed work of Boston-area buildings, illustrating the wide variety of approaches possible within this theoretically objective discipline and exploring the influence of photography on the perception and practice of contemporary architecture.

Speculation: An Installation, Hayden Gallery and Hayden Corridor Gallery, January 28 - March 4, 1984. During their residency, San Francisco artists Jock Reynolds and Suzanne Hellmuth studied and used historical photographs and artifacts from the MIT Museum in order to create an installation which, focusing on MIT's Radar Laboratory during World War II, raised questions about the content of scientific and technological education and practice. A site-specific photographic work, a permanent documentation of their research, will be sited in the Medical Department as part of MIT's Permanent Collection. (Supported by NEA Art in Public Places Program; artists' book forthcoming.)

Visions of Paradise: Installations by Vito Acconci, David Ireland, and James Surls, Hayden Gallery and other locations, March 24 - April 29, 1984. The three artists each created a work to stimulate reflection on the individual within society and the possibility of an idealized future. Acconci constructed a schematic house between Hayden Library and Building 2, Ireland transformed Hayden Gallery through an architectural installation investigating qualities of mystery vs revelation, and Surls created a large wood and metal spiral of palmettes installed between Hayden Library and Building 18. (Supported by NEA Museum Program; exhibition catalogue forthcoming.)

John Baird: Two Weeks, Hayden Corridor Gallery, March 24 - April 29, 1984. This young Pennsylvania artist showed a diaristic cycle of 14 diptychs, combining drawing and printmaking, which reflected his interest in alchemy and bookmaking.

Aesthetics of Progress, Hayden Gallery and Hayden Corridor Gallery, May 19 - June 24, 1984. The design of consumer products from the 1930s and the 1980s investigated different symbolic attitudes toward the notion of progress in the United States. The Hayden Gallery installation was designed by Tod Williams and Associates, Architects, New York. Posters, drawings, magazine covers, and photographs demonstrated the same disparity in attitude through two dimensional material in the Hayden Corridor Gallery. (Supported by NEA Design Arts Program; 36-page exhibition catalogue published.)

ACQUISITIONS

The Permanent Collection grew through both gifts and purchase. Among major additions were 22 photographs, including examples by Harry Callahan, Robert Frank, Lee Friedlander, Duane Michaels, Eve Sonneman, and Jerry Uelsman, representing highlights of the past 30 years of American photography; prints by Terry Winters, Susan Rothenberg, and Aaron Fink; portfolios of photographs by William Wegman, Gary Winogrand, and Edouard Boubat; paintings by Jennifer Bartlett and Dona Nelson; and drawings by Charles Garabedian, Gary Wiley, Susan Belton, and David Salle. Twenty-nine prints were added to the List Student Loan Program and four works to the Stratton Student Loan Collection. (A complete list of 1983-84 acquisitions is appended.)

New Sitings, Installations, Conservation and Loans

Michael Mazur's monumental monotype diptych, Wakeby Day/Wakeby Night, was installed at 500 Memorial Drive (Dormitory W71) through the One Percent for Art Program. Other One Percent sitings included the survey of recent American photography in the new EG&G building (34) and several works located in the Medical Department Health Services Center (E23). Numerous other works were sited in E19-284, Personnel, the President's Office and other Institute locations.

Restorative work was done by Steven Tatti, Conservator, to Michael Steiner's Niagara; a sculpture by Tsai and three paintings by Jack Youngerman, Neil Williams, and Conrad Marca-Relli received treatment at the Center for Conservation Studies, Fogg Art Museum, Cambridge.

Works were loaned to the Williams College Art Museum (Hans Hofmann, Blue Interior; Thomas Hart Benton, Fluid Catalytic Crackers; Charles Sheeler, GM #2 and Elizabeth Murray, Last Night); to the Institute for Art and Urban Resources, Long Island City (Robert Grosvenor, Untitled) and the Boston Museum of Fine Arts (Ellen Phelan, Tree).

EDUCATIONAL PROGRAMS

A wide range of educational activities, both tied to and independent of the exhibition program, were organized by the CVA to broaden awareness of artists' historical context, various working methods, and thematic concerns.

Undergraduate Seminar

In response to the recommendation of last year's CVA Education Subcommittee, an undergraduate seminar focusing on "Issues in Contemporary Art" was organized by Gary Garrels, Assistant Curator, for both the fall and spring semesters. Visits to area museums and galleries as well as talks by area curators, artists, and collectors were arranged. In view of the enthusiastic response, the Seminar will be offered again next year.

Artist-in-Residency

Suzanne Hellmuth and Jock Reynolds, in residence for six months from August through the January IAP period, met with countless members of the MIT community and attended a variety of activities including classes, meetings, and lectures. During the construction of their installation, the Hayden Gallery was open on two occasions to allow visitors to discuss the issues and approaches with the artists.

Talks, Tours, and Lectures

Gallery talks and tours of the collection were arranged for a number of both visiting and MIT groups, including those returning for their 50th class reunion. A series of three public dialogues was organized around the Visions of Paradise exhibition; the first involved the three artists, the second brought Professor Philip Morrison together with Professor K. Eric Drexler, and the third Professor Leo Marx with Professor David Halperin.

Educational Materials

Descriptive and interpretative material was prepared to accompany and explicate the collection of contemporary work on paper housed at 500 Memorial Drive and for many of the Student Loan prints.

CVA STAFF
BORIS MAGASANIK

Council for the Arts

1983-84, the twelfth year of operation for the Council for the Arts at MIT, was a period of accomplishment and of continued financial stability. A major achievement was the completion of a five-year planning document, which provides a framework for our programs until 1988.

During this past year, Council activities focused on two areas: increased programming in the arts, with an emphasis on the performing arts; and more publications and information about the arts at MIT.

ARTS PROGRAMMING

The Grants Committee made 47 grants totalling over \$63,000 to individuals and organizations associated with the Institute. The Council staff assisted grantees to raise an additional \$118,000 of matching support in cash and \$113,000 of in-kind contributions (an increase of 300 percent and 150 percent, respectively, over last year). The number of proposals submitted to the Grants Committee also increased from 56 to 75, an increase of 42 percent over last year. There was a similar increase in requests for technical assistance: over 20 faculty and students came to the Council staff each week for advice about fund-raising and assistance with proposal writing.

Last year, the staff encouraged more applications to the grants program from MIT individuals and organizations in the performing arts and literature. The response was so impressive that the number of proposals received in these disciplines doubled, as did the number of awards. Of special note was the Writing Program's "Women, Writing, and Society," a lecture and reading series by international poets and writers attended by standing-room-only crowds. Paul Earls, Fellow at the Center for Advanced Visual Studies, received support for his multi-media opera Icarus. It was heralded by critics in The Boston Globe, The New York Times, and The New Yorker.

Funding from the grants program enabled the New Orchestra of Boston, in residence at MIT, to make its public debut at Kresge Auditorium. Six additional grants supported music activities; five supported programs in the dramatic arts; and four grants were awarded for dance projects.

To allow more Council members and grantees to become better acquainted, the staff and Grants Committee Chairman Bradford Endicott planned "A Day with the Artists" on May 3rd. Council members and guests who attended were treated to a full day of site visits and demonstrations by students and faculty. The success of this exchange resulted in a unanimous recommendation to make this an annual event -- a "live annual report" from the Grants Committee.

For the fourth consecutive year, Council efforts and support ensured continued participation in the Boston Museum of Fine Arts university membership program. MIT students are entitled to free admission and other Museum privileges. The Museum staff recorded over 11,000 visits by MIT students during the academic year. The Council staff, assisted by two MIT students, planned a special evening of performances and tours at the Museum in April. "The Event" was coordinated with nine other colleges and universities in the Boston area. The Chorallaries of MIT and the MIT Shakespeare Ensemble gave performances, and Tau Beta Pi installed its musical sidewalk (a project originally funded by the Grants Committee).

The Council received two endowments this year -- the Abramowitz Lecture/Concert Fund and the Louis Sudler Prize in the Arts. The Abramowitz Fund, formerly administered by the Department of Humanities, was established in 1961 by William L. Abramowitz '36 as a memorial to his father. It will enable the Council to present one major artistic event each year for the benefit of the Institute and local community. The Louis Sudler Prize in the Arts was established last year by Louis Sudler, a Chicago arts patron and performer. This award is for a graduating senior who has demonstrated the highest standards of proficiency in music, theatre, painting, sculpture, design, architecture, or film. The Council now administers five endowed funds. MIT, in total, has eleven endowed student art awards -- significantly more than most other universities in the country.

This year, the majority of our awards were made for excellence and participation in the performing arts. The McDermott Award was presented to professor and playwright Albert R. Gurney, Jr. for his contribution to the arts. A generous addition of \$5000 to the endowment of the McDermott Award, given by Mrs. Margaret McDermott, enabled Professor Gurney to establish a student award in the dramatic arts. The MIT Student Drama Writing Award of \$500 will be made annually for the next three years for the best one-act play written by an MIT student.

The Laya and Jerome B. Wiesner Student Art Awards, established by Council members in 1979, are given annually to individuals and organizations which have contributed significantly to the MIT community

through the arts. This year the awards of \$500 each were presented to Film/Video graduate student Barry Strongin for service in the creative arts, and to the MIT Symphony Orchestra and the MIT Concert Band for their contributions to the musical life at MIT.

The first recipients of the Gyorgy Kepes Fellowship Prize were Robert Rosinsky, a candidate in the M.S. Visual Studies program, and Bernd Kracke, a Fellow at MIT's Center for Advanced Visual Studies. The awards recognized their concern for human values as reflected in the relationship between art and the environment. The Louis Sudler Prize was presented to William Glickman '84 for his outstanding accomplishments in drama, particularly with the MIT Shakespeare Ensemble.

After numerous annual meetings devoted to the visual arts and media technology, the Council's Twelfth Annual Meeting featured the performing arts. The MIT Brass Ensemble heralded the opening session; the MIT Chorallaries entertained members at a luncheon reception at McCormick Hall; and the Meeting closed with dance music by the Intermission Trio, led by Council Secretary Roy Lamson. The most memorable performance was by Tony Award-winning actress Zoe Caldwell. For the 66 members and 64 guests who were in attendance, Ms. Caldwell's address was unforgettable. For those unable to attend, her words were recorded and distributed on tape.

At the luncheon address, President Paul Gray spoke on the role of the arts in undergraduate education at MIT. "I believe that significant contributions to science and technology will come more often from men and women who are broadly cultured than from those who are narrowly specialized. We must ensure that our students have the humanistic dimension to appreciate a wide range of values in order to become responsible decision-makers and creative problem solvers in the modern world." He then challenged the membership to use the coming years "to enhance and encourage student experience in the arts."

Because previous annual meetings have been so tightly scheduled with Council business, awards, and presentations, this year we arranged a special reception and dinner on the evening before. Held at the MIT Museum, this gathering gave members and special guests an opportunity to talk informally, reminisce, and become better acquainted. It also provided an appropriate setting to honor Paul Tishman and Yulla Lipchitz, whose photographs were on display.

VISIBILITY

The Council staff made a special effort this year to ensure that information about the arts at MIT was more visible and readily available to alumni, students, prospective students, and the MIT community. Many of our activities resulted from recommendations made in the Grants Program Evaluation and Report, completed in the spring of 1983. Of the 19 recommendations for action, 16 were fully addressed this year -- an accomplishment that far exceeded our expectations. These included specially-designed displays and banners, public presentations by the staff, mailings, and articles for publication. The staff also organized an Open House at the Council office in September to introduce students, staff and faculty to our programs and services.

Publications continued to be an important method of providing information about the arts at MIT. For instance, we printed and distributed 7000 grant program guidelines. We also completed the preliminary draft of a new publication, entitled The Arts at MIT Today. To be published this summer, it is designed to serve incoming freshmen, educational counselors, and high school guidance counselors. Twenty-three thousand copies of MIT Arts in the News, a sampler of press clippings about MIT artists and arts activities, were distributed in the September 14 issue of Tech Talk. They were also used extensively by the Educational Council and the Alumni Association. This sampler has proven to be an effective way of providing the MIT community with an overview of the many arts activities at the Institute. The staff also published six issues of the arts calendar and newsletter which is distributed to a mailing list of 6500.

At the invitation of the editor of Connections, the quarterly magazine of the National Association of Local Arts Agencies, we contributed three articles which dealt with the Council generally, the grants program, and the Arts and Media Technology facility. The first two articles appeared in March and June; the third will be published in September.

As part of our effort to inform more alumni about the arts programs at the Institute, we held two salons in Riverside, Connecticut, and Chicago, Illinois. Both featured the performing arts. In December, members of the MIT Shakespeare Ensemble performed to an audience of alumni, friends, and special guest Zoe Caldwell at the home of Council member Ida Rubin. Members of the music faculty, John Buttrick and Marcus Thompson, performed a concert for a similar audience at the Fortnightly Club in Chicago in May. Our host was Council member Tony Grunsfeld.

DEVELOPMENT EFFORTS

For the second consecutive year, the Council was able to raise 100 percent of its budget from Council members and friends by the close of the fiscal year on June 30. Our efforts were greatly enhanced by the

charm and perseverance of Gregory Smith, chairman of the Grants Committee. Sixty-four Council members provided direct support to the Council's operations, with an average gift of \$2500. This support was supplemented by 57 gifts from friends of the Council at an average of \$689.

The staff engaged in a major development effort this year to identify prospective donors and to expand the Council's base of support. Our first direct-mail solicitation, to 72 members of MIT's Baton Society (an honorary musical society active from the 1940's through the 1960's), was conducted this winter. To date we have received gifts from 15 new donors for a response rate of 20 percent, well above the average rate for this type of mailing. The solicitation also identified potential Council members and added to our mailing list. Additional mailings to alumni with known arts interests are in the planning stages, as are increased efforts to approach foundations and corporations for special project support.

We have continued to encourage direct sponsorship of MIT arts activities by Council members. This year Solomon Manber again sponsored the MIT student membership program at the Boston Museum of Fine Arts. Ragnar Naess made another generous gift to his endowed scholarship fund in the Music Section for training in music performance. Kenneth Germeshausen has graciously underwritten the cost of our forthcoming brochure, The Arts at MIT Today.

Our staff also provides assistance to faculty members and students who are seeking funds from foundations, corporations, and government agencies for art projects. This year, the Rollins Foundation supported a graduate fellowship in electro-optical arts -- the first graduate fellowship in the Media Laboratory. We also helped faculty and graduate students pursue, successfully, fellowship and project support. Our members and staff raised a total of \$49,000 this year for non-Council arts activities.

Five endowed funds are now under the supervision of the Council for the Arts, bringing our total endowment to \$275,000. As mentioned earlier, we gained two new endowments this year, plus a substantial addition to the principal of the McDermott Award Fund. A bequest from the late Walter Campbell, former Council member, was added to the principal of the Laya and Jerome B. Wiesner Student Arts Awards at the request of Mr. Campbell's son. This will enable the awards to be increased to \$1,000 each.

Council members again contributed numerous works of art to the collections maintained by the Committee on the Visual Arts. Gifts to the MIT Permanent Collection included the following: a Jennifer Bartlett enamel painting contributed by Albert and Vera List; and Josef Albers' Interaction of Color, a portfolio of 80 screenprints, contributed by Mr. and Mrs. Mitchell Silverstein. Albert and Vera List also contributed 20 works on paper, including woodcuts, screenprints, and lithographs, to the List Student Loan Program. Mr. and Mrs. Alan M. May contributed three collages by Jiri Kolar to the Catherine N. Stratton Student Loan Collection.

Through the efforts of Jerome B. Wiesner, Nicholas Negroponte, Vernon R. Alden and Leo Beranek, another \$3 million in gifts and pledges was raised this year for the Arts and Media Technology facility. Of the \$27 million needed for the total project cost, almost \$24 million has been raised to date. Approximately \$7 million of this has come from Council members and through the efforts of Council and staff members.

MEMBERSHIP

Eight new members began their terms in July 1983. All but Andrew Silver ('64 SB, '67 SM) were mentioned in last year's annual report. Two new members accepted membership terms beginning in July 1984 -- Louis Sudler and Zoe Caldwell Whitehead. The Council now has 93 members. Twenty-eight of these members (30 percent) are affiliated with the Institute solely through the Council for the Arts. Over the past two years, we have identified new members who demonstrate scholarship, creativity, and distinguished service in the performing arts. We hope to do the same in the next two years for the media arts and the design arts. With a stronger membership constituency than ever before, the Council is in an excellent position to serve the Institute in its efforts to integrate, encourage, and support the arts within the MIT curriculum and the Institute community.

PERSONNEL

Following the resignation of Stacia Zabusky, Alison Shafer joined the staff as our grants administrator. Three interns assisted us with publication coordination -- Rachel Keyser, Nancy Faulkner, and Patricia Onorato. Barbara Baker, a local arts consultant, coordinated our direct-mail efforts.

DEBORAH A. HOOVER

Vice President for Financial Operations

It is a source of considerable satisfaction to note that the financial operations of the Institute in fiscal 1984 resulted in a small surplus of unrestricted funds which will be added to funds functioning as endowment. The budget for the year had forecast a small operating deficit and the turn for the better was due principally to two very significant factors. For the first time in several years there was a substantial favorable variance in the employee benefit cost pool and it is especially noteworthy that the rate of increase in health care costs within that pool has slowed considerably. The overall effect of the employee benefit factor was to help swing the operating deficit into an operating surplus as well as having a further beneficial effect of putting some downward pressure on employee benefit rates and indirect cost rates. The second major factor was an increase in the support of sponsored research. As noted in the report of the Director of the Office of Sponsored Programs the increase in volume of campus research was 11%. The result of this is that sponsored research is once again picking up its share of the indirect costs of the Institute whereas in more recent years it had lagged behind the instructional side as the inflation-driven indirect costs had increased.

One of the primary concerns in recent years has been that lack of graduate student support would result in erosion in the numbers of graduate students because the Institute was not competitive with its sister institutions in acquiring funds for research support. Furthermore, our accounting system was biased towards the professional researcher rather than the graduate student. In response to overcoming those problems, a change was made in the accounting system of the Institute which averaged and distributed the tuition remission of all Teaching Assistants and Research Assistants over the entire salary base of MIT. As a result of this change the charges for graduate student participation to individual research projects were lessened and resulted in not only preventing the erosion of enrollment in the graduate school but helped to produce an overall increase of 100 students. Generally speaking, this has been looked upon by both the faculty and the administration as a very favorable change.

In the undergraduate student area the major problem continues to be the need for unrestricted funds to support the present scholarship program within the overall financial aid package. There is no easy solution in sight. On the other hand, the report of the Task Force on Undergraduate Financial Aid will soon be out and should result in mitigating the present circumstances somewhat although the basic problem will undoubtedly persist for years to come.

The seemingly ever-present problem of indirect cost reimbursement of Federally sponsored research is now in the hands of the Federal Office of Science and Technology Policy (OSTP) and the more contentious aspects of the problem appear headed for resolution. OSTP is in a position to view the sponsorship of research from an overall and broad government perspective and it is not constrained by the financial and accounting aspects of the problem alone. OSTP is also in a position to weigh the effects of cost reimbursement on graduate education in the United States particularly in the areas of science and engineering. With the help of university groups and the participation of many individual faculty members, the focus of their review is being narrowed to faculty effort involved in the administrative aspects of sponsored research. It is hoped, and it is realistic to expect, satisfactory resolution of this most important factor in reaching an understanding of fair and reasonable reimbursement of indirect costs for Federally sponsored research. Other favorable developments which may occur in the not too distant future relate to a possible provision for independent research and development and a more rapid amortization of scientific equipment and new construction and renewal of facilities. There is a growing recognition within OSTP and several agencies of the Federal government that all of these things are necessary to provide and maintain a healthy research climate and regain the momentum and rate of achievement of the post-Sputnik period.

On June 1, 1984, the reins of leadership of the financial operations' team were turned over to James J. Culliton, a very worthy successor. I wish him well in his new assignment and hope he will find the personal and professional pride and satisfaction that I have had in being a part of this group and its relationships to all of the people of MIT.

STUART H. COWEN

Office of the Comptroller

In March 1984, a revised system for Accounts Payable Commitments was successfully installed on a Digital Equipment Corporation VAX 780 located in the Joint Computer Facility. The system has eliminated a considerable amount of clerical effort and improved the flow and tracking of invoices through the payment cycle. Shortly after implementation, we experienced a significant increase in response time due to a sharp increase of student end-of-term use of the Joint Computer Facilities. In order to better serve our needs, a VAX 780 (785) has been ordered for delivery in the summer of 1984 which will be devoted to Purchasing/Accounts Payable System applications.

After a significant interruption, during which we implemented several major modifications (most notably the benefits cafeteria plan), we resumed programming on the Student/Voucher Payroll System for conversion into the new and already functioning payroll system. In addition to that programming effort, an implementation plan was completed for the Student/Voucher Payroll segment. The Staff Appointments conversion, which is the final task in the overall payroll conversion project, was begun. A detailed set of specifications and an implementation plan were completed for this task.

On March 1, 1984 the Institute contracted with four travel agencies to provide the necessary travel arrangements for Institute travelers. These agreements will foster competition and should result in substantial cost savings to the Institute.

The Lincoln Fiscal Office has continued its accounting system conversion to an interactive operating system utilizing an IBM System/38. The System/38 was expanded during the year to a Model 6 which will accommodate a new payroll system which is nearing completion.

During the fiscal year, the Audit Division engaged in its continuing task of verifying that management policies and procedures are being properly implemented, that internal controls are being maintained, and that assets are safeguarded. Audits of departments and functions ascertain whether units are operating according to MIT guidelines and within prescribed contractual and budgetary limitations. Audits of administrative units determine whether internal control procedures are adequate and functioning as intended. The Audit Division's findings and recommendations continue to receive serious attention from the auditees, resulting in noted errors being promptly adjusted and weaknesses in internal control being appropriately addressed.

Personnel Changes

The following staff changes occurred during the past year: In September 1983, Paul J. Arsenault was promoted to Assistant Accounting Officer; Lois A. Hill was appointed Staff Accountant; and Demetri A. Karageorge was appointed Staff Accountant. In January 1984, Carl A. Seagren was promoted to Assistant Accounting Officer. In March 1984, Philip L. Philips was promoted to Accounting Officer; and Teresa M. Rodrigues retired after 18 years of service.

PHILIP J. KEOHAN

Office of the Director of Finance

Fiscal 1984 ended on a favorable note with a surplus of \$805,000, the first surplus in three years and the fifth in the last decade. The favorable outcome reflects the continued strong efforts at cost reduction and control combined with a moderate increase in inflation (about 4 percent in the Boston area).

Total operating expenses reached \$658,611,000 -- up 12 percent from the previous year. Total operating revenues and funds used were \$651,932,000 -- an increase of 13 percent over 1982-83. The Institute defines the difference between these two numbers as the "operating gap" (in the Report of the Treasurer it is called the "additional need for unrestricted revenues and funds" -- see Schedule A in that report). It is at this point that the Institute would optimally like to be in balance. To meet the operating gap there are unrestricted revenues derived from gifts, grants, bequests, patent revenues, and the use of facilities allowances from sponsored research contracts. Unlike most universities, MIT does not budget these revenues as a part of its operating budget. The philosophy behind this method of handling these funds is simply the desire to free them for use in capital expansion, new programs, and other needs that contribute to a secure long-term financial position. In fiscal 1984 these sources totaled \$7,484,000. To fund the operating gap required \$6,679,000 of these sources, leaving a surplus of \$805,000.

In fiscal 1981-82 the Institute embarked on a budget reduction and control program in the support areas designed to deal, in part, with the chronic imbalance between operating revenues and expenses. That program called for budget reductions approximating 15 percent over the three-year period of fiscal years 1983 through 1985. The budgeting for that program was completed during fiscal 1984 with the preparation of the fiscal 1985 budget. A total of \$10.8 million was pared from the Institute's already tight support budgets over this period. The efforts that all the managers of the support departments put into this program has contributed markedly to the Institute's long-term financial health. While it was a trying time, it nonetheless gave us all the opportunity to find new ways of doing the same work with less resources.

This report would not be complete without mentioning the retirement of Stuart H. Cowen as Vice President for Financial Operations. Stu was always a believer that finances are only one of the resources of a great university, and certainly not the most important one. His concern for the financial health of MIT was always tempered by a willingness to take financial risks over the short term, if it enabled the faculty to achieve their academic goals. To a mentor, friend, and colleague, all of us who deal with the finances of MIT say, "Thank you for a job well done."

PERSONNEL

During the year Donna M. Ridewood resigned as an Assistant Budget Officer in the Fiscal Planning and Budget Office to pursue her academic studies. In addition, Catherine Ormond was promoted to Budget Officer II and Karen Yegian was promoted to Budget Officer I. James L. Maclary was promoted to the position of Senior Budget Officer. Shortly after the close of the fiscal year, Jim Maclary died suddenly, ending twenty-four years of service to the Institute. Jim's knowledge and experience will be missed, but perhaps his patience and gentle manner in helping the novice with the budget, will be missed most of all.

JOHN A. CURRIE

Office of Registration and Student Financial Services

The name of the Office of Student Financial Services was changed in March of this year to the Office of Registration and Student Financial Services to reflect the aggregate of the office's activities, now that they include the Office of the Registrar. The Office of Student Financial Services was formed in October of 1981, linking what were then known as the Student Accounts Office and the Student Loan Office with the Office of Student Financial Aid. In early 1982, the Student Accounts Office and the Student Loan Office were merged to become the Bursar's Office responsible for both account and loans.

Last July the Office of the Registrar was also added to those reporting to the Office of Student Financial Services, and the new name - Office of Registration and Student Financial Services - is intended to take into account this addition.

BURSAR'S OFFICE

Student Accounts

Total student account billings for the year were \$104,266,164, an increase of 12.2 percent. Income from late payment fees declined by approximately \$47,000 while income from finance charges rose by approximately \$30,000. The total decrease in income from both sources is attributed to a higher percentage of on time payments. This seems to confirm our original contention that the Bursary Payment Plan would encourage prompter payment of tuition and fees.

Beginning with the Fall Term, 1984, the Bursar's Office will replace the flat \$50 late payment fee with a monthly charge of 1.5 percent on the unpaid balance of a student's account. We view it as more equitable than the flat fee, since those students having the greatest delinquency will bear the highest portion of the cost.

The total number of transactions processed by Student Accounts was 207,816, up less than one percent from a year ago.

In the Fall Term, 1983, in consonance with the fact that all but a few students are enrolled for a full academic year, we began billing student sponsors on an annual rather than a term basis. For those few sponsors who indicated they could not pay on an annual basis we maintained term billing, but most could and have. This has reduced by almost half the number of bills sent to sponsors and has quickened the flow of tuition dollars to the Institute.

A joint program has been developed with the Admissions Office to aid in the identification of newly admitted students who indicate they will not be attending M.I.T. By sharing information that the Bursar's Office receives in July it becomes possible to identify some of these students earlier than heretofore, thereby creating openings in a more timely fashion for others who are still awaiting admission to the Institute.

Student Loans

Student loan notes receivable amounted to \$34.3 million at the close of the fiscal year, an increase of 3.1 percent. These notes are funded by \$8,832,000 of M.I.T. loan funds established by friends and alumni of the Institute, \$17,895,000 of Federal funds in support of the National Direct Student Loan (NDSL) Program, \$261,000 in funds borrowed from the Federal government to support our contribution to the NDSL Program, \$2,866,000 borrowed from the Student Loan Marketing Association, \$3,100,000 from a local bank, and \$1,346,000 from Institute investments.

M.I.T. established the Parent Loan Program in 1977 to assist parents of students receiving little or no financial aid in paying the cost of education. The program has grown each year and now totals 580 active accounts with an outstanding balance of \$3,134,000. A total of \$2,791,000 was disbursed during the year and principal collected totalled \$2,099,000. This program has been

funded from Institute investments since its inception. During this past year we negotiated a long term line of credit with the Student Loan Marketing Association to fund these loans; this is the first time S.L.M.A. has funded a non-government student loan program. Our total S.L.M.A. borrowings are now \$6,000,000.

Work has begun which will enhance the capabilities the student loan data processing system by providing for daily updates and expanded flexibility and capacity.

Student Loan Collection

A comparison of student loan delinquency status from June 1983 to June 1984 shows that total loans receivable increased to \$34,273,114 and loans in active repayment status rose 3.3 percent to \$19,935,101. Despite these increases, delinquency as a percent of active loans decreased by 5.2 percent and the total number of delinquent accounts dropped 11.2 percent from 1,824 to 1,620.

This was accomplished chiefly by concentrating on the two year and older delinquencies. Further reductions will result if we can maintain this progress with older notes while catching more of the earlier delinquencies before they are allowed to age.

The default rate on National Direct Student Loans (NDSL) decreased to 2.3 percent, one of the lowest default rates among major universities in the country. Default rates on Federal Insured Student Loans (FISL) rose one half of one percent from 5.2 percent in 1982 to 5.7 percent in 1983. The national default rate is 16 percent for NDSL loans and 8.8 percent for FISL.

Greater diligence in the collection of international student loans has produced an increase in the number of favorable settlements. A larger number of accounts have been turned over to commercial collection agencies and have become the subject of legal action in several foreign countries.

Staff Notes

Richard Davidson, Assistant Bursar for Student Accounts resigned in December to return to public school administration. Joanne Barrett, formerly Assistant to the Bursar for Student Accounts has been promoted to the position.

G. Thomas Plew, Assistant to the Bursar for Control and Accounting resigned to accept a position at the Carroll Center for the Blind, as director of a program teaching computer skills to visually impaired students.

Cathleen M. Feeley, Assistant to the Bursar for Loan Collections also resigned.

REGISTRAR'S OFFICE

Enrollment

In 1983-84 student enrollment was 9,577, compared with 9,475 in 1982-83. This total was comprised of 4,602 undergraduates (compared with 4,619 the previous year), and 4,975 graduate students (compared with 4,856 the previous year). Graduate students who entered MIT last year held degrees from 381 colleges and universities, 227 American and 154 foreign. The international student population was 2,106, representing 12 percent of the undergraduate and 31 percent of the graduate population. These students were citizens of 97 countries.

In 1983-84, there were 2,066 women students (1,090 undergraduate and 976 graduate) at the Institute, compared with 1,977 (1,048 undergraduate and 929 graduate) in 1982-83. In September 1983, 259 first-year women entered MIT, representing 24 percent of the entering class.

In 1983-84, there were 1,107 minority* students (914 undergraduate and 193 graduate) at the Institute, compared with 968 (817 undergraduate and 151 graduate) in 1982-83. The first year class entering in September 1983 included 270 minority students representing 25 percent of the class.

Degrees Awarded

Degrees awarded by the Institute in 1983-84 included 1,169 bachelor's degrees, 1,162 master's degrees, 72 engineer's degrees, 415 doctoral degrees -- a total of 2,818.

Tabular Presentation

Most of the above 1983-84 figures are taken from the several tables which follow. These tables, together with others dealing primarily with historical comparisons and demographic data, comprise the annual Registrar's Report, separately published and available upon request.

Staff Notes

Elizabeth C. Bradley was promoted from Assistant to the Registrar to Assistant Registrar with responsibility for the records section.

STUDENT FINANCIAL AID OFFICE

This year we report on two highlights of especial interest. Since the Reagan Administration assumed its responsibilities in 1981, aid officers (and all others concerned with the funding of higher education) have been on "red-alert" to the threat of deep cuts in federal student financial aid programs. We have witnessed (and to some extent participated in) extensive debate on the matter, have anxiously followed congressional action, have monitored proposed federal regulations -- all in the posture of dogged vigilance that reacts to a serious threat to higher education. In contrast to these early fears, the actual cuts that have been reported here have not been "that bad." And 1983-84 actually saw a turn-around, with some programs enjoying increased funding. These are detailed below.

Last year we reported the establishment of MIT's Task Force on Undergraduate Financial Aid Policy. This group finished its work in camera, early in the summer of 1984, but has not as yet formally reported its findings. We thus defer the expected commentary and analysis of their work until next year's report. It will suffice, for now, to state that in providing staff support for the Task Force, the Aid Office made significant progress in reviewing and characterizing the way our students borrow -- the debt levels they assume, and their excellent repayment record.

Scholarship and Grant Programs

In 1983-84, the "self-help threshold" (the loans/earnings expectation of aid recipients) was increased 7.5% to \$4300. But since the costs composing the standard student budget rose by 9.6%,

*Minority students include 319 Blacks (non-Hispanic), 21 native Americans, 199 Hispanics, and 568 Asian Americans.

the aggregate need for grant funds rose even higher -- by almost 20%. A total of \$14.7 million was provided from all scholarship and grant sources, to meet the need of undergraduates. (See Table.)

Scholarships and Grants

(awarded to students with need)

| Source | 1982-83 | 1983-84 |
|-----------------------|--------------|--------------|
| Pell Grants | \$ 795,000 | \$ 761,000 |
| SEO Grants | 1,039,000 | 1,111,000 |
| ROTC Scholarships | 832,000 | 998,000 |
| Scholarship Endowment | 3,538,000 | 3,831,000 |
| Current Gifts | 511,000 | 601,000 |
| Direct Grants | 1,425,000 | 1,460,000 |
| Special Program | 172,000 | 115,000 |
| Unrestricted Funds | 4,008,000 | 5,871,000 |
| | \$12,320,000 | \$14,748,000 |

The two federal grant programs -- Pell Grants and Supplemental Educational Opportunity Grants -- remained substantially "level-funded" in 1983-84. But the ROTC scholarships carried by students with need again rose -- this time considerably more than tuition (in terms of percentage) -- and provided nearly \$1,000,000 in awards. Federal grant and scholarship funding in sum was up over \$200,000.

The endowment for scholarships enjoyed a healthy income distribution, and provided a total of \$3,831,000 in useable income -- an eight percent increase. A substantial portion of this was placed into an escrow fund to fulfill the intent of the 1978 Loan Task Force. As we reported in the 1978 President's Report, MIT decided then to assure that all loans made to students would be secured or guaranteed, to avoid erosion of loan principal due to defaults. Some loans made to international undergraduates were to be secured by a transfer of expendable, unrestricted endowment income. Since the first loans made under that policy have now entered repayment status, it was appropriate to establish the security fund this year.

An eighteen percent increase was experienced in current gifts received for scholarship purposes, but the level of direct grants made directly to students by agencies outside MIT did not show its customary increase commensurate with MIT's tuition rate. This scholarship resource rose by only 2 1/2 percent.

A significant element of the special program for minority students phased out in 1983-84 -- the lower than normal self-help threshold in the first two years of attendance at MIT. This feature was introduced in 1972, together with plans gradually to reduce the benefit to zero over a ten year period. Two brief interruptions to this schedule resulted in a two year extension of the program. The special program will continue to subsidize reduced self-help levels for the classes enrolled during 1983-84 until they graduate, including substantial relief from normal loan obligations attendant upon a ninth or tenth term of attendance; and the program will continue, through a formula used over the past fourteen years, to expect a somewhat lower parental contribution than would be the case for a non-minority family.

The supplemental allocation from unrestricted operating funds reached a new high level, at \$5,871,000, although the rate of rise has slowed a bit. This year's level is 46% higher than last's, while the previous year's rate of increase was 52%. This item was the principal concern of MIT's Task Force on Undergraduate Financial Aid, and will be subjected to a reduced rate of growth over the next several years.

Loan Programs

Guaranteed Student Loan borrowing volume again fell last year -- by six percent. This third drop in succession must signal a greater dependence by middle-income parents on other resources for paying their childrens' college costs, since all other financial aid parameters bespeak no substantial changes in the relative level of need, nor in the percentage needy among undergraduates; nor any significant changes in the availability of grants nor in the use of term-time earnings. MIT's own lending to graduate students under the GSLP amounted to \$228,067, a three percent decrease under this program. Graduate students received \$1,632,194 from MIT's Technology Loan Fund, a 60% increase, reflecting the fact that GSL annual loan limits have not been increased. NDSL loans remained about level with last year while the Technology Loan Fund for undergraduates experienced decreased demand, dropping five percent to \$484,260 in volume. A significant new loan program was inaugurated in 1983-84, by a \$300,000 gift from the Parsons Foundation. A total of \$147,783 was loaned from this source during the year.

Student Employment

Student earnings on-campus during 1983-84 increased three percent, partly reflecting a seven percent increase in student minimum wage and partly demonstrating students' continued determination to earn a good proportion of their real educational costs. Heavy dependence on federal loan programs was still apparent among needy students, and overall the number of students working again remained constant.

The College Work-Study Program grant realized a ten percent, one year only, increase in funding level that went entirely to subsidize the on-campus student employment program. Approximately half of the total 1983-84 grant went to subsidizing undergraduate work, and half to subsidize graduate student teaching assistantships.

Staff Notes

Some organizational changes were made during August, 1983. Stan Hudson was appointed Associate Director and Executive Officer, and has become generally involved in the task of managing the mission of the Office. Lucy Van der Wiel relinquished her directorship of the Student Employment Office, to become Assistant Director for Donor Relations, where she will give most of her time to managing our scholarship funds and maintaining good Institute relations with their donors. Jane Smith was appointed Director of Student Employment.

JACK H. FRAILEY

ACADEMIC STAFF COUNT 1983-84

| | Professors* | Administration also Professors* | Institute Professors* Emerit-Part Time | Adjunct Professors* | Associate Professors* | Assistant Professors* | Sr. Lecturers and Professors Emerit* | Sr. Lecturers | Lecturers | Sr. Research Scientists | Instructors | Technical Instructors | Sr. Research Associates | Postdoctoral Associates | Research Assistants | Teaching Assistants | Instructor Grad | Total | Visiting Professors | Others |
|--|-------------|---------------------------------|--|---------------------|-----------------------|-----------------------|--------------------------------------|---------------|-----------|-------------------------|-------------|-----------------------|-------------------------|-------------------------|---------------------|---------------------|-----------------|--------------|---------------------|------------|
| Institute Professors | 13 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 15 | 1 | - |
| SCHOOL OF ARCHITECTURE AND PLANNING | | | | | | | | | | | | | | | | | | | | |
| Architecture | 14 | 2 | - | 3 | 11 | 9 | - | - | 8 | - | 5 | 5 | - | - | 18 | 41 | 2 | 118 | 5 | 14 |
| Urban Studies and Planning | 15 | - | - | 1 | 7 | 3 | - | - | 8 | - | 1 | - | - | - | 21 | 6 | 13 | 75 | 3 | 16 |
| Total | 29 | 2 | - | 4 | 18 | 12 | - | 16 | - | 6 | 5 | 5 | - | - | 39 | 47 | 15 | 193 | 8 | 30 |
| SCHOOL OF ENGINEERING | | | | | | | | | | | | | | | | | | | | |
| Aeronautics and Astronautics | 1 | 1 | - | - | 3 | - | - | 1 | - | - | - | - | - | - | - | - | - | 6 | 1 | - |
| Chemical Engineering | 23 | 2 | - | 2 | 4 | 10 | 5 | 6 | 12 | - | 3 | 3 | - | 2 | 119 | 3 | - | 191 | - | 14 |
| Civil Engineering | 15 | 2 | - | 2 | 6 | 6 | 1 | 1 | 3 | - | 2 | 1 | 1 | 4 | 95 | 31 | 1 | 171 | 1 | 18 |
| Electrical Engineering and Computer Science | 16 | 4 | - | - | 13 | 7 | 1 | 4 | 3 | - | - | - | 1 | 3 | 101 | 25 | 3 | 181 | 1 | 15 |
| Materials Science and Engineering | 50 | 14 | - | 4 | 25 | 23 | 3 | - | 12 | 3 | 2 | 1 | 1 | 3 | 270 | 125 | 1 | 536 | 1 | 32 |
| Mechanical Engineering | 21 | 3 | - | 1 | 8 | 5 | 1 | - | 1 | - | - | 2 | 1 | 12 | 150 | 23 | 1 | 229 | 2 | 41 |
| Nuclear Engineering | 30 | 4 | - | - | 15 | 12 | 1 | 7 | 17 | 1 | - | 4 | 1 | 6 | 195 | 16 | - | 309 | 3 | 18 |
| Ocean Engineering | 14 | 2 | - | 1 | 5 | 5 | 1 | - | - | - | - | - | - | 1 | 67 | 23 | - | 119 | 2 | 9 |
| | 12 | 1 | - | 1 | 8 | 3 | - | - | 4 | - | - | - | - | 2 | 41 | 8 | - | 80 | 2 | 12 |
| Total | 182 | 33 | - | 11 | 87 | 71 | 13 | 18 | 53 | 4 | 2 | 12 | 5 | 33 | 1,038 | 254 | 6 | 1,822 | 13 | 159 |
| SCHOOL OF HUMANITIES AND SOCIAL SCIENCE | | | | | | | | | | | | | | | | | | | | |
| Economics | 1 | 1 | - | - | 1 | - | - | 1 | 5 | - | 1 | 3 | - | 1 | - | - | - | 13 | 3 | 5 |
| Humanities | 17 | 1 | - | - | 4 | 4 | - | - | - | - | - | - | - | 1 | 11 | 31 | - | 70 | 5 | 15 |
| Anthropology/Archaeology | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Foreign Languages and Literature | 1 | 1 | - | - | 3 | 2 | - | 5 | - | - | - | - | - | - | - | - | - | 12 | - | - |
| History | 2 | 1 | - | - | 7 | 7 | - | 1 | 16 | - | 1 | 16 | - | - | - | - | - | 34 | - | 1 |
| Literature | 6 | 1 | - | - | 4 | 4 | - | 4 | 4 | - | - | - | - | - | - | - | - | 15 | - | - |
| Music | 4 | 1 | - | - | 4 | 5 | 1 | - | 3 | - | - | - | - | - | - | - | - | 18 | - | 1 |
| Writing Program | 3 | - | - | - | 6 | 1 | - | 2 | 6 | - | - | - | - | - | - | - | - | 18 | - | 17 |
| Linguistics and Philosophy | - | - | - | - | 3 | 8 | - | 1 | 11 | - | - | 2 | - | - | - | - | - | 25 | 1 | 3 |
| Political Science | 13 | 1 | - | - | 2 | 2 | - | 1 | 1 | - | - | - | - | - | 7 | 1 | 1 | 27 | 2 | 16 |
| Psychology | 16 | 2 | - | 1 | 4 | 6 | - | 2 | - | - | - | - | - | 4 | 48 | 10 | - | 89 | - | 6 |
| Science, Technology and Society | 8 | 2 | - | 1 | 5 | 3 | - | - | - | - | - | 3 | - | 4 | 18 | - | - | 44 | - | 35 |
| | 5 | 1 | - | - | 6 | - | - | - | 1 | 1 | - | - | - | - | - | - | - | 14 | 2 | 26 |
| Total | 76 | 11 | - | 2 | 49 | 42 | 1 | 5 | 50 | 2 | 2 | 8 | - | 5 | 77 | 48 | 1 | 379 | 13 | 125 |
| SLOAN SCHOOL OF MANAGEMENT | | | | | | | | | | | | | | | | | | | | |
| Management | 33 | 2 | - | 3 | 17 | 22 | 1 | 9 | 6 | - | - | 1 | - | 1 | 21 | 49 | - | 165 | 6 | 27 |
| SCHOOL OF SCIENCE | | | | | | | | | | | | | | | | | | | | |
| Biology | 28 | 2 | - | - | 6 | 5 | 1 | - | 1 | - | 3 | - | 1 | 55 | 34 | 3 | - | 139 | 1 | 81 |
| Chemistry | 22 | 2 | - | - | 4 | 2 | 3 | - | 1 | - | 2 | - | 2 | 62 | 113 | 47 | - | 258 | - | 51 |
| Earth, Atmospheric, and Planetary Sciences | 22 | 1 | - | - | 9 | 9 | - | - | 2 | 1 | - | - | 11 | 100 | 12 | - | - | 167 | 6 | 24 |
| Mathematics | 38 | 1 | - | - | 6 | 12 | - | 1 | 2 | - | 20 | - | 3 | 10 | 54 | - | - | 147 | 4 | 27 |
| Nutrition and Food Science | 10 | 2 | - | 1 | 9 | 4 | 1 | 2 | 8 | 1 | - | - | 28 | 78 | 9 | - | - | 153 | 3 | 75 |
| Physics | 64 | 8 | - | - | 9 | 6 | 1 | - | 13 | - | 5 | - | 9 | 208 | 36 | - | - | 359 | 3 | 27 |
| Total | 184 | 16 | - | 1 | 43 | 38 | 6 | 3 | 12 | 16 | 24 | 7 | 1 | 168 | 543 | 161 | - | 1,223 | 17 | 285 |

CLASSIFICATION OF STUDENTS BY SCHOOLS, COURSES AND YEARS, 1983-84

ALL STUDENTS

SPECIAL STUDENTS

| COURSE NAME | 1983-84 | | | | | | Non Res. | Total | 1983-84 | | | | | | Total |
|--|------------|------------|------------|--------------|-----------|--------------|----------|----------|----------|------------|------------|--------------|-------|--|-------|
| | 2 | 3 | 4 | 6 | Res. | Total | | | 2 | 3 | 4 | 6 | Total | | |
| SCHOOL OF ARCHITECTURE AND PLANNING | | | | | | | | | | | | | | | |
| Architecture, IV | 21 | 22 | 27 | 241 | 9 | 320 | - | 1 | - | 8 | 9 | IV | | | |
| Architecture, IV-B | - | 1 | 1 | - | - | 2 | - | - | - | - | - | IV-B | | | |
| Urban Studies and Planning, XI | 1 | 2 | 2 | 172 | 37 | 214 | - | - | - | 25 | 25 | XI | | | |
| Total | 22 | 25 | 30 | 413 | 46 | 536 | - | 1 | - | 33 | 34 | Total | | | |
| SCHOOL OF ENGINEERING | | | | | | | | | | | | | | | |
| Aeronautics and Astronautics, XVI | 95 | 65 | 82 | 196 | 1 | 439 | 1 | 1 | 1 | 10 | 13 | XVI | | | |
| Aeronautics and Astronautics, XVI-B (Cooperative) | 1 | 2 | - | - | - | 3 | - | - | - | - | - | XVI-B | | | |
| Aeronautics and Astronautics, XVI-C (Internship) | - | 9 | 8 | - | - | 17 | - | - | - | - | - | XVI-C | | | |
| Chemical Engineering, X | 65 | 112 | 114 | 213 | 1 | 505 | - | 1 | - | 6 | 7 | X | | | |
| Chemical Engineering, X-C (Cooperative) | 1 | - | 4 | - | - | 5 | - | - | - | - | - | X-C | | | |
| Civil Engineering, I | 29 | 14 | 30 | 223 | 7 | 303 | - | - | - | 9 | 9 | I | | | |
| Civil Engineering, I-A | - | 1 | - | - | - | 1 | - | - | - | - | - | I-A | | | |
| Civil Engineering, I-W (Woods Hole) | - | - | - | 6 | - | 6 | - | - | - | - | - | I-W | | | |
| Electrical Engineering and Computer Science, VI | 249 | 163 | 209 | 586 | - | 1,541 | 1 | 2 | 3 | 70 | 78 | VI | | | |
| Program 1-Electrical Science and Engineering | 1 | 71 | 62 | 96 | - | 290 | - | - | - | - | - | VI-A | | | |
| Program 3-Computer Science and Engineering | - | 32 | 28 | - | - | - | - | - | - | - | - | VI-W | | | |
| Electrical Engineering and Computer Science, VI-W (Woods Hole) | - | - | - | 2 | - | 2 | - | - | - | - | - | III-B | | | |
| Materials Science and Engineering, III | 22 | 8 | 16 | 249 | - | 295 | - | 1 | - | 8 | 9 | III-B | | | |
| Materials Science and Engineering, III-A | 5 | 2 | 2 | - | - | 9 | - | - | - | - | - | III-A | | | |
| Materials Science and Engineering, III-B (Cooperative) | 6 | 20 | 34 | - | - | 60 | - | - | - | - | - | III-B | | | |
| Mechanical Engineering, II | 149 | 108 | 144 | 424 | 2 | 827 | - | - | - | 49 | 49 | II | | | |
| Mechanical Engineering, II-A | 2 | 7 | 15 | - | - | 24 | - | - | - | - | - | II-A | | | |
| Mechanical Engineering, II-B (Internship) | - | 22 | 16 | - | - | 38 | - | - | - | - | - | II-B | | | |
| Mechanical Engineering, II-W (Woods Hole) | - | - | - | 2 | - | 2 | - | - | - | - | - | II-W | | | |
| Nuclear Engineering, XXII | 7 | 6 | 8 | 167 | 2 | 190 | - | - | - | 3 | 3 | XXII | | | |
| Nuclear Engineering, XXII-A (Internship) | - | 3 | 3 | - | - | 6 | - | - | - | - | - | XXII-A | | | |
| Ocean Engineering, XIII | 7 | 15 | 10 | 103 | - | 135 | - | - | - | 1 | 1 | XIII | | | |
| Ocean Engineering, XIII-W (Woods Hole) | - | - | - | 9 | - | 9 | - | - | - | - | - | XIII-W | | | |
| Naval Construction and Engineering, XIII-A | - | - | - | 56 | - | 56 | - | - | - | - | - | XIII-A | | | |
| Ocean Systems Management, XIII-B | - | - | - | 15 | - | 15 | - | - | - | - | - | XIII-B | | | |
| Center for Advanced Engineering Study, EN | - | - | - | 53 | - | 53 | - | - | - | 53 | 53 | EN | | | |
| Total | 769 | 746 | 903 | 2,400 | 13 | 4,831 | 2 | 5 | 6 | 209 | 222 | Total | | | |

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE

| | | | | | | | | | | | | |
|---|-----------|-----------|-----------|------------|-----------|------------|----------|----------|----------|-----------|-----------|--------------|
| Economics, XIV | 14 | 20 | 18 | 121 | 11 | 184 | - | - | - | 5 | 5 | XIV |
| Humanities, XXI | 1 | 1 | 6 | - | - | 8 | - | - | - | - | - | XXI |
| Humanities and Engineering, XXI-E | 3 | 6 | 3 | - | - | 12 | - | - | - | - | - | XXI-E |
| Humanities and Science, XXI-S | - | 2 | 4 | - | - | 6 | - | - | - | - | - | XXI-S |
| Linguistics and Philosophy, XXIV | - | 3 | 1 | 53 | 8 | 65 | - | - | - | 2 | 2 | XXIV |
| Political Science, XVII | 6 | 7 | 12 | 127 | 46 | 198 | - | - | - | 6 | 6 | XVII |
| Political Science, XVII-A (Public Policy) | - | - | 2 | - | - | 2 | - | - | - | - | - | XVII-A |
| Psychology, IX | 4 | 10 | 6 | 32 | - | 52 | - | - | 1 | - | 1 | IX |
| Total | 28 | 49 | 52 | 333 | 65 | 527 | - | - | 1 | 13 | 14 | Total |

SLOAN SCHOOL OF MANAGEMENT

| | | | | | | | | | | | | |
|--------------------------------------|-----------|-----------|-----------|------------|-----------|------------|----------|----------|----------|-----------|-----------|--------------|
| Management, XV | 14 | 21 | 30 | 442 | 12 | 519 | - | - | 2 | 13 | 15 | XV |
| Management Fellows, XV-A | - | - | - | 65 | - | 65 | - | - | - | 8 | 8 | XV-A |
| Management-Operations Research, XV-B | - | - | - | 9 | - | 9 | - | - | - | - | - | XV-B |
| Total | 14 | 21 | 30 | 516 | 12 | 593 | - | - | 2 | 23 | 25 | Total |

SCHOOL OF SCIENCE

| | | | | | | | | | | | | |
|--|------------|------------|------------|--------------|-----------|--------------|----------|----------|-----------|-----------|-----------|--------------|
| Biology, VII | 61 | 57 | 59 | 136 | - | 313 | - | - | 2 | 4 | 6 | VII |
| Biology, VII-A | 2 | 4 | 5 | - | - | 11 | - | - | - | - | - | VII-A |
| Biology, VII-B | 11 | 14 | 11 | - | - | 36 | - | - | - | - | - | VII-B |
| Biology, VII-W (Woods Hole) | - | - | - | 22 | - | 22 | - | - | - | - | - | VII-W |
| Chemistry, V | 47 | 30 | 40 | 191 | 7 | 315 | - | - | - | - | - | V |
| Earth, Atmospheric, and Planetary Sciences, XII | 14 | 12 | 14 | 123 | 3 | 166 | - | - | - | - | - | XII |
| Earth, Atmospheric, and Planetary Sciences, XII-W (Woods Hole) | - | - | - | 62 | - | 62 | - | - | - | - | - | XII-W |
| Mathematics, XVIII | 47 | 42 | 56 | 110 | 9 | 264 | 2 | - | 12 | 7 | 21 | XVIII |
| Nutrition and Food Science, XX | - | - | - | 141 | - | 141 | - | - | - | 6 | 6 | XX |
| Physics, VIII | 67 | 57 | 92 | 299 | 4 | 519 | 1 | - | - | 11 | 12 | VIII |
| Total | 249 | 216 | 277 | 1,084 | 23 | 1,849 | 3 | - | 14 | 28 | 45 | Total |

Health Policy and Management, HPM
Health Sciences and Technology, HST

| | | | | | | | | | | | | |
|-------------------------------------|--------------|----------|----------|----------|----------|--------------|-----------|----------|----------|----------|-----------|---------------------|
| Health Policy and Management, HPM | - | - | - | 3 | - | 3 | - | - | - | - | - | HPM |
| Health Sciences and Technology, HST | - | - | - | 67 | - | 67 | - | - | - | 40 | 40 | HST |
| Undesignated | 83 | - | - | - | - | 83 | 17 | - | - | - | 17 | Undesignated |
| First Year | 1,088 | - | - | - | - | 1,088 | - | - | - | - | - | First Year |

| | | | | | | | | | | | | | | |
|--------------------|--------------|---------------|---------------|---------------|--------------|------------|--------------|----------|-----------|----------|-----------|------------|------------|--------------------|
| Grand Total | 1,088 | 1,165* | 1,057* | 1,292* | 4,816 | 159 | 9,577 | - | 22 | 6 | 23 | 344 | 395 | Grand Total |
|--------------------|--------------|---------------|---------------|---------------|--------------|------------|--------------|----------|-----------|----------|-----------|------------|------------|--------------------|

(Not included in the above figures)

| | | | | | | | | | | | | |
|--------------------------------------|----|----|----|---|---|-----|---|---|---|---|---|-----|
| Non-Institute students from Brandeis | 18 | 25 | 13 | 1 | - | 1 | - | - | - | - | - | 1 |
| Non-Institute students from Harvard | 9 | 12 | 3 | - | - | 405 | - | - | - | - | - | 24 |
| Non-Institute students from Tufts | 6 | 56 | 68 | - | - | 186 | - | - | - | - | - | 186 |

1 Non-Resident graduate students

*These totals include 1 student in the second year, 13 students in the third year, 14 students in the fourth year on Foreign Study; 2 students in the third year on Domestic study.

WOMEN STUDENTS BY SCHOOLS, COURSES AND YEARS, 1983-84¹

| COURSE | 2 | 3 | 4 | REGULAR | GRADUATE | | SPECIAL | TOTAL |
|---|------------|------------|------------|------------|-----------|--------------|-----------|------------|
| | | | | | RESIDENT | NON RESIDENT | | |
| SCHOOL OF ARCHITECTURE AND PLANNING | | | | | | | | |
| Architecture, IV | 10 | 9 | 10 | 76 | 4 | 4 | 4 | 113 |
| Urban Studies and Planning, XI | 1 | - | 1 | 72 | 19 | 4 | 4 | 97 |
| Total | 11 | 9 | 11 | 148 | 23 | 8 | 8 | 210 |
| SCHOOL OF ENGINEERING | | | | | | | | |
| Aeronautics and Astronautics, XVI | 26 | 13 | 8 | 14 | - | 1 | 1 | 62 |
| Aeronautics and Astronautics, XVI-C (Internship) | - | 1 | 2 | - | - | - | - | 3 |
| Chemical Engineering, X | 18 | 29 | 35 | 32 | - | 4 | 4 | 118 |
| Chemical Engineering, X-C (Cooperative) | - | - | 2 | - | - | - | - | 2 |
| Civil Engineering, I | 9 | 5 | 8 | 24 | 1 | 2 | 2 | 49 |
| Electrical Engineering and Computer Science, VI | 27 | 21 | 24 | 68 | - | 11 | 11 | 203 |
| Program 1-Electrical Science and Engineering | 21 | 9 | 22 | - | - | - | - | - |
| Program 3-Computer Science and Engineering | - | 10 | 8 | 9 | - | - | - | 36 |
| Electrical Engineering and Computer Science, VI-A (Cooperative) | - | 5 | 4 | 4 | - | - | - | 13 |
| Program 1-Electrical Science and Engineering | 11 | 2 | 8 | 43 | - | 3 | 3 | 67 |
| Program 3-Computer Science and Engineering | 2 | 2 | 1 | - | - | - | - | 5 |
| Materials Science and Engineering, III-A | 3 | 8 | 14 | - | - | - | - | 25 |
| Materials Science and Engineering, III-B (Cooperative) | 46 | 26 | 32 | 28 | - | 7 | 7 | 139 |
| Mechanical Engineering, II | - | 5 | 4 | - | - | - | - | 9 |
| Mechanical Engineering, II-A | - | 3 | 2 | - | - | - | - | 5 |
| Mechanical Engineering, II-B (Internship) | - | 2 | - | 13 | - | - | - | 15 |
| Nuclear Engineering, XXII | - | - | 1 | - | - | - | - | 1 |
| Nuclear Engineering, XXII-A (Internship) | - | 3 | 2 | 3 | - | - | - | 8 |
| Ocean Engineering, XIII | - | - | - | 2 | - | - | - | 2 |
| Ocean Engineering, XIII-W (Woods Hole) | - | - | - | 3 | - | - | - | 3 |
| Naval Construction and Engineering, XIII-A | - | - | - | 3 | - | - | - | 3 |
| Center for Advanced Engineering Study, EN | - | - | - | - | - | 1 | 1 | 1 |
| Total | 163 | 144 | 177 | 239 | 1 | 29 | 29 | 753 |

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE

| | | | | | | | |
|-----------------------------------|----------|-----------|-----------|-----------|-----------|----------|------------|
| Economics, XIV | 4 | 10 | 1 | 15 | 3 | 1 | 34 |
| Humanities, XXI | 1 | 1 | 1 | - | - | - | 3 |
| Humanities and Engineering, XXI-E | 1 | - | - | - | - | - | 1 |
| Humanities and Science, XXI-S | - | 1 | 1 | - | - | - | 2 |
| Linguistics and Philosophy, XXIV | - | - | - | 18 | 5 | 1 | 24 |
| Political Science, XVII | 1 | 2 | 1 | 29 | 15 | 1 | 49 |
| Psychology, IX | 2 | 6 | 6 | 11 | - | - | 25 |
| Total | 9 | 20 | 10 | 73 | 23 | 3 | 138 |

SLOAN SCHOOL OF MANAGEMENT

| | | | | | | | |
|--------------------------------------|----------|----------|----------|------------|----------|----------|------------|
| Management, XV | 6 | 7 | 9 | 114 | 4 | 6 | 146 |
| Management Fellows, XV-A | - | - | - | 8 | - | 1 | 9 |
| Management-Operations Research, XV-B | - | - | - | 3 | - | - | 3 |
| Total | 6 | 7 | 9 | 125 | 4 | 7 | 158 |

SCHOOL OF SCIENCE

| | | | | | | | |
|--|-----------|-----------|-----------|------------|----------|----------|------------|
| Biology, VII | 19 | 30 | 28 | 45 | - | 1 | 123 |
| Biology, VII-A | 1 | 2 | 2 | - | - | - | 5 |
| Biology, VII-B | 7 | 9 | 4 | - | - | - | 20 |
| Biology, VII-W (Woods Hole) | - | - | - | 13 | - | - | 13 |
| Chemistry, V | 13 | 14 | 10 | 46 | 3 | - | 86 |
| Earth, Atmospheric, and Planetary Sciences, XII | 4 | 3 | 4 | 21 | 1 | - | 33 |
| Earth, Atmospheric, and Planetary Sciences, XII-W (Woods Hole) | - | - | - | 26 | - | - | 26 |
| Mathematics, XVIII | 13 | 8 | 17 | 20 | 2 | 1 | 61 |
| Nutrition and Food Science, XX | - | - | - | 62 | - | 3 | 65 |
| Physics, VIII | 13 | 14 | 10 | 34 | 1 | 1 | 73 |
| Total | 70 | 80 | 75 | 267 | 7 | 6 | 505 |

Health Policy and Management, HPM
Health Sciences and Technology, HST

| | | | | | | | |
|---------------------|-----------|----------|----------|----------|----------|----------|-----------|
| | - | - | - | 1 | - | - | 1 |
| | - | - | - | 3 | - | 9 | 12 |
| Undesignated | 30 | - | - | - | - | - | 30 |

First Year

259

Grand Total

| | | | | | | | |
|--|-----|-----|-----|-----|----|----|-------|
| | 289 | 260 | 282 | 856 | 58 | 62 | 2,066 |
|--|-----|-----|-----|-----|----|----|-------|

Also included in Classification of Students
Total undergraduate women 1,090; 10 special undergraduate women are included.

NUMBER OF DEGREES AWARDED IN SEPTEMBER 1983, FEBRUARY 1984, AND JUNE 1984

| | S.B. | | | S.M. | | | M.ARCH. M.C.P. | | | ENGINEER | | | PH.D. | | | SC.D. | | | TOTAL | | |
|---|-----------|-----------|------------|------------|------------|------------|-------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|------------|--------------|-----------|------------|----------|
| | S | F | J | S | F | J | S | F | J | S | F | J | S | F | J | S | F | J | S | F | J |
| SCHOOL OF ARCHITECTURE AND PLANNING | | | | | | | | | | | | | | | | | | | | | |
| Architecture | - | - | - | - | - | - | 3 | 9 | 25 | - | - | - | - | - | - | 3 | 9 | 27 | - | - | - |
| Undesignated | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 |
| Architecture Studies | - | - | - | 1 | 3 | 28 | - | - | - | - | - | - | - | - | - | 1 | 3 | 28 | - | - | - |
| Art and Design | - | 1 | 17 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 17 | - |
| Visual Studies | - | - | - | - | 3 | 10 | - | - | - | - | - | - | - | - | - | - | - | 3 | 10 | - | - |
| Urban Studies and Planning | - | - | 2 | - | - | - | 4 | 2 | 32 | - | - | - | 1 | 7 | 4 | - | - | 9 | 38 | - | - |
| TOTAL | - | 1 | 20 | 1 | 6 | 38 | 7 | 11 | 57 | - | - | - | 1 | 7 | 6 | - | - | 9 | 25 | 121 | - |
| SCHOOL OF ENGINEERING | | | | | | | | | | | | | | | | | | | | | |
| Aeronautics and Astronautics | 1 | 9 | 58 | 11 | 18 | 24 | - | - | - | 2 | 1 | - | 1 | 2 | 3 | 15 | 30 | 87 | - | - | - |
| Undesignated | - | - | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 6 | - | - |
| Ceramics | - | 2 | 7 | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | - | - |
| Chemical Engineering | 2 | 7 | 107 | 9 | 11 | 8 | - | - | - | 2 | 4 | 2 | 3 | 1 | 2 | 18 | 29 | 121 | - | - | - |
| Undesignated | - | 1 | 5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 | - | - | - |
| Chemical Engineering Practice | - | - | - | 10 | 12 | 11 | - | - | - | - | - | - | - | - | - | - | - | 12 | 11 | - | - |
| Civil Engineering | 3 | 2 | 28 | 10 | 25 | 29 | - | - | - | 1 | - | 2 | 3 | 4 | 9 | 17 | 32 | 70 | - | - | - |
| Undesignated | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Computer Science and Engineering | 13 | 15 | 84 | - | - | - | - | - | - | - | - | - | - | - | - | 13 | 15 | 84 | - | - | - |
| Electrical Engineering | 19 | 35 | 180 | - | - | - | - | - | - | 4 | 7 | 11 | 8 | 9 | 13 | 19 | 35 | 180 | - | - | - |
| Electrical Engineering and Computer Science | - | - | - | 26 | 51 | 85 | - | - | - | - | - | - | - | - | - | 26 | 51 | 85 | - | - | - |
| Electronic Materials | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Materials Engineering | - | - | - | - | 2 | 2 | - | - | - | - | - | - | - | - | - | - | - | 2 | 2 | - | - |
| Materials Science | - | - | - | 2 | 2 | 3 | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - |
| Materials Science and Engineering | 1 | 2 | 43 | - | - | - | - | - | - | 1 | - | - | 8 | 6 | 9 | 11 | 11 | 57 | - | - | - |
| Undesignated | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - |
| Mechanical Engineering | 5 | 11 | 118 | 23 | 42 | 66 | - | - | - | 1 | 1 | 1 | 2 | 7 | 7 | 30 | 65 | 195 | - | - | - |
| Undesignated | 1 | 2 | 10 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 2 | 10 | - | - | - |
| Metallurgy | - | - | - | 1 | 2 | 4 | - | - | - | - | - | - | - | - | - | - | - | 4 | - | - | - |
| Naval Architecture and Marine Engineering | - | - | 6 | 5 | 6 | 23 | - | - | - | - | - | - | - | - | - | - | - | 29 | - | - | - |
| Nuclear Engineering | 1 | 3 | 5 | 7 | 14 | 15 | - | - | - | 2 | 5 | 4 | 4 | 12 | 8 | 17 | 34 | 34 | - | - | - |
| Ocean Engineering | 1 | 1 | - | 6 | 5 | 8 | - | - | - | 1 | 3 | 18 | 1 | 1 | - | 9 | 9 | 27 | - | - | - |
| Undesignated | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Ocean Systems Management | - | - | - | 5 | 3 | 8 | - | - | - | - | - | - | - | - | - | - | - | 8 | - | - | - |
| Polymers | - | - | - | 1 | 1 | 3 | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - |
| Technology and Policy | - | - | - | 1 | 6 | 6 | - | - | - | - | - | - | - | - | - | - | - | 6 | - | - | - |
| Total | 47 | 87 | 655 | 118 | 201 | 297 | - | - | - | 13 | 21 | 38 | 30 | 42 | 51 | 215 | 364 | 1,062 | - | - | - |

Office of Sponsored Programs

For fiscal year 1984, the total volume of sponsored research performed on campus approximated \$221,581,000, an increase of 11.2% over fiscal year 1983 volume of \$199,273,000.

The level of research support provided by four major Federal agencies increased in real dollar terms, with programs funded by the Department of Health and Human Services (primarily NIH) showing the most substantial growth.

With respect to non-Federal sponsorship, the 40% increase in industrial support is particularly striking and was broadly distributed across single-sponsor projects, consortia programs and institutional agreements.

It might be noted that Federal funding constituted 89% of on-campus research volume in 1968 and 79% in 1984, while the Department of Defense supported 31% of total on-campus research in 1968 and 16% in 1984.

CAMPUS RESEARCH VOLUME BY SPONSOR

(in thousands of dollars)

| | <u>1968</u> | <u>1978</u> | <u>1979</u> | <u>1980</u> | <u>1981</u> | <u>1982</u> | <u>1983</u> | <u>1984</u> |
|---|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Department of Defense (DOD) | 17,285 | 13,694 | 15,223 | 19,183 | 23,011 | 27,429 | 31,883 | 34,626 |
| Department of Energy (DOE) | 9,841 | 32,338 | 42,005 | 50,004 | 49,562 | 46,283 | 48,271 | 51,489 |
| Department of Health and Human Services (formerly DHEW) | 7,843 | 18,855 | 22,061 | 25,320 | 29,175 | 30,911 | 30,870 | 36,324 |
| National Aeronautics and Space, Administration (NASA) | 6,170 | 8,064 | 9,505 | 9,295 | 10,525 | 11,053 | 10,445 | 11,888 |
| National Science Foundation (NSF) | 7,073 | 21,832 | 23,469 | 25,055 | 29,913 | 29,776 | 31,003 | 30,876 |
| Other Federal Sponsors | 1,711 | 7,363 | 8,727 | 9,554 | 10,211 | 11,811 | 10,400 | 9,783 |
| <u>Total Federal Sponsorship</u> | <u>49,923</u> | <u>102,146</u> | <u>120,990</u> | <u>138,411</u> | <u>152,397</u> | <u>157,263</u> | <u>162,872</u> | <u>174,986</u> |
| Industry | 2,148 | 6,745 | 8,151 | 13,058 | 17,164 | 19,695 | 19,753 | 27,686 |
| Foundations and Other Nonprofits | 3,159 | 7,917 | 9,538 | 9,654 | 11,614 | 11,699 | 13,196 | 15,743 |
| Other | <u>598</u> | <u>2,466</u> | <u>2,627</u> | <u>1,999</u> | <u>1,795</u> | <u>3,313</u> | <u>3,452</u> | <u>3,166</u> |
| <u>Total Non-Federal</u> | <u>5,905</u> | <u>17,128</u> | <u>20,316</u> | <u>24,711</u> | <u>31,573</u> | <u>34,707</u> | <u>36,401</u> | <u>46,595</u> |
| <u>Total Research Volume</u> | <u>55,828</u> | <u>119,274</u> | <u>141,306</u> | <u>163,122</u> | <u>183,970</u> | <u>191,970</u> | <u>199,273</u> | <u>221,581</u> |

SIGNIFICANT DEVELOPMENTS

As in past years, a variety of continuing developments and new events had an impact on MIT sponsored research programs. Among these were the following:

Export Controls

Debate over the application of export control restrictions to teaching and research activities conducted by American universities continued in fiscal 1984. In particular, university and Department of Defense representatives continued to address the issues involved in the DOD proposal that Federally funded research con-

tracts involving unclassified but "sensitive" military technology include restrictions on the dissemination of information and on the participation of foreign nationals. Although it appeared toward the end of the year that a restrictive approach unacceptable to many universities might be adopted, a DOD spokesman announced on June 14, during Congressional testimony, that a new administration policy had been drafted. That policy would provide that the results of fundamental research in science and engineering would be controlled only when essential for national security reasons and solely by security classification. Research grants and contracts would be periodically reviewed for potential classification and no other restrictions would be imposed. Although a number of questions must still be answered, and the policy approved by the White House, the year ended on a note of renewed optimism.

Indirect Costs - HHS Proposals

In fiscal years 1983 and 1984, Congressional appropriations committees rejected proposals by the Department of Health and Human Services that only 90% of negotiated indirect costs for research grants be awarded. HHS did not renew that proposal for fiscal 1985, but has concentrated instead on containing the growth of those components of indirect costs which it considers least firm, with particular emphasis on departmental administration. HHS has negotiated limitations on departmental administration with a number of institutions, agreeing in return to revised accounting procedures which will reduce indirect costs and/or increase recovery in other indirect cost pools. University and HHS representatives are currently reviewing various alternatives for containing departmental administration and other indirect costs in exchange for trade-offs such as reduced effort reporting requirements, more rapid depreciations of equipment, and increased use allowances. In addition, the Association of American Universities has urged that faculty principal investigators be included in discussions on indirect costs in order to increase their understanding of the problems and issues involved and to seek their views on how these should be addressed.

Employment of Research Assistants

Last year's report discussed the change under which, beginning in fiscal 1984, the tuition of graduate student research assistants would be charged to the employee benefit pool rather than as a direct charge to research grants and contracts, thereby reducing that portion of the cost of the research assistant which is charged to a research grant or contract by some \$8,000 on a twelve-month appointment. This change has apparently achieved its purpose of providing principal investigators with greater incentive for the use of research assistants compared, for example, with postdoctoral research associates. Current figures indicate that the number of Research Assistant appointments in fiscal 1984 increased by more than 20% over 1983.

Competition in Contracting

In recent years, reforms in the Federal procurement system have focused on the need for greater competition, especially in the procurement of defense supplies and services. Reflecting this emphasis on competition, a public law passed by the Congress in August of 1983 required that, with certain exceptions, proposed research and development procurements must go through a process involving, among other steps, announcements in the Commerce Business Daily and an opportunity for other interested parties to respond. The university community expressed concern over the impact of this legislation on unique and innovative unsolicited proposals from faculty investigators, including the likelihood of delays in the renewal and award of contracts, and consequent gaps in funding. However, another public law, enacted in June of 1984 and still under review at year end, appears on its face to be responsive to university concerns by establishing separate criteria for research proposals subject to a peer review or scientific review process.

Survey of Equipment Acquisition and Use

Continuing attention was given nationally in fiscal 1984 to the needs of universities with respect to facilities and the replacement and updating of scientific equipment, and MIT participated in two major survey projects. Phase II of an NSF sponsored National Survey of Academic Research Instruments and Instrumentation Needs, oriented toward the biological and environmental sciences, was undertaken in 1984. In addition, the Association of American Universities, the National Association of State Universities and Land-Grant Colleges, and the Council on Governmental Relations initiated a project to assess and disseminate information on alternative approaches to meeting university equipment needs. A major portion of the project involves an exploration of creative financing methods, potential changes in tax laws, and other issues of a financial and administrative nature. In addition, a project team visited universities and commercial and government laboratories in order to obtain the views of individual scientists, engineers, and administrators with respect to the acquisition and management of equipment.

PERSONNEL CHANGES

During the year the following changes occurred in the Office of Sponsored Programs: Carol E. Van Aken was promoted to Associate Director from Special Projects Director, effective August 1, 1983; Susan L. Woodruff was promoted to Assistant Director from Assistant Contract Administrator effective November 1, 1983; and Steven D. Goode, Assistant Director, left MIT on May 18 to relocate in Iowa.

GEORGE H. DUMMER

Senior Vice President

This past year marked the completion of the second year of operation under the Institute's plan for reducing administrative expenses by 15 percent over three years. While each department has achieved its required reductions in its own way, some have found unique approaches which, in the long run, will result in more efficient modes of operation. Still, the most difficult period is yet to come during the next year -- the final year of the reduction program. In spite of the problems that will arise from further reductions, the operating units appear to be equal to the task.

Energy expenses, which have been relatively stable for the past several years, grew at a rate somewhat greater than inflation because of the instability in the pricing of fuels due to the continuing unrest in the middle east and a continuation in the growth of electric use in our research programs. The pattern toward more energy intensive research programs continues with the ATHENA program being a visible example.

This year showed a marked change in the Institute's building program with a shift from new construction to primarily renovation work. Only one new building, the EG&G (Edgerton, Germeshausen and Grier) Education Center was completed during the year. With the completion of the Arts & Media Technology Facility and the Microsystems Technology Laboratories next year, new construction activity on campus will cease for the first time in over a decade.

Following are the individual department reports.

WILLIAM R. DICKSON

Campus Police

The Campus Police continued to provide 24 hour professional police and emergency medical services to members of the MIT community. In addition, the Special Services Division provided a wide range of specialized assistance to faculty, staff and students in the areas of crime prevention, consumer and legal affairs and criminal investigations.

For the second consecutive year, the number of complaints received by the department decreased. This year's total of 1,903 was down 2 percent compared with last year. Of these, 25 were in the crimes against persons category, the most common complaint being assault and battery.

As in the past, larceny continued to be the most frequently committed crime on the campus. Institute property losses for the year totaled \$43,947, an increase of \$12,096 over last year. Still, the loss was the second lowest in the past five years. Personal property (non-residence) losses were also the second lowest in five years at \$24,930. Residence hall losses, however, rose to \$22,945, an increase of \$14,965 over last year's record low. The department's annual crime prevention program, which has raised the level of awareness in the MIT community to criminal victimization, continued to curtail extreme upswings in these figures.

This year's total of 44 stolen vehicles was an increase of seven over the record low reported last year, while the 56 bicycle thefts represents the second lowest figure in the past five years.

Emergency medical service continued to increase during the year. A total of 2,670 runs, including emergencies, transfers, and medical shuttles were performed.

A total of 11,193 escorts were conducted during the year, the first decrease (3 percent) since the inception of this service in 1974.

The department looks forward to continuing to provide the MIT community with professional police and emergency medical services in the coming year.

JAMES OLIVIERI

Child Care

The overall demand for child care on campus continues to increase. Between 50 and 70 available family day care spaces were filled during the year as well as 100 center-based spaces. Waiting lists have existed throughout the year.

CHILD CARE OFFICE

The Child Care Office serves the many child care needs of the MIT community by providing information and referral services. The family day care system on and off campus continues to be used primarily for infant and toddler care and some flex-time care for pre-schoolers. The office staff visits licensed homes regularly and lends support to providers and users. The Child Care Office also offered a number of brown bag lunch discussions, IAP sessions, and an extended swim program to the campus community. Providers participated in various office sponsored workshops, English lessons, film presentations, and potluck suppers. Together with a regularly published newsletter, these activities have provided a greater sense of community and professionalism for family day care providers and have increased contact with other child-related activities and issues. The Child Care Office again organized and managed Commencement Day child care for children from infancy through age ten. A successful showing of a series of parent directed films was undertaken cooperatively by the Child Care Office, Technology Children's Center (TCC), and the MIT Health Education Office.

TECHNOLOGY CHILDREN'S CENTER

The TCC and the Child Care Office continue to work toward increased utilization and sharing of services and resources within the Institute and the larger Boston area. TCC offers center-based care for children two years, nine months to five years in East and Westgate. The program is designed to promote social, emotional, and cognitive development. The Center encourages the informal participation of parents in the program. It also serves as a field placement site in education for several area colleges and universities. MIT's child care facilities receive frequent inquiries regarding their operations and are visited often by interested persons from this country and abroad.

LUISE FLAVIN

Endicott House

This year was a period of extraordinary and progressive change for Endicott House. The impetus for this change was the completion of the Brooks Center in February 1983. With this event, we more than doubled our guest capacity, introduced air conditioning, and acquired first class educational facilities.

Completion of the Brooks Center made it possible for the Sloan School of Management to significantly increase their Senior Executive Program. Although this resulted in additional gross revenue over an 18 week period, the addition of 24 guest rooms for the remaining 34 weeks of the year resulted in 5,212 room days that must be effectively marketed. Toward this end, we are currently developing a concerted marketing program that we hope to execute by summer's end. This effort includes publishing a brochure and other sales tools, as well as initiating a selected media advertising and direct mail program. We anticipate this aggressive marketing effort will result in highly favorable occupancies. Other special promotions will also be evaluated and considered.

As we increase our business, we must be in a position to effectively manage it. Our standards of guest service must be exceptionally high, but no less important is the need to develop internal controls that will result in an acceptable financial yield to permit adequate maintenance of the facility. In this regard, we have re-organized our management structure to more effectively take advantage of our staff's abilities and experience.

We have also decided to computerize our administrative and marketing endeavors in order to obtain the financial data and operating statistics that are a prerequisite to sound management.

ALBERT H. FOREST

Graphic Arts and Audio Visual Services

During the year, the Quick Copy operations in Building 3 were relocated to Building 11. The new location is larger, visually more attractive, and most important, more efficient. The self-service area was expanded to seven machines and offers ample floor and table space for copying, collating, and working with original material.

The dollar volume at Graphic Arts Service increased by approximately 12 percent over the previous year. This is significant in light of the 7 percent drop reported for FY 1982-83, the first year of the Institute's three year budget reduction program. The turn-around was accomplished by more vigorously pursuing potential business on the campus, offering more efficient and timely service, and increasing prices in selected areas.

Departmental increases were consistently in the 10 to 15 percent range with only the Institute copier program registering a decline and the Photographic Section showing no change from the previous year.

The only major equipment purchase was a Xerox 8200 Copier for use in the Building E52 Copy Center.

Frank Cook, Manager of the Audio-Visual Department, retired after 20 years of service.

JAMES W. COLEMAN

Housing and Food Services

The department submitted its five-year plan outlining the mission, broad objectives, and major goals for Housing, Food Services, and the Faculty Club. The positive participation and contributions by the senior management staff made this a very pleasant undertaking.

A change in the access policy for married and single graduate students as recommended by the Administrative Housing Group was implemented this spring. The policy stipulates that half of all summer and fall vacancies for the apartment buildings will be offered to new students, the remaining half to continuing students. This policy change will help to alleviate the difficulties many new students and their families face in locating housing in an unfamiliar area.

Four years ago, when the commons program was implemented, the freshmen of East Campus, Senior House, and each of the four houses with dining facilities were required to participate in the program. Each succeeding class was then phased into the program during the following years. There have been some major changes in the program this past year. East Campus and Senior House residents are no longer required to participate as they now have 17 kitchen-dining units within their residences. These units were opened prior to the fall term and the residents have been enthusiastic in their acceptance and use. Also, at 500 Memorial Drive, a la carte service was offered in place of commons meals during the past year. This change in service came about through a student proposal to the Dining Advisory Board. Food Services is continuing to evaluate and make changes in menus and services, where possible, in an attempt to meet the ever-changing needs of the students and the community.

Food Services, as part of a continuing self evaluation, invited the Directors of Food Services from Dartmouth College, Brown University and Smith College to spend some time on campus observing our operations and talking with the students and employees. Their report will be presented to the Dining Advisory Board over the summer. It will also be available to the community.

The Faculty Club facilities have been upgraded this past year. The main dining room and lounge was re-carpeted. The furnishings in the lounge were replaced, the main dining room tables and chairs were cleaned and refinished, and the private dining rooms received much needed attention. Also, the freezer/refrigeration units and several older pieces of equipment in the kitchens were replaced.

A critical evaluation of the Faculty Club operations and services has resulted in several changes. A complete staffing review was conducted which resulted in changes in employee schedules and hours. New menus were offered and have been well received. These and other changes stem from a detailed evaluation and recommendations from Service Systems, Inc., the management operator.

All in all, it has been a good year for the department and I would like to take this opportunity to thank the personnel for their contributions.

HARMON E. BRAMMER

Information Systems

At the beginning of the year, the Information Systems group was formed by bringing the Institute's Information Processing Services and Telecommunications Systems organizations into a common management structure. The group is headed by the Director of Information Systems who, in addition to having management responsibility for the group, has responsibilities for oversight of MIT's educational, research, and administrative computing and telecommunications resources. These resources include central and departmental/laboratory computer facilities, computer networks and personal computers, as well as office automation and word processing systems.

This year was the first full year of operation with our hardware resources (two IBM 3033s, an IBM 4341, and a two-processor Honeywell DPS/70M Multics System), operations staff, and systems programmers in Building W91. The staff responsible for interfacing with users and providing consulting service is located in Building 11. From an operations point of view, the year was without any major difficulty; operating systems were brought up to date, performance on the administrative systems was improved and additional data control and library utilities were added.

Significant activities of the year include:

- Initiating an expanded menu of distributed computing services.
- Extending the external network services available to the campus through the development and operation of MAILNET which provides electronic mail services between a growing number of university campuses in the United States and Europe.
- Major progress on a number of administrative projects including work on the payroll systems to permit changes in the Institute's employee benefit plans, development of a personnel system to track job applicants, development of specifications for the student and voucher sections of the new payroll system, completion of the requirements definition for a new budget system, and work on the Institute's new pension accounting system.
- Development and release to qualified vendors of a request for proposal for a digital switch to replace the Institute's present CENTREX based system.

Further details on these activities as well as other accomplishments of the past year are provided in the following sections.

This year also marked a number of personnel changes. Perhaps the most significant of these were the retirements of Weston J. Burner and Joseph R. Steinberg, Director and Associate Director respectively of Information Processing Services. Their joint retirement represents over half a century of service and many accomplishments in computing at MIT. In addition, Jean C. Bonney, Associate Director of Information Processing Services and Director of Administrative Information Systems, resigned in April 1984 to accept a position at Digital Equipment Corporation.

JAMES D. BRUCE

INFORMATION PROCESSING SERVICES

During the year, Information Processing Services (IPS) operated with a staff reduction of 7 percent over last year. Reductions were the result of budget constraints in an effort to hold costs down in anticipation of reduced revenues. The Institute continued to experience a growth in distributed and personal computing by its departments, laboratories, and centers which resulted in a decrease of activity at the central facility.

ACADEMIC AND RESEARCH COMPUTING SERVICES

- Distributed Computing -- Considerable effort in both Systems Programming and Academic and Research Computing Services (ARCS) has gone into the support of distributed computing at MIT. The staff has taken every opportunity to develop proficiency in the use of microcomputers. Some have their own machines - others are available from several manufacturers including DEC, Apple, and IBM in the staff terminal rooms.
- Graphics -- Two interactive graphics packages, DISSPLA and TELAGRAF, have been added to the repertoire of services offered. IPS negotiated a contract with the supplier which covers several different computers on the campus. These packages are device independent and provide a flexible and sophisticated but easy-to-use facility.
- Project Athena -- In addition to handling the distribution of Project Athena documentation, ARCS has begun to work with Project Athena on course development in anticipation of the large freshman orientation program planned for the fall of the coming year.

SYSTEMS PROGRAMMING

One of the major systems programming activities in the Multics environment has been MAILNET. Developed in conjunction with EDUCOM, this mail system allows each participating institution to continue to use its own mail system while providing the capability to send and receive mail with other schools in the network. The development work is now complete and MAILNET has become an operating reality, serving about 17 schools directly. In addition, Multics has become a MAILNET-BITNET gateway. (BITNET is another inter-university electronic mail and file transfer facility).

ADMINISTRATIVE INFORMATION SYSTEMS

Administrative Information Systems (AIS) consists of four service groups -- Applications, Database & Technical Support, Production, and Documentation. Substantial progress has been made in several areas:

- Application Development -- Work by AIS and client office staff during the year fulfilled many of the AIS Steering Committee's expectations, including the following five priority projects:
 - 1) Cafeteria Plan: Major changes to both the old staff and new hourly/weekly payroll systems were made to handle the introduction of cafeteria-style benefits effective last January.
 - 2) Applicant Flow: A new subsystem in the personnel database to track job applicants was implemented.
 - 3) Student and Voucher Payroll: Specifications and an implementation plan for running the payrolls from the new payroll database were published.

4) Budget System: Requirements for the central database maintenance phase were published and a hardware alternatives study and application design was completed.

5) Pension Accounting System: A firm foundation for defining the system's details was provided with the release of the pension plan proposal last fall. Live data from the old system has been converted to the new files. Batch functions are scheduled for completion this fall so the system can become operational in January of next year.

In addition to these projects, the AIS worked on projects relating to Physical Plant, financial systems, life income trusts, staff payroll, alumni register, and vacation and sick leave accrual.

- Documentation -- All the priority applications that are in test or in production have user guides; most have thorough technical documentation. All new systems are being documented as they develop and are being evaluated for adherence to design guidelines.
- Database Management -- All production and test ADABAS/VM databases were converted to a common execution standard which facilitates central support, trouble-shooting, and software maintenance. A new production environment for the language NATURAL with enhanced functions and security is being established. Tools to improve database thrupt and to produce database activity reports are being evaluated. Database software and support needs for the VAX systems are being assessed.
- Systems Performance Improvement -- With last year's serious response-time delays occurring to online production systems running ADABAS/VM, a major effort was required to discover the sources of the delays and to implement corrections. Success was evident in the generally satisfactory response time users have enjoyed since February. We continue to seek further improvements and to identify how to predict bottlenecks before they occur.
- End-User Computing -- In order to provide client staff with the tools, training, and support to do their own computing with administrative data, development work was aimed at providing administrative databases and end-user inquiry languages for users to write their own applications. This year courses were offered in Easytrieve, NATURAL, project management, and use of CMS, the operating environment on the IBM machines.
- Methodology and Standards -- This past winter a development methodology statement was published and augmented by presentations on project management issues for senior administration, managers in administrative offices, and our own staff.
- Microprocessors -- The AIS personal computer task force, like other such groups within IPS, has been exploring the burgeoning field of microcomputers. Emphasis has been on the applicability of micros to the administrative community and the services a central group might provide those users. Consultation has been provided on configurations for clients, evaluations have been made for various word-processing packages, equipment has been installed, software for transferring files between micros and hosts has been investigated, and administrative applications developed.
- 370/148 Demise -- Significant effort has gone into moving the various systems from the computer during the year. The OS batch systems will be completely moved by the end of summer. Remaining components of the demise are the move of the student systems to the administrative 3033 and the conversion of remaining DOS batch systems to the OS operating environment or their replacement. Plans call for the 148's demise by July of next year.

TELECOMMUNICATIONS SYSTEMS

The Telecommunications Office was divested from Physical Plant and incorporated within the Information Systems as Telecommunications Systems early in the year. This organization continues to be responsible for telecommunications services within the Institute. In addition, its responsibilities are being expanded in FY 1984-85 to include full responsibility for both the campus computer and the cable television networks. The latter responsibility was previously assigned to Educational Video Resources. Telecommunications Systems' organization is structurally divided into three parts: networking and software support, voice communications, and data communications.

For the past several years, the telecommunications industry has been undergoing changes. These changes are reflective of new technology, increased usage of networked computers, and regulatory actions. Within the Institute these changes have caused an evaluation of how telecommunications services are derived and provided to the Institute community. One analysis suggested that the Institute would be better served by a state-of-the-art digital switching system than by the present telephone company provided Centrex System. This has resulted in a request for proposal released to selected vendors on May 1, 1984. The plan is to replace the Centrex System with a coherent and integrated telecommunications system, capable of transporting all forms of messages (voice, data, video, and facsimile). If we proceed to implementation, the new system may go into operation in the latter half of 1986.

In line with this effort and in support of Project Athena, the Institute's underground telecommunications duct system is being enhanced. In addition, dialogue has been initiated with the City of Cambridge towards developing a spirit of cooperation between whomever the City selects to install its CATV system and the Institute. Our goal is a joint venture between the cable provider and the Institute, enabling the Institute to extend its cables to off-campus sites. This would extend on-campus computer and related services to those off-campus sites as well as provide for the bilateral transfer of programs, seminars, etc., between the Institute and the City.

The campus computer network is being designed to provide high speed data communications to as many of the on-campus computer systems as possible. This includes personal workstations, mainframe computer systems, and special server computer systems. In the initial phase of this effort, the network will connect Phase 1 Project Athena servers. Towards that end, fiber optic technology is being used to provide a broad bandwidth path between Project Athena nodes and the Laboratory for Computer Science. The initial fiber optic cable installation will consist of multiple fiber, 50 micron, multi-mode, graded index cables. Through the use of wave length division multiplexing, it will be possible to transmit 90 Mbps duplex signals over a single fiber. The initial cable, configured in a doubly redundant ring network, will connect wiring nodes in Buildings 4, 36, E15, E40, and NE43. Junction boxes will be installed in these locations to allow for future reconfiguration of fiber optic links. From these nodes, connections will be made to Project Athena sites in Buildings 1, 11, 36, 66, E40, and the Laboratory for Computer Science in NE43.

The cable plant will be expanded to serve additional Project Athena sites in Buildings 4, 37, and W20, and then to other non-Project Athena sites such as departmental and laboratory facilities and the mainframe computing center in W91. The installation of the cable is targeted for July 1984, followed in August with the installation of gateway hardware complete with connections to fiber, and the completion of software development and its installation in September.

Recent regulatory actions such as the restructuring of the American Telephone & Telegraph Co. have not lessened the need for continued Institute participation in regulatory affairs. Telecommunications Systems has continued to participate in such activities in order to ensure telecommunications services at reasonable costs. Evidence of such was participation at the Federal level in seeking reconsideration by the Federal Communications Commission of its ruling on access charges; and, at the local level in an on-going hearing at the Department of Public Utilities on the restructuring of Centrex rates, and the reconsideration of a wire use rate plan that could result in increased costs to the Institute.

WESTON J. BURNER
JOSEPH R. STEINBERG
MARILYN MCMILLAN
MORTON BERLAN

Office of Facilities Management Systems

FACILITIES MANAGEMENT

The Office of Facilities Management Systems (OFMS) is responsible for the collection, maintenance, and reporting of data for more than 25,800 individual spaces at MIT, comprising 7.6 million net usable square feet. Using INSITE 3, an MIT-developed space accounting system, two major updates to the space inventory were completed, each followed by the distribution of standard reports to academic and administrative offices. Numerous special reports were also requested throughout the year. A new approach for studying space utilization was designed and carried out on a pilot basis. Further use of the methodology will be necessary to prove its validity.

INSITE CONSORTIUM

Another major responsibility of OFMS is to provide support to the existing Consortium of external users of the INSITE Technology, as well as to foster the continued growth of the Consortium in both its membership and the quality of its facilities management.

COMPUTER SUPPORT

Of significance this year was the effort involved in the design, programming, and testing of required INSITE 3 enhancements, including an interactive frontend and report formatter, and the support of other systems and data input needs in the property management area. A Computer-Aided Drafting (CAD) and micro-version of MIT's INSITE system culminated in a demonstration of that system at the year's end. Further refinement of the new INSITE system will continue in order to assure a continuity for MIT's facilities management needs.

PROPERTY MANAGEMENT

During the year, more than 14,000 newly acquired items of movable equipment were identified and tagged with bar code labels, bringing the number of such tagged items on the campus to near 170,000. The inventory of those items began this year using a hand-held wand scanner. All departments will be inventoried by the end of 1985. Also, over 250 final inventory reports pertaining to contracts and grants were prepared. Additionally, starting with this fiscal year, the Property Group began a monthly reconciliation of the Accounting records with the Property records.

Almost \$200,000 (original acquisition cost) of excess Federal government equipment was acquired along with \$13,000 of surplus State equipment. Also, items of equipment and materials were acquired from the National Association for the Exchange of Industrial Resources and from other private sources.

Approximately 1,500 items with an acquisition value of \$600,000 were transferred from one MIT department to another for reutilization. Almost \$90,000 of equipment unneeded or unusable by the MIT community was sold. Most of the equipment available for reutilization or sale continued to be displayed at the MIT Equipment Exchange.

In conjunction with the Society for Property Administrators, the OFMS was responsible for presenting a Property Management Seminar in Williamsburg, Virginia. More than 100 attendees from the United States and Canada were present at the seminar. A newsletter was published for the nearly 400 Society members.

ARCO GRANT

A grant from the Atlantic Richfield Company (ARCO) to research the state-of-the-art of computer-aided drafting (CAD) systems was completed, along with specifications for the design of such a system. These specifications are being used for the design of INSITE 4.

KREON L. CYROS

Physical Plant Department

SUPPORT SERVICES AND BUILDING MAINTENANCE

Further reductions in peripheral services and frequency of housekeeping were experienced this year due to personnel reductions as a part of the Institute's three year program to reduce support costs. Management emphasis is on training of personnel, identification of more efficient cleaning equipment, and better supervisory procedures.

An in-house review of the plant motor vehicle fleet has been initiated to measure fleet efficiency, explore leasing options and develop a systematic replacement program.

Preliminary work has begun on a deferred maintenance program which has as its initial target the rehabilitation of our parking garages. The program will consist of building inspection, the assembly of computerized data concerning building condition and cost of repairs, and the establishment of priorities. Once estimates and priorities are set, working drawings and specifications will be prepared, bids taken, and reconstruction started.

BUILDING OPERATIONS

During the year, we continued to concentrate on the professional development of the supervisory staff. The scope of our training program was expanded to include presentations by representatives of Personnel, Environmental Medical Services and the Safety Office. Arrangements were also made for supervisors to visit comparable medical and laboratory facilities within local educational institutions.

In an effort to further exploit the capabilities of our energy management system, we assigned the department's environmental engineer to a position where he has more direct day-to-day interaction with our facilities control system (FCS) in the Operations Center. This assignment and the corresponding actions taken by him has resulted in further reductions in the use of heating and air conditioning for building environments.

UTILITIES & ENGINEERING

The Institute's energy bill for FY 1983-84 grew at a rate slightly higher than inflation due to two factors -- instability in the pricing of both primary heating fuels and electricity and a continuation in the growth of electric use in our research programs. Energy pricing of fuel oil and gas, up over 10 percent for MIT in the past year, has shown the effects of new vitality in the OPEC cartel and the shock waves of the continuing unrest in the near east. Electricity prices have been unstable as a result of the utility industry's difficulties in coping with the financial problems of investments in abandoned and delayed nuclear generators.

The pattern toward more energy intensive research programs in all research areas which has been evident for several years continues. This is most clearly seen in the proliferation of computation equipment which typically requires both primary power and air conditioning for environmental control. The Athena Program is an example of a very visible, new energy intensive program.

Offsetting somewhat the trend to higher research power use on campus is the continued effectiveness of our energy conservation programs and central computer control for optimizing building operating systems.

ARCHITECTURE, ENGINEERING & CONSTRUCTION

This year was marked by major changes both in the Institute's building program and the Architecture, Engineering and Construction group itself. The volume of major new construction has decreased very substantially and will virtually cease by the end of the calendar year. Since there are no major projects currently in either the programming or design phases, this means no major new construction for a minimum of 18 months to two years. However, the volume of renovation or space change work continues at about a \$2 million per year rate, most of which is designed and administered by plant personnel.

In anticipation of the reduction in new construction, Physical Plant moved to consolidate all its design and construction activities on the second floor of the Ford Building. This resulted in support cost savings and better communication with the other operating divisions of the plant.

One new building, the EG&G (Edgerton, Germeshausen and Grier) Education Center adjacent to the Fairchild Electrical Engineering Building was completed during the year. Major renovations completed, totalling just under \$10 million, were the Undergraduate Chemistry Laboratories (4-440); 175 Albany Street for the Plasma Fusion Laboratory and the Nuclear Magnetic Resonance research group; upper floors of the Sloan Building for the Sloan School and Department of Economics; Building 11-first floor for the Joint Computer Center and Project Athena; and new kitchens and dining areas in East Campus and Senior House Dormitories.

Major projects under construction and scheduled for completion this fall are the Arts & Media Technology Building on Ames Street and the Microsystems Research Laboratories in Building 39 on Vassar Street. The latter building, scheduled to be turned over to the research staff in December, will require up to another year for installation of complex research equipment.

Smaller projects scheduled for fall completion include the Center for Real Estate Development on the top floor of the old Armory Building (W31) on Massachusetts Avenue; the Mechanical Engineering Design Center on the fourth floor of Building 3; portions of the second and third floors of Building 2 for Chemistry research laboratories; and a relocation of Amherst Alley on the West Campus between Danforth Street and Burton Connor House to move the road away from the student residence facilities and create a more attractive and safe environment.

The Project Athena program has been a challenge to the in-house plant design group because of the problems of identifying appropriate space and providing adequate power and air conditioning for several dozen mini-computers and several thousand micro-computer work stations all on a very tight schedule.

PAUL F. BARRETT

Planning Office

The Planning Office's mission this year has been two-fold; 1) to assist the senior administration and other members of the MIT community in the development and maintenance of the Institute's long-range planning goals and objectives through use of physical, financial, and policy analyses; and 2) to maintain an integrated long-range plan for the Institute through the timely production of plans, programs, and analytical studies that describe the Institute's physical needs, financial resource requirements, demographic trends, and community relations.

Within that mission, the Planning Office's activities over the past year have encompassed a broad range of tasks. They have included: the preparation of MIT's contribution to a National Science Foundation survey of the state of the nation's scientific research facilities; the preparation of a number of physical planning alternatives to accommodate the pressing needs of the Department of Humanities; a review of the Institute's service system; the development of a proposal to add locker and shower accommodations to the Carr tennis facility; and the installation of additional overhead traffic signals and lighting at 77 Massachusetts Avenue.

Based on a review of the campus landscape program, final plans were made for modifications along Amherst Alley which will improve circulation, safety, and access for vehicles and pedestrians, and greatly enhance the quality of the environs. Similarly, the Planning Office is cooperating in the landscape planning for the new Arts & Media Technology Facility in an effort to balance both utilitarian and aesthetic considerations.

These environmental considerations extend to the Institute's off-campus areas as well. At Millstone Hill in Westford, site of the Haystack Observatory, MIT has land holdings which may offer resources in forest products. The development of a Forest Management Plan has been under study and several consulting foresters have been invited to submit proposals. The plan may not only prove to be sound environmental management, but also provide a previously untapped source of revenue to help offset MIT's operating costs at the Westford site.

The Planning Office has identified other opportunities for generating new income or recovering certain expenses from other sources. In reviewing the student academic exchange program between MIT and Harvard University, it has become apparent that an imbalance exists in student cross-registrations. Based on information generated by the Planning Office, the two institutions have now agreed on a formula which will provide some reimbursement when the exchange is out of balance. As a result of a detailed review of the Institute's ROTC programs, reimbursement has already been received from Harvard and is being negotiated with Tufts University based on their fair share of those program expenses.

With the completion of the Faculty Club Study for the Housing and Food Services' Office, several cost-saving measures have been introduced and a more detailed review of renovation options which would increase the Club's revenue-generating ability is underway.

As part of a continuing effort to assess the range of services available to members of the Institute community, the office is cooperating with Housing and Food Services, Hillel, and the Office of the Dean for Student Affairs to develop plans for the renovation of the Campus Room within Ashdown House for a new and expanded Kosher Dining Service. Assistance has also been provided to the Harvard Cooperative Society and its consultants in a study of the MIT community's retail shopping needs and a review of alternative locations for the Tech Coop.

In an effort to make the general campus area more accessible to visitors, development has begun in cooperation with the Admissions Office and the Information Office for a touch-screen television information system as part of an overall Campus Information System.

O. ROBERT SIMHA

Purchasing and Stores

Major projects accomplished or initiated this year are as follows:

1) An automated, interactive Authorized Signature File became operational at the beginning of the year. The system enables rapid and accurate screening of incoming requisitions, invoices, requests for payment, and travel forms to verify approval signatures and valid account numbers at the General Purchasing Office, the Office of Laboratory Supplies, and the Graphic Arts Department, and at the Comptroller's Accounting Office. The system satisfies internal and external audit requirements and has proven to be a vital administrative aid.

2) A Purchasing Task Force, convened by the Senior Vice President to review centralization of certain purchasing functions as suggested by the Director of Purchasing and Stores, recommended merging, if feasible, the purchasing agencies at the Laboratory for Nuclear Science (LNS) and the Research Laboratory of Electronics (RLE). Such an arrangement would be similar to the present Purchasing Field Office which provides procurement services to both the National Magnet Laboratory and the Plasma Fusion Center.

Discussions with members of the LNS and RLE directorates and feasibility studies have commenced. Discussions and studies will continue with the goal of establishing a second Purchasing Field Office during the coming year.

3) Under a new agreement negotiated with Digital Equipment Corporation (DEC), MIT students, faculty, and other employees were able to purchase directly from MIT, at substantial discounts, DEC personal computers and accessories for personal use. The same arrangement and discounts were available for purchases made on behalf of MIT departments, laboratories and centers. The Office of Laboratory Supplies provided the administration and logistic support necessary to ensure a manageable and efficient personal computer acquisition/resale/distribution program. Negotiation of similar agreements with IBM and Apple Computer, Inc. are in process and it is expected that IBM and Apple personal computers and accessories will also be available for resale under similar arrangements by September of the coming year.

4) The Department of Purchasing and Stores and the Comptroller's Accounting Office jointly purchased a Digital Equipment Corporation VAX Computer for implementation of an on-line, interactive Purchasing/Accounts Payable automated system. The computer is scheduled to be installed and operational in September of the coming year. It will be used initially for the existing Purchasing/Accounts Payable Commitment Recording and Reporting/Disbursement System. Effort will commence during the coming year to continue the development of automated purchasing functions to enable the simultaneous entry of data and

automatic production of purchase orders by Purchasing and terminal display and processing using full purchase order information by Purchasing and Accounts Payable. Representatives of other administrative offices which require interface and access capability to purchasing/accounts payable information will participate in the planning of this further automation. Longer range plans include providing the capability for departments, laboratories, and centers to access selected information from the Purchasing/Accounts Payable System.

GENERAL PURCHASING OFFICE

Purchasing activity for the year continued at the previous year's level. Major emphasis continued to be placed on negotiating discount agreements with suppliers.

The completion of the automation of accounts payable functions on equipment common to the automated Purchasing Commitment Recording and Reporting System resulted in a successful interface between offices. This automation interface contributed to improved processing of business, improved vendor relations, and improved relations between personnel of both the Accounts Payable and General Purchasing Offices.

OFFICE OF LABORATORY SUPPLIES

Combined sales of office and laboratory items and furniture/furnishings increased 17 percent over the previous year. Sales of office and laboratory items increased 15 percent and sales of furniture and furnishings increased 19 percent.

Arrangements were made to stock Digital Equipment Corporation (DEC) DECmate II Word Processors and new VT200-Series Terminals as a service to avoid lengthy delivery delays by DEC. The established Office of Laboratory Supplies' systems for receiving, storage, inventory control, delivery, coordination with the Property Office, and internal billing were utilized to ensure that requisitions were promptly and correctly filled.

MINORITY BUSINESS AND WOMEN-OWNED BUSINESS PURCHASING PROGRAMS

Business placed Institute-wide under these affirmative actions procurement programs resulted in the award of over \$4.65 million to minority business concerns and women-owned business concerns. For the first time, the Institute exceeded the \$2 million level in awards to minority business concerns. Over \$2.25 million was awarded to 175 minority businesses and over \$2.4 million was awarded to 500 women-owned businesses.

BARRY M. ROWE

Safety Office

Passage of the Right to Know Legislation in the Commonwealth of Massachusetts provided the impetus for the dominant activity of the Safety Office during the year. Efforts ranged from evaluating the law's applicability to the Institute, to upgrading departmental and laboratory hazard communication programs, to the appointment of the Director to an advisory committee to assist in drafting state agencies Right to Know Regulations.

EDUCATION AND TRAINING

The following educational programs were conducted during the year:

- Laboratory safety training seminars were presented to personnel from Aeronautics and Astronautics, Biology, Chemistry, Chemical Engineering, Medical, Laboratory for Nuclear Science, Civil Engineering, Plasma Fusion Center, and the National Magnet Laboratory. A courtesy seminar for the Boston University Chemistry Department was also held.
- Chemical labeling and lifting seminars were presented to the Office of Laboratory Supplies and the Physical Plant shippers and receivers.

- A new Fire Safety Training Seminar was presented to approximately 100 tutors of the Residence System.
- Nineteen Cardio Pulmonary Resuscitation (CPR) and two first aid courses were given to a total of 210 persons representing seven departments and laboratories on campus. In addition, 21 CPR courses were given to 215 persons at Lincoln Laboratory. It should be noted that next year the Athletic Department will assume responsibility for the CPR training program. The Safety Office will monitor the effort.

A rigging seminar being developed in cooperation with Liberty Mutual Insurance Company is almost complete. It will be presented this coming year to personnel from the Plasma Fusion Center, Bates Linear Accelerator, Physical Plant and Lincoln Laboratory.

The Emergency Action Plan Program is being implemented. Approximately 12 departments on Campus as well as Lincoln Laboratory have completed plans. Target completion dates for all other laboratories and centers have been set for the coming year.

LABORATORY SAFETY

The volume of waste chemicals increased slightly over last year with an apparent flattening in growth for the first time in several years.

The total number of departmental safety coordinators has reached 117. An effort is underway to pay an annual visit to each of them.

The Safety Office has been assisting the Cambridge Hazardous Materials Committee in the drafting of an ordinance to protect fire fighters from entering potentially dangerous laboratories with inadequate information about the facility.

FIRE PROTECTION

Fire Alarm system evaluations were made in the following buildings: 13, 14, 20, W20, NW12, NW13, NW14, and NW21. Additional alarms were added where necessary. Alarm systems were changed in 7 buildings: 54, NW12, NW13, NW14, E17, E18, and E34. The program of live testing of fire alarms to evaluate their effectiveness is continuing. Forty-seven buildings were evaluated this year. Fire evacuation drills were held in Buildings: 13, 14, 15, 16, 20, 21, E17, E18, E34, E38, and NW12.

Three fraternity fire and safety inspections were made. Guidelines for use of fireplaces in fraternities were developed and distributed as well as guidelines for purchasing decorations, furnishings and interior finishes to comply with State fire codes.

A two-day exhibit of fire protection apparatus and equipment and associated educational materials was displayed in Lobby 7 during National Fire Prevention Week.

SAFETY AUDITS

Safety Audits continue to be a significant part of safety office activities. Where audits are performed annually, significant progress has been made to improve housekeeping and general physical safety. Also, many outside agencies made inspections of facilities - The Cambridge Building Department, Kemper Insurance Company, and the Department of Energy on the main campus along with the Air Force Fire Prevention and Safety Office at Lincoln Laboratory.

A Housing Safety Check List was developed in cooperation with the Housing Office.

LINCOLN LABORATORY

A significant activity was the generation of safety procedures by the Lincoln Laboratory Safety Committee.

Emergency Action Plans for the Laboratory have been developed and approved.

The Army Corps of Engineers has begun a program to install automatic sprinklers and smoke detectors in all laboratories. In addition, all corridor smoke doors are being equipped with magnetic door holders connected to hall smoke detectors.

A new chemical storage facility has been built and a system has been developed to monitor hazardous chemicals and gases.

INDUSTRIAL ACCIDENTS

The total number of accidents experienced by the MIT community over the past several years has remained fairly constant, the accident rate being 2.4 injuries/illnesses for every 100 employees. The Bureau of Labor Statistics quotes 5.2 injuries/illnesses per 100 employees for our work category.

As compared to the industry average, MIT's accident costs have consistently shown an improvement in performance. The industry average dollar loss per 100 employees for FY 1982-83 was \$13,185 as compared with MIT's losses of \$2,909 for a performance ratio of 0.22. For the ten months of FY 1983-84, the performance loss ratio was 0.24, i.e. our losses are \$2,687 to the Industry average of \$10,977.

Training in workers compensation policy and procedures continues with the staff of Endicott House, Lincoln Laboratory and the Linear Accelerator (LINAC).

JOHN M. FRESINA

Vice President, Research

Francis Bitter National Magnet Laboratory

The Francis Bitter National Magnet Laboratory, with support from the National Science Foundation, operates a high magnetic field facility available, free of charge, to qualified scientists throughout the country. The Laboratory also designs and builds magnets, and performs research in condensed matter physics, condensed matter chemistry, and biophysics.

Highlights of the User Program for the past year include:

- 1.) Continued studies of 2D electron dynamics. About ten groups are now regularly using the high fields at NML to investigate electron motion in reduced dimensionality. The topic is now the second most important (after superconductivity) at the Laboratory. The systems studied are: GaAs/(Ga,Al)As, Si MOSFET's, InAs/GaSb, graphite, 100Å Pd layers, TaSe₂, HgTe/CdTe. Some of these experiments were performed above 28T at temperatures below 100 mK. H. Stormer (Bell), D. Tsui (Princeton), and A. Gossard (Bell) were recently awarded the Oliver E. Buckley Prize for discovery of the anomalous quantized Hall effect in 2D GaAs/(Ga,Al)As layers at NML.
- 2.) Pulsed Field Facilities. The Laboratory now provides pulsed fields to users. The capacitor-driven system generates 45T in 10 msec pulses. Data acquisition and other dedicated instrumentation are available. About ten different experiments were performed in this facility during the past year.
- 3.) High Field/Low Temperature Facilities. NML, with great assistance from Professor J. Brooks of Boston University, has coupled a dilution refrigerator to its highest field Bitter magnets. The cryostat routinely achieves 50mK at 22T; it is available to qualified users groups. User experiments during the past year include: the quantum Hall effect in semiconductor devices, superconductivity and anomalous magnetotransport in organic conductors and ultra-thin metal films, high field magnetization of ³He, and magneto-capacitance in n-Si.

SUPERCONDUCTIVITY

- 1.) Powder metallurgy processed Cu-Nb-Sn materials were improved by adding Ti to the Sn core. Critical current densities have been raised to 10⁴A/cm² at 19 tesla.
- 2.) Improvements in powder processed Nb-Al have also been achieved. This material has less strain sensitivity than Nb₃Sn; even better performance is expected if T_c can be raised.
- 3.) Upper critical fields of more than 30 tesla were measured for Nb₃Sn thin films at 4.2K with small additions of Ga. This exceptional increase in H_{c2} suggests that remarkable improvements may be possible for practical superconducting Nb₃Sn if such additives can be incorporated.
- 4.) The upper critical fields of PbMo₆S_{8-x}O_x and SnMo₆S_{8-x}O_x were measured for well characterized materials with controlled oxygen content. Non-oxygenated PbMo₆S₈ has an H_{c2}(0) of 60 tesla. Additions of oxygen reduce T_c and H_{c2} in a systematic manner and it appears that variability of some early works in the literature may have been caused by inadvertent oxygen contamination.

Research In Thin Film Superconductivity

V₃Ga films, with third elements added, were synthesized by simultaneous evaporation, and the critical magnetic fields were measured. The goal of this work is to increase the spin-orbit scattering and thus the critical field of this technologically important superconductor. Vanadium-deficient films with 2% Nb were shown to have higher critical fields than vanadium deficient films without Nb.

Spin-polarized tunneling measurements on VN films showed spin-splitting of the superconducting density of states and a spin-orbit parameter $b \approx 0.3$. This result proves that the critical field of the VN films is paramagnetically limited and might be substantially raised by heavy impurities.

Reactively sputtered NbN films have been made in a range of thickness from 300 to 8000 Å, with transition temperatures from 8 to 15 K. Perpendicular critical fields were as high as 32 teslas and slightly larger than the parallel critical fields, presumably because of a columnar structure of the films. The superconducting penetration depth was determined from the temperature dependence of the self inductance of meander lines etched from the films.

Ultra-thin Nb films have been made by electron beam evaporation in thicknesses from 30 to 100 Å with transition temperatures from 4 to 8 K. A thin coating of Al on the Nb surface prevented the formation of niobium suboxides which otherwise would render such thin samples non-superconducting. The measured parallel critical fields were as high as 16 teslas, which would allow a spin-polarized tunneling measurement of the spin-orbit scattering of pure Nb for the first time.

1.) Measurement and Theory of Fermi Liquid Parameter in High Field Superconductors (J.A.X. Alexander, graduate student; Dr. P.M. Tedrow, Professor T.P. Orlando - MIT; and Professor D. Rainer - Univ. of Bayreuth)

A theory has been developed to further our understanding of high field superconductivity by including fermi liquid effects. Superconducting tunneling and critical field measurements confirm it and provide the first measurement of fermi liquid parameters in aluminum.

2.) Design Digital Filter for Analyzing Superconducting Tunnel Junction (Professor T.P. Orlando and G.B. Hertel, graduate student)

Digital filters allow one to improve resolution in identifying important superconducting parameters and also to obtain information previously thought inaccessible. These filters have contributed to a better understanding of areas as diverse as high field superconductivity, junction device characterization, and localization theory.

3.) Sputtering Synthesis of Thin Films of Advanced Superconducting Materials (Professor T.P. Orlando and G.B. Hertel, graduate student)

A multiple target sputtering system has been designed and built in order to grow thin-films and tunnel junctions of superconducting compounds and ternaries. The system has recently been tested; and thin films of Nb, V, and Nb/Al bilayers have been successfully fabricated.

SEMICONDUCTORS

1.) Electroluminescence was observed from p-n junctions in semimagnetic $\text{Hg}_{0.80}\text{Cd}_{0.18}\text{Mn}_{0.20}\text{Te}$ epilayers. This result suggests that the addition of Mn to $\text{Hg}_{0.80}\text{Cd}_{0.20}\text{Te}$, widely used for infrared applications, improves its crystal quality.

2.) In semimagnetic semiconductors, for example (Cd,Mn)Se, (Cd,Mn)Te and (Zn,Mn)Se, we study the s-d exchange interaction and bound magnetic polarons in magnetic fields using Raman scattering, photoluminescence, and nonlinear optics.

3.) A model for the magnetic properties of semimagnetic semiconductors was developed and confirmed experimentally. It was shown that the Mn distribution in the semimagnetics is random. The antiferromagnetic exchange constant between nearest neighbor Mn^{2+} ions in CdMnSe was determined to be 8.7 K via optical and magnetization measurements.

Collective and single particle excitations of 2-dimensional electrons and holes in GaAs/AlGaAs multiple quantum wells were investigated in high magnetic fields using Raman scattering and photoluminescence.

4.) Epilayers of n-HgMnTe, with $n=10^{15}/\text{cc}$ and $\mu = 2 \times 10^5 \text{cm}^2/\text{vsec}$, were grown via two-zone LPE.

High quality, graded composition (HgCdMn)Te epilayers were grown with CVD techniques. Functions in these layers have good I-V characteristics; and near optimal photoresponse at 5μ and 10μ .

5.) The theory of cyclotron resonance of Frohlich polarons confined at low temperatures to an interface between polar semiconductors has been worked out in preparation for measurements to be made at the NML in pulsed magnetic fields.

6.) A novel spectral feature has been observed at intermediate excitation intensity in multiple quantum wells of GaAs-GaAlAs. The feature appears to be a new collective excitonic state. Experimental and theoretical work on single quantum well PbTe lasers in magnetic fields is continuing.

7.) The cyclotron resonance, free electron laser has demonstrated tuning with energy. This work was done in collaboration with Prof. G. Bekefi of RLE.

LIQUID CRYSTALS

The nematic-isotropic phase transition in lyotropic liquid crystals was found to be nearly second order for certain systems. The interaction between liquid crystals and solid substrates has been quantified and related to nematic order. Magnetic and structural information has been obtained for purple membranes using optical techniques in high fields. Finally, magnetoactive bacteria have been

shown to be microaerophilic using optical birefringence techniques.

NUCLEAR MAGNETIC RESONANCE PROGRAM

We have performed ^{13}C and ^{15}N MASS (magic angle sample spinning) NMR experiments on bacteriorhodopsin to determine the complete configuration of the retinal. We have developed new methods for manipulating sidebands in MASS spectra. Finally, we have made significant progress in understanding the molecular dynamics of lipid bilayers with ^2H NMR experiments.

MAGNET TECHNOLOGY

14 T NMR Program

The niobium-titanium sections have been successfully tested to full field. Joints between niobium-tin and niobium-titanium wire have been made reliably. The niobium-tin sections of the coil are being wound.

Pulse Coils

A 250 kJ capacity bank has been ordered for delivery in August 1984. Test coils have been cut in aluminum and stainless steel to test manufacturing techniques. The design of a 50 T coil is nearly complete, and maraging steel billets have been obtained for its construction.

Continuous Field Magnets

Bitter magnets of new design are setting records for longevity, efficiency, field intensity, linearity, and retention of homogeneity in the face of changing operating conditions. Each new design employs two concentric coils clamped by tie rods and connected electrically in series. Two magnets are of 33 mm bore and generate 23.0 teslas. The other two are of 54 mm bore and generate homogeneous fields of : (#1) 18.1 T and, (#2) 14.2 T, or 24.2 T when operated in a 7.0 T background field. Particularly gratifying is the performance of the first of these "tie-rod" magnets, which has lasted as long as the best of its predecessors, none of which ever generated more than 22.6 T, even though consuming more power.

APPLIED MAGNETISM

1.) Magnetic Separation

Continuous and more selective magnetic separation techniques for complex primary materials have been developed under a continuing NSF grant. Work has begun on a DOE funded cooperative project with General Electric on the enhancement of coal pyrite magnetism by selective heating using high power microwave for the purpose of improving coal desulfurization by high gradient magnetic separation.

2.) Electromagnetic Launching

Testing has been completed on the two-stage induction accelerator. Over 300 successful firings were performed. Two stage operation was confirmed and over 600 m/s velocity was achieved with 13 gram magnesium rings. A higher performance single stage accelerator designed to operate in vacuum is now under development. 8 gram aluminum rings have been accelerated to over 800 m/s with this device.

3.) Metal Vapor Vacuum Arc Switching

The magnetically augmented vacuum arc switching project has been completed. Commutation was reliably demonstrated at the 10 kV and 5 kA levels. Increased power rating is being pursued with the development of a triggered rod array gap.

MAGNETISM IN LIVING SYSTEMS

The Low Field Group has devoted the main portion of its effort to carry out research in using magnetic measurements to obtain information about electrical sources in the brain. In particular, a novel method of combining magnetoencephalographic and electroencephalographic measurements to obtain such information has been tested and found to work very well. This technique has yielded interesting information about previously misunderstood sources in the somatosensory region of the brain.

PETER A. WOLFF

Center for Materials Science and Engineering

The Center for Materials Science and Engineering (CMSE) was founded in 1960 for the study of the structure and properties of materials. Major funding for the Center programs is provided by the National Science Foundation (NSF) under the Materials Research Laboratory (MRL) program. The Center operates central facility laboratories which provide state of the art instrumentation and the expertise of professional staff to foster research projects and enhance funding opportunities by the materials community at MIT. Major items acquired this past year include a new transmission electron microscope, a differential scanning calorimeter, a gel permeation chromatograph to measure molecular weight distributions in polymers, and a mirror bender for our x-ray scattering spectrometer at the Brookhaven National Synchrotron Light Source. A Directory listing our central facilities, their capabilities, and how to arrange to use them was published in May 1984. Copies are available at the Center administrative headquarters.

The Center also funded 37 research projects carried out by 31 faculty from the Departments of Chemical Engineering, Chemistry, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Physics. This is collaborative interdisciplinary research of a type difficult to fund through direct grants from funding agencies to a single investigator, and is organized into several areas of thrust.

As an important part of our research program, the Center provided seed funding of programs to six investigators during the past year. This funding provides an opportunity for junior faculty or new senior faculty to develop strong programs which can either be incorporated into one of our areas of thrust or receive continuing support from other sources.

A weekly colloquium series covering a range of topics as broad as the interests of members of the Center was conducted, along with support of weekly seminar series on polymer research as well as one devoted to condensed matter physics. The central facilities laboratories offered several program training courses during IAP which provided hands-on training for students and staff.

Below, we outline briefly the activity of the research thrust areas during the past year, which was the second of a three-year grant from the NSF. The names and departmental affiliations of the individual researchers are given.

Research on Flow and Fracture in High Temperature Alloys

This group has carried out a number of related studies of refractory alloys. Creep and fatigue crack initiation and growth are investigated both empirically and fundamentally; various materials are prepared and subjected to environmental stresses, then examined using the electron microscopy facilities of the Center. Theoretical modelling is both phenomenological and microscopic; the latter based on the interactions of dislocations at grain boundaries and with precipitate dispersions.

On the basis of the creep investigations, a new theory of primary creep has been developed, in which the creep rate is governed by the evolution of an isotropic deformation resistance. Incorporation of strain hardening, along with static and dynamic recovery into the model, has given a general framework that can account quite well for the evolution of hardness in the creep experiment, the uninterrupted strain-time law, and transients due to both up and down changes in the applied stress. The evolutionary creep law has been generalized into three-dimensional form and has already been used successfully in computational programs for creep damage.

Faculty/Department: Professors Robert Balluffi, Nicholas Grant, Regis Pelloux, Samuel Allen (Materials Science and Engineering); and Ali Argon, Frank McClintock (Mechanical Engineering).

Structure and Properties of Microcrystalline and Glassy Alloys Produced by Rapid Solidification

Amorphous and microcrystalline metals produced by rapid cooling continue to gain in technological and economic importance. The goal of this thrust area is to produce new varieties of these materials, to study their properties, and to acquire the basic understanding needed for materials design. This understanding has progressed to the point that it is possible to predict which materials will have superplastic behavior, and the predictions were verified in aluminum alloys as well as microduplex stainless steels (ferrite plus austenite) that were produced this past year. Quantitative prediction of the superplastic deformability remains elusive. On a very fundamental level, quantum mechanical calculations to predict the electronic structure and glass forming capability of amorphous alloys continued. These materials often have excellent corrosion resistance, and these properties were also studied. There are now about 20 faculty who are involved in various studies based on the metastable glassy and microcrystalline alloys produced by rapid solidification.

A group of 35 to 40 staff and graduate students are directly involved in producing alloys of interest and in the associated research. There is significant interest in RST in the Departments of Materials Science and Engineering, Mechanical Engineering, and Nuclear Engineering. For this reason, we have taken the initial steps to establish a central facility for rapid solidification processing.

Faculty/Department: Professors Nicholas Grant, Keith Johnson, Ronald Latanision, John Vander Sande (all of Materials Science and Engineering).

Catalytic Activity and Surface Structure

The focus of the basic research programs in this thrust area is the effect of local surface environment on electronic structure and catalytic activity. These effects are studied experimentally and theoretically by modification of the catalyst-support interactions on electrode surfaces and by modification of the surface structure on single crystal transition metal surfaces.

Chemical modification of electrode surfaces to provide catalytic routes for electron transfer reactions is being studied. Specifically, this includes the modification of impregnated polymers confined to electrode surfaces so as to attain both long-term durability of the polymers and useful electrochemical rates of such technologically important reactions as the reduction of CO₂ by H₂. Theoretical work by self-consistent molecular orbital calculations of palladium impregnated polymer catalysts attached to electrode surfaces as well as the electrolyte interactions is proceeding.

The effects of surface structure on the first step of a surface chemical reaction, that of adsorption, are under investigation. By varying the energy of the incident molecule, the dynamics of the adsorption process is probed, thereby providing insight into how the interaction potential between the adsorbing species and the surface is modified by the presence of structure such as steps on the surface. Systems under investigation include the dissociative adsorptions of CO₂ and CO on Ni and Pd, gas phase analogs of the reduction reactions under investigation in an electrochemical environment. These adsorption mechanisms are studied theoretically by calculating their energy transfer rates with methods which range from the solution of the classical equations of motion via the generalized Langevin equation to the solution of the quantum mechanical time dependent Hartree equations for the surface-molecule system. The interaction potential modeled, and hence the adsorption and scattering process, will be refined by the experimental information obtained.

Faculty/Department: Professors Keith Johnson (Materials Science and Engineering), Sylvia Ceyer, Robert Silbey and Mark Wrighton (Chemistry).

Defects in Solids

The common theme of this thrust area is now the study of defects in electronic and opto-electronic materials, and the area is closely linked by a common application of microelectronics processing technology to both investigate and to exploit these materials. Fruitful collaborative efforts are active in research on understanding the electronic properties of amorphous silicon and chalcogenide glasses, and on the nature and role of defects in silicon and III-V crystalline semiconductors. The expansion of the facilities of the Microelectronics Laboratory and upgrading of the Ion Implantation Facility have had a major positive impact on this area; and continued growth in the semiconductor technology and device area is expected as part of a rapidly growing research effort in Very Large Scale Integration (VLSI) at MIT.

A low pressure chemical vapor deposition (CVD) process was developed for the deposition of silicon epitaxial films at temperatures as low as 650°C, both with and without plasma enhancement. This represents the lowest silicon epitaxial deposition temperature ever reported for a thermally driven CVD process. The predisposition in-situ cleaning of the substrate surface was found to be the most critical step in determining whether epitaxial deposition will occur at these relatively low temperatures. If preliminary results are confirmed, these films show great promise for photovoltaic applications.

A Molecular Beam Epitaxy system has been installed and high quality, high mobility undoped and n-type gallium arsenide and aluminum gallium arsenide epilayers have been grown on gallium arsenide substrates.

A method has been developed for calculating the total energy of solids. The method is formulated within the framework of a selfconsistent local density function theory and a non-local pseudopotential theory. An important, but unexpected, result was that the electron correlation energy is positive. A careful reexamination of old experiments and some results of new experiments indicated that the theoretical prediction is, in fact, correct. These are the first realistic total energy calculations of charged defects in solids.

Faculty/Department: Professors David Adler, Dimitri Antoniadis, Clifton Fonstad, Rafael Reif, Stephen Senturia (Electrical Engineering and Computer Science); John Joannopoulos, Marc Kastner, Patrick Lee (Physics); and Harry Tuller (Materials Science and Engineering).

Phase Transitions

The continuing goal of this thrust area is to understand the many phases that occur in condensed matter as fundamentally as possible. The theoretical approach is to use phenomenological models where necessary, but to solve the statistical mechanics of the many body Hamiltonian, using the most modern computational techniques, wherever possible. Experimentally, behavior is probed using quasielastic light scattering, high resolution X-ray scattering, neutron scattering, and precision calorimetry.

X-ray scattering from monolayers of krypton adsorbed on graphite have revealed a liquid phase which forms a two-dimensional solid on cooling and melts into a liquid on further cooling. This is thought to be the result of a competition between the lattice period of the substrate and that preferred by the krypton. Such re-entrant behavior is also observed in liquid crystal material with competing periods. It seems likely that the basic mechanisms are closely related.

Faculty/Department: Professors Carl Garland (Chemistry); and Robert Birgeneau, David Litster, Thomas Greytak, George Benedek, Ahmet Berker and Toyochi Tanaka (Physics).

Deformation and Fracture in Polymer Composites

The goal of this thrust area is to understand the micro-structural causes and mechanisms of toughness in polymer composites. There has been increased emphasis on the production of perfect graphite fibers, modified by intercalation, for reinforcing polymer composites.

The research on heterogeneous polymers went through a gradual transition during the past year, from block copolymers of polystyrene/polybutadiene to semi-crystalline polymers of Nylon 6. In another development, it was found that combinations of redox polymers and noble metals such as platinum, palladium, and rhodium can be useful electrocatalyst systems.

One of the fundamental areas where a particularly significant study has been made is in understanding factors controlling charge transport through a redox polymer film. The particularly novel finding is that it is possible to measure, *in situ*, thickness changes of the redox polymer upon cycling between the three redox levels. These can be as large as 50 percent, with significant changes in charge transport properties. An additional practical outcome may be insight into mechanisms for electrochemical devices for converting electrical signals to mechanical signals. This study serves as the basis for future effort on the electrochemical properties of surface-confined polymers.

It has been shown that dramatic increases in the electrical conductivity (14 orders of magnitude) of a number of normally insulating polymers can occur through ion implantation at influences of 10^{15} to 10^{16} ion/cm². This work has attracted considerable industrial interest because of the demonstration that properties of a polymer can be modified in a controlled way to synthesize new materials with specifically desired properties.

Faculty/Department: Professors Ali Argon (Mechanical Engineering); Robert Cohen (Chemical Engineering); Mildred Dresselhaus (Electrical Engineering and Computer Science); and Donald Uhlmann (Materials Science and Engineering).

J. DAVID LITSTER

Division of Comparative Medicine

The past year has been marked by the passage of legislation in the State of Massachusetts which will effectively eliminate the use of pound dogs and cats in research by the year 1986. In addition, the Commonwealth of Massachusetts, under the Commissioner of Public Health, will have powers to routinely visit animal care and use facilities to monitor experimentation utilizing dogs and cats and all sentient animals.

Also, new proposed National Institutes of Health guidelines will require the MIT Animal Care Committee to review and approve all animal research protocols. These new proposed guidelines are analogous to the human use committee requirements and demonstrate further the increased scrutiny and regulation of animal experimentation on a nation-wide basis. The Institute Animal Care Committee, having recognized the increased public sensitivity to animal experimentation, had already adopted and implemented institutional policies for protocol review of animal experimentation. This review is patterned after that which is employed when humans are used as experimental subjects.

Part of the responsibility of the Division of Comparative Medicine (DCM) is to manage a central animal resource program that now totals approximately 80,000 square feet. In the last year, plans have been formulated to include the new Whitehead animal research facility under the management and direction of the Division. This new facility of 16,000 square feet will be occupied in July of 1984. The Division is also pleased to announce that as of July, 1984, the substandard E10 animal care facility will no longer be included as a satellite facility. All animals have been relocated to modern facilities that are approved by the American Association for Accreditation of Laboratory Animal Care.

Progress continues in computerizing the Division's administrative records, and this past year, an animal census and billing program was implemented. Animal-related research at the Institute has been active and growing during the past year; the Division provided some 15 different species of laboratory animals for the research community. Some ungulates such as swine and sheep have been added to the numbers of animals being used at the Institute.

The Division's research activities continue to grow. During the last year, extramural support for the Division's research and diagnostic activities approached \$500,000; the Division's current budget is nearly \$2 million. In addition, the postdoctoral training program for graduate veterinarians in comparative medicine has continued to grow; we now have five postdoctoral fellows in our program. Dr. Christian E. Newcomer was promoted to Associate Director, in charge of clinical activities and animal resources.

The Division is proud to announce the publication by Academic Press of the first comprehensive teaching text, entitled *Laboratory Animal Medicine*; it is hoped that this text will be used not only for veterinary students, but for all graduate students in the biomedical sciences interested in animal experimentation. In addition, 25 articles were published by DCM faculty and staff. The Division also has published 19 abstracts during the past year, and has presented numerous papers at both national and international symposia on comparative medicine.

JAMES G. FOX, DVM

Energy Laboratory

The main purpose of the Energy Laboratory is to encourage problem-oriented research on a broad range of energy issues through the interactive participation of people drawn from most of MIT's academic departments. The greatest single research emphasis is the efficient, economic, and socially responsible use of the increasingly "dirty" fuels of the future such as coal, tars, heavy crudes, and shale. Specific projects focus on combustion in furnaces and engines, health effects of emissions, energy supply and demand, and conversion to clean fuels. In addition to that work, Laboratory programs include research on conservation, renewable energy sources, nuclear energy, and conventional oil and gas in both technological and economic/policy projects.

Operating expenses of the Energy Laboratory during fiscal year 1984 were about \$9.4 million compared to about \$9.2 million in 1983. The large funding cuts experienced during 1981-1983 appear to be over and we look forward to modest growth. Our sponsorship is now more diversified with about half the funding coming from the private sector and less than one quarter from the US Department of Energy; five years ago, DOE accounted for more than 60 percent of our support. The numbers of participating faculty and graduate students have been stable over the last few years at about 55 and 200 (both ± 10 percent) respectively; the funding cuts were accommodated largely by reducing paid research staff by more than 50 percent during the period, but no further reductions are planned. About a dozen academic departments have been represented by participants in Laboratory research projects during each of the last few years.

The Laboratory prepared its first formal five-year plan during fiscal 1984. The plan was reviewed and endorsed by the Laboratory's Steering Committee (an MIT group) and by our Advisory Board (an external group). As noted in part above, the plan calls for modest growth, diversified sources of funding, diversified portfolios of smaller projects, and continued reliance on faculty and students rather than on a large staff. In building stable and diversified programs, the Laboratory has increased its effort to attract cooperative or consortium support for research projects from industrial sponsors, relying less on single-company support and on government support. That effort was particularly successful in 1984 in three consortia, one old (electric utilities) and two new (ceramics and synthetic fuels) whose total support now exceeds \$3 million/year. Most of that support is in the Electric Utility Program (EUP) which helps develop and coordinate research projects in four main areas: combustion, nuclear, environmental, and electrical equipment. The EUP now performs that function not only for the Energy Laboratory but also for the Laboratory for Electromagnetic and Electronic Systems. Early in the year, a new consortium of Japanese and US companies began sponsorship of what is now a four-year program to synthesize ceramic powders by laser-induced reactions. Late in the year, a new consortium (initially comprising five US companies) began sponsorship of a diversified program of long-term research on synthetic fuels.

Specific research accomplishments during the year covered a large and diverse set of topics. Some of the topics of more general interest were summarized in our quarterly research bulletin, e-lab, under the following headings, grouped here in three categories:

Management, Economics, and Policy

- Natural gas: Famine to feast to famine
- Energy price shocks and capital depreciation
- Oil and gas exploration in developing countries

Environment, Health, and Safety

- Reducing atmospheric buildup of CO₂
- Evaporation from cooling ponds
- Sulfuric acid from coal combustion
- Removing sulfur from flue gases
- Cooling towers, the environment, and human health

Other Technical Research

- Combined cycles: Improving efficiency
- Designing engine combustion chambers
- Coal-water slurries
- Thin films made with lasers
- Measuring flows in gas pipelines
- Secondary reactions in coal pyrolysis
- Tracing hydrogen atoms in coal liquefaction

Information on all the projects being performed in the Laboratory may be obtained from Project Summaries, July 1, 1983 - June 30, 1984. The following material describes the major thrusts of the Energy Laboratory's principal research groups.

RESEARCH GROUPS

The Energy Laboratory's International Energy Studies Program conducts research on economic, political, and strategic aspects of international energy trade (oil, nuclear fuels, and other energy commodities) and on the financial implications of the large reciprocal flows of wealth associated with that trade. New directions for research include couplings between domestic US and foreign markets, security of supply concerns and their effect on national policies and international relations, the roles of public and private sectors in dealing with supply crises, and the energy problems of the developing world. (Dr. Thomas L. Neff, program director)

The Energy Markets, Pricing, and Regulation Program conducts research on the structure and performance of energy industries, markets, and economy interactions. Current projects include research on the effects of energy price shocks and uncertainty upon industrial productivity and capacity utilization; wealth and income distribution effects of changing energy prices; structure and regulation of the electric utility industry and the natural gas production and distribution industry; project evaluation methods for large-scale energy technologies; and studies of consumers' valuations of design innovations affecting energy efficiency of automobiles. (David O. Wood, program director)

The Combustion Research Facilities Program emphasizes parallel modeling and experimental investigations of combustion of gaseous, liquid, and solid fuels in both steady and unsteady operation. A special feature of the experimental studies is that detailed flame data are obtained in large-scale pilot plant combustors in which the combustion-heat transfer processes closely simulate industrial practice. (Professor Janos M. Beér, scientific director)

Research in the High-Temperature Reactions and Health Effects Program concentrates on thermal chemical reactions of fuels and renewable resources and on techniques for controlling emissions from combustion processes. Of particular interest are coal char gasification and rich mixture combustion, which involve problems of catalysis, capture of sulfur, and reduction of particulates and nitrogen oxides. Studies of the formation of mutagens in hydrocarbon combustion involve a team effort among engineering, analytical chemistry, and biological sciences. (Professor John P. Longwell, program director; Dr. William A. Peters, program manager)

The Transportation Propulsion Program is based on the activities of the Sloan Automotive Laboratory. The work includes fundamental combustion studies, internal combustion engine research, gas turbine and burner research, and policy and technology studies. (Professor John B. Heywood, program director; Dr. Jack A. Ekchian, program manager)

The Energy Systems Program studies options for future energy systems by evaluating their impacts and by defining R&D needs to solve the problems identified. Research focuses on four areas: electric utility operations and control; economics and policy decisions associated with new energy technologies; development of modeling tools for utility operation and expansion; and economics of regulation/deregulation of the electric power system. (Professors Thomas H. Lee and Fred C. Schweppe, program directors; Dr. Richard D. Tabors, program manager)

The Advanced Energy Materials Program examines new and emerging technologies in such areas as electrodes and electrolytes for high density batteries and fuel cells, synthesis of ceramic powders using laser heat sources, rapid solidification of molten ceramics, solar heating/cooling, amorphous photovoltaics, and broad band antireflective coatings. (Dr. John S. Haggerty, program director)

Research in the Environmental Program seeks to identify and reduce the environmental impacts of energy-related facilities and includes a diverse range of research projects. Current projects consider cooling systems for electric power plants, water management issues associated with coal development, impacts of acid rain, local effects of air emissions, and environmental implications of ocean thermal energy conversion. (Professor Jay A. Fay, program director; Dr. E. Eric Adams, program manager)

The Nuclear Program has the following broad objectives: to provide direct technical contributions to nuclear plant reliability and safety; to investigate possible improvements in nuclear plant design for more efficient utilization of nuclear fuel resources; and to develop and communicate information that will contribute to public understanding of nuclear power. (Professor Norman C. Rasmussen, program director; Dr. William D. Hinkle, program manager)

The Energy-Efficient Buildings and Systems Program examines the behavior of existing buildings and components and seeks to develop new technologies with better energy efficiency. Current projects include studies of the transfer and accumulation of moisture in structures retrofitted with insulation, heat loss from building foundations, and the insulating value and aging characteristics of closed-cell foam insulation. (Dr. Leon R. Glicksman, program director)

The Center for Energy Policy Research focuses on policy research and analysis and on making results available and useful to policy makers. With support from its Associates, a wide range of US and international corporate and noncorporate interest groups, the Center holds conferences and seminars to bring

together key government and private organizations to work on energy-related policy issues. The work of the Center is done by professional staff members from the Energy Laboratory, faculty and students from several MIT departments (particularly the Sloan School of Management and the Department of Economics), and specialists from the Center's Associates. (Loren C. Cox, director)

The Synthetic Fuels Center focuses on research on conversion of coal, oil shale, and other energy resources to liquid and gaseous fuels. Support for the research comes from cooperating industrial organizations who review proposals from interested MIT faculty and staff. (Dr. Malcolm A. Weiss, director)

The Electric Utility Program serves to inform participating companies about ongoing MIT research activities, to identify and discuss utility needs and priorities, and to develop research projects responsive to those needs. The member companies currently participating in the program include 9 utilities and 8 other companies involved in supplying fuel, equipment, or services to the industry. (Dr. William D. Hinkle, director)

PUBLICATIONS

During the past year, Energy Laboratory research resulted in 14 technical reports, 13 working papers, and about 80 other publications (journal articles, workshop and conference presentations, etc.). Energy Laboratory Headquarters has available a list of reports and working papers published since 1978 as well as copies of Project Summaries and e-lab.

MALCOLM A. WEISS

Nuclear Reactor Laboratory

During the past year the Nuclear Reactor Laboratory (NRL) engaged in joint activities with seven academic departments and interdepartmental laboratories, the Charles Stark Draper Laboratory, and 26 other universities and nonprofit research institutions, such as teaching hospitals. The spectrum of these joint research or teaching and training activities includes neutron scattering studies of condensed matter, nuclear materials research and development, radiochemistry and trace analysis applied to health effects of coal use, nutrition studies, earth and planetary sciences, nuclear medicine, reactor engineering, computer control of reactors, and training in reactor operations.

INTERNATIONAL SYMPOSIUM

July 21, 1983 marked the 25th anniversary of the date when the MIT Research Reactor, NRL's principal facility, first went into operation. In recognition of the occasion and with the help of international advisory and technical program committees, NRL organized and hosted at MIT on October 16-19 a symposium on the "Use and Development of Low and Medium Flux Research Reactors." There are 285 such facilities worldwide, 102 of which are in the USA, and half of the latter are at universities. The attendance, 208 registrants from 21 countries, and the number of papers presented, 146, exceeded expectations and showed that research and academic programs of the type described in this NRL activities report are flourishing throughout the world. A number of papers were devoted to past reactor upgradings and to plans for major improvements in the future. Proceedings have been published. The symposium was sponsored by the American Nuclear Society, American Physical Society, Department of Energy, Institute of Electrical and Electronics Engineers, and National Science Foundation. Immediately after the symposium, on October 20 and 21, NRL hosted the annual meeting of the National Organization of Test, Research and Training Reactors, which is attended by representatives from most such reactors at universities, US national laboratories, and commercial facilities.

NEUTRON SCATTERING RESEARCH

Professors Clifford G. Shull and Anton Zeilinger and their Physics Department group have continued their studies of the wave properties of thermal neutrons and the diffraction physics of neutrons and crystals. The existence of an "effective mass" for neutrons under diffraction by a crystal, which can be many orders of magnitude smaller than the classical mass, has been fully established in deflection experiments. Further studies have shown without ambiguity that two groups of neutrons of positive and negative mass are observable, as had been predicted by theory. Experiments have been performed with a neutron interferometer in which the focusing action of a full cylinder lens (and the counterpart hole in block) has been measured. Equivalent focusing and redirection of ray trajectories is to be expected with suitable zone plates, and experimentation is planned to demonstrate this. The transverse coherence of neutron radiation has been studied in an interferometer using slit limitation of the traveling wave components. A very large interferometer crystal has been obtained and fabricated into an interferometer system and its performance will be tested in the near future. If successful in operation its very large area (15 times that of existing units) will open a new regime of interferometer applications. The piezoelectric strain constant in quartz has been measured in a double-crystal neutron spectrometer and found to be significantly larger than that established by conventional measurement. Interpretation of this is not known at present.

Studies of polymer structure carried out by Dr. Charles V. Berney, his colleagues, and a graduate student in the Department of Chemical Engineering have focused on the statistics of chain conformation in a restricted environment. Model systems, such as phase-separated diblock copolymers, have been synthesized and studied using small-angle neutron scattering (SANS); results were recently published. Deuterium substitution has been used to label chains for which the statistics of conformation are to be assessed. Experiments are currently being planned which will determine behavioral differences between free polymer chains and those bonded to the matrix material. In addition, exploratory determination of inelastic neutron scattering from biologically active materials (e.g. collagen, gramicidin) have been carried out with the cooperation of Dr. V. Renugopalakrishnan of the Harvard Medical School.

NUCLEAR MATERIALS RESEARCH AND DEVELOPMENT

A major alloy development project for fusion reactor first wall materials was continued for the sixth year. This research is directed by Professor Nicholas J. Grant, of the Department of Materials Science and Engineering, and Professor Otto K. Harling, director of the NRL. Professor John B. Vander Sande, of the Department of Materials Science and Engineering, also participated in the project. Senior research staff included Drs. Janez Megusar, Douglas Imeson, and Marvin Lee. Two graduate students completed their Ph.D. dissertations and one his S.M., and several others are currently doing their research on this project. More than 45 journal articles and formal reports have been completed to date as a result of project activities. A major thrust of this research effort has been the exploration of the use of innovative alloy processing techniques, such as rapid solidification from the melt, for the purpose of developing primary first wall alloys for fusion reactor first wall applications. The development of improved first wall alloys is on the critical path toward economical fusion power. The MIT approach provides a means to manipulate alloy microstructure and microchemistry in order to benefit irradiation performance. Alloy design, alloy production, irradiation testing, and postirradiation characterization are the major parts of this interdisciplinary project. Important results from the program included a model for irradiation performance of Ti and C containing austenitic stainless steels and successful testing of highly irradiated (~ 40 dpa) miniature alloy specimens using a miniature tensile test developed at the NRL. Emphasis in this project has shifted from austenitic

stainless steels to ferritic steels and high performance copper alloys. The ferritic materials are inherently more resistant to radiation induced void swelling but are susceptible to hydrogen embrittlement and exhibit a ductile-to-brittle transformation which after irradiation can shift to the normal operating temperature range. Major emphasis is being placed on improving the ductile-to-brittle transformation temperature by alloy design. A major irradiation experiment on high performance copper alloys is proceeding on schedule. This experiment is expected to provide, for the first time, information on the irradiation performance of copper alloys at service temperatures and for significant neutron doses. Significant progress was also achieved in the development of a new miniature specimen test for the determination of the ductile-to-brittle transition temperature. Graduate students involved in all phases of alloy design, production, and testing obtained unique research experience in radioactive materials research.

A research project using the MITR-II for nuclear materials irradiations was initiated by Professor Harling and Dr. Gordon Kohse. This project is related to breeder reactor materials and will determine the effects of time, temperature, and fast neutron irradiation on the microstructure and mechanical properties of a prototypic breeder alloy which will be used in the low flux peripheral regions of breeder reactors.

Sodium chloride crystals were irradiated for Professor Robert W. Balluffi, Department of Materials Science and Engineering. The smooth cleavage surfaces of the radiation-damaged crystals were used in making thin films of gold for grain boundary studies.

RADIOCHEMISTRY AND TRACE ANALYSIS

Professor Frederick A. Frey and his research group continue to rely on the MITR-II for neutron activation analysis of geologic samples. The abundances of trace elements that are obtained by this technique are extremely useful in developing an understanding of the origin and evolution of volcanic rocks that erupt in various plate tectonic regimes of the earth. During the last year his research group has made significant advances in understanding the evolution of Hawaiian volcanoes, volcanism within an oceanic plate, and in understanding the source and development of Andean volcanoes which form in response to collision between an oceanic and a continental plate. The neutron activation laboratory supervised by Professor Frey and Dr. P. Ila, research staff, was utilized for geochemical studies by five graduate students and one undergraduate in the Department of Earth, Atmospheric and Planetary Sciences and by 11 guest researchers from four other New England educational and research institutions.

Dr. Morteza Janghorbani's radiochemistry group has continued their activities in the area of stable isotope applications in human studies. In earlier research they developed methodology for metabolic studies of MIT young adults in the areas of zinc, selenium, and copper nutrition. Much of the work is based on recently developed concepts of biologically labeled foods and has been carried out for the first time at MIT. In addition to their metabolic studies, carried out jointly with Professor Vernon R. Young of the Department of Nutrition and Food Science and the MIT Clinical Research Center, they have continued to develop collaborative programs in areas for which stable isotopic methods are the sole practical approach: studies with neonates, mineral metabolism in relation to human pregnancy, and many human metabolic disorders. They have ongoing programs with researchers at such other institutions as Purdue University (biological labeling of human foods), Wayne State University (zinc marginal deficiency in man; homeostasis of zinc-copper in Wilson's disease), and Yale University (mineral nutrition of neonates). This group has continued to provide key technical support for the coal combustion research of Professor Adel F. Sarofim in Chemical Engineering. Late last winter, Dr. Janghorbani resigned from his position at NRL to accept a faculty appointment at Boston University's School of Medicine. Dr. Bill Ting has likewise transferred to BU. The above collaborative programs with MIT and other researchers continue, however, as does their use of the MIT Reactor for activation of materials under study in those programs. A replacement for Dr. Janghorbani is being sought.

In collaboration with Professor Alexander Varshavsky and Dr. Robert M. Snapka, Biology Department, neutron radiography has been combined in a unique manner during the past year with chromatograph evaluation of amino acid systems; assay sensitivity is increased by an order of magnitude.

COMPUTER CONTROL OF REACTORS

Professor David D. Lanning, Nuclear Engineering Department, and Dr. John A. Bernard continued studies on the closed-loop, digital control of nuclear reactors during both steady-state and transient operation. A general set of control principles, based on reactivity constraints and intended for non-linear conditions, have been deduced and experimentally demonstrated on the MIT Reactor. This approach is unique in that it is based on the general equations of reactor dynamics rather than measurements of specific response characteristics. This work, which is now supported by the National Science Foundation, resulted in one Ph.D. thesis and six publications during the past year. In addition, a collaborative effort with the Charles Stark Draper Laboratory in the areas of signal validation and fault detection remains ongoing. This research resulted in one S.M. and one S.B. thesis during the past year.

NUCLEAR MEDICINE

Professor Gordon L. Brownell, Nuclear Engineering Department, continues a program of basic study leading towards the successful application of boron neutron capture therapy. Working with Dr. John Kirsch, track etch autoradiography is being developed to determine the boron distribution in tissue samples. Resolutions approaching the theoretical limit of about 0.5 μ m for present techniques have been achieved and make it possible to determine boron distributions at the cellular level. Under study is the feasibility of using electron microscopy and image processing, which could further

improve resolution by orders of magnitude. The First International Symposium on Boron Neutron Capture Therapy was held at MIT October 12-14, 1983, and was attended by 96 experts from eight countries. Forty-four papers were presented and have been published in the proceedings of the meeting.

Medical imaging using reactor produced isotopes is assuming increased importance in biomedical research. Studies on F-18 production at the MIT reactor have indicated that this isotope can be produced in adequate quantities. Studies have been completed by NRL to show that carbon-11 can be produced in the MIT Reactor. A patent for this process has been submitted. Subject 22.55 Biological and Medical Applications of Radiation and Radioisotopes (Professor Brownell) and Subject 22.56 Principles of Medical Imaging (Professors Brownell and Lele) make use of the MITR-II. Six and eight students, respectively, were enrolled in these two subjects.

Enrollment in a new master's subspecialty in Health Radiation Physics, initiated in 1982-83 by Professor Otto K. Harling and Dr. Barry W. Wessels, expanded to five students and promises further growth next year. This program in the Nuclear Engineering Department is designed to educate students to a high level of proficiency in radiation management and control. An important part of the curriculum involves use of the MITR-II, the Bates accelerator, and various other radiation related facilities in the Boston area to provide realistic laboratory experience for the students.

REACTOR IRRADIATIONS AND SERVICES FOR RESEARCH GROUPS OUTSIDE MIT

In nuclear medicine the development of radioisotopes for use by researchers at hospitals and other universities, included: 1) production of Cl-38 for Drs. Bernard Hoop and D. C. Johnson, of the Pulmonary Unit in the Department of Medicine, Massachusetts General Hospital, who are studying the control of ventilation through the regulation of chloride ions in the cerebrospinal fluid in a dog model, 2) production of Au-198 seeds for cancer therapy for Dr. Philip Cobb of the New England Deaconess Hospital, 3) research activities for Professor Webster S. S. Jee of the University of Utah Radiobiology Laboratory using solid state neutron track detectors to study the distribution and transport of plutonium in animal models, and 4) production of Dy-165 for Dr. Michael R. Zalutsky of the Whitaker College of Health Sciences, Technology, and Management for research studies in the treatment of arthritis.

The subject of improved training for nuclear power plant operators has received considerable attention in recent years. The MIT reactor staff provided two series of hands-on operator training sessions using the MITR and an additional series of lectures on reactor physics, thermodynamics and hydraulics for Boston Edison's operator candidates from the Pilgrim Nuclear Station at Plymouth, Massachusetts.

In a number of other areas, also, reactor irradiations and services were performed for research groups outside MIT: 1) the irradiation of sulfur targets for the production of 12 Curies per week of P-32 to label proteins for use in biological research was continued; 2) a Wellesley College UROP student, supervised by Professor Gene M. Simmons of the MIT Department of Earth, Atmospheric and Planetary Sciences, used solid state nuclear track detection techniques to study the distribution of uranium and thorium in New England granite; 3) Professor John Zotos of Northeastern University and one graduate student, using solid state nuclear track detectors, continued their studies of the uranium content of silicon; 4) research in geology using neutron activation analysis (NAA) for trace element determination was carried out by Professor Ray A. Coish of Middlebury College; 5) material specimens were irradiated for Dr. Edward Fireman of the Harvard-Smithsonian Center for Astrophysics for fission track dating of Antarctic ice; 6) Professors J. Christopher Hepburn and Rudolph Hon and five students of Boston College used NAA to determine trace elements in geological systems; 7) neutron activation analysis was used by an MIT graduate student to determine trace elements in oceanic systems for Woods Hole Oceanographic Institute; 8) irradiations were conducted for neutron activation analysis of filter and oceanic sediment by Dr. A. Fleer and two research assistants at the Woods Hole Oceanographic Institute; 9) a Harvard University physics student used particle track etch techniques to assay the uranium content of urine specimens; 10) Dr. Robert Tiernan of GTE Sylvania Inc. used the reactor to study the effect of sodium diffusion through aluminum oxide on the performance of sodium vapor lamps; 11) Professor Clive Perry, Northeastern University, utilized the MITR neutron mechanical chopper and a neutron diffraction spectrometer for his undergraduate "Wave Laboratory" Course 11.260, 14 students; and 12) Professors G. Collins and C. Hohenemser, with one graduate student, Clark University, irradiated targets to make Mossbauer sources for study of the nuclear relaxation of dysprosium-161 in gadolinium above the Curie point.

MIT RESEARCH REACTOR

The MIT Reactor, as mentioned earlier, completed its 25th year of operation, its ninth since the 1974-75 shutdown for upgrading and overhaul. During the past year it continued its usual Monday through Friday operating schedule at the design power level of 5 MW, averaging 90.3 hours per week at full power, holidays included. Energy output for the MITR-II, as the upgraded reactor is now called, totaled 167,291 megawatt-hours at June 30, 1984. The MITR-I generated 250,445 MWH from 1958 to 1974.

The Reactor was well utilized during the year, although still more experiments and irradiations can be accommodated due to the number and versatility of its many facilities. The reactor, as an integrated whole, was and continues to be used in a series of experiments designed to demonstrate the feasibility and advantages of reactor control by digital computer, as described further above. The neutron beam ports saw substantial utilization for neutron diffraction experiments, as described earlier. The number of material specimen irradiations was 3071, close to last year's total. Improvements to facilities on the reactor include renovation of the triple-axis inelastic neutron scattering spectrometer installed on the 6SH1 beam port. Digital control of the neutron energy (wavelength) of neutrons incident on materials of interest

has been added to the spectrometer instrumentation to simplify utilization. The thermal neutron beam "chopper" installed on port 4DH1 last year has been well utilized by MIT's Department of Physics junior laboratory and by Northeastern University students.

The US Department of Energy (DOE) renewed its reactor-sharing grant whereby MIT is reimbursed for use of the Reactor by other educational institutions needing such a facility for teaching or research purposes. Over 200 students and 28 faculty and staff from 14 educational institutions (including teaching hospitals) benefited from visits and use of the MITR. A 50 percent increase in this funding has been granted for the coming year.

OTTO K. HARLING

Patent, Copyright and Licensing Office

During Fiscal Year 1984, the Patent, Copyright and Licensing Office (Office) has concentrated on achieving two key primary, complementary goals:

- A. Increase effectiveness in the broadening of communication and interaction with the faculty and staff.
- B. Increase technology transfer and licensing income while broadening the licensing base to offset what had initially been projected as a year of sharply reduced royalty income and to provide a more diversified and stable income program for the long term.

Simultaneously, we are increasing the automation of the program for improved turnaround time, while seeking to fill personnel positions with qualified individuals to bring the Office to its increased authorized strength.

As indicated below, overall 1984 results have been satisfying.

PROGRAM COMMUNICATION

The Office has retained the services of specialized outside experts and consultants in patent law and marketing evaluation, who have begun a program of personal discussions and visits with the faculty to explain the patent program and to maximize faculty interactions with the program. The experts and consultants are working directly with inventors in the evaluation, disclosure and prosecution of licensable technology.

Departmental presentations planned for the Fall will be structured based upon the accumulated expertise and specific needs perceived from the interviews.

During Fiscal Year 1984, we restructured the invention disclosure review process with the goal of communicating patent filing decisions more quickly. On those inventions for which it is decided not to file patent applications, a responsive policy of granting waivers to inventors has been established to the extent allowed by Institute policies.

An ad hoc committee of outside experts from industry is being formed to assist the Office in the commercial evaluation of invention disclosures to enhance the technology transfer process. This committee will be fully operational by October 1st.

It is hoped that, once the Office is automated and fully staffed, the communication program will produce increasingly improved results.

1984 Fiscal Year net royalty income to inventors and departments has increased by 25 percent over the previous year. Research support from industry directly related to the patent licensing program has also increased significantly (\$1,216,000 versus \$836,574 for FY '83.)

The increased emphasis on marketing internationally has provided an additional channel for expanding technology transfer opportunities abroad.

LICENSING AND MARKETING

Original projections were that gross (royalty) income for Fiscal Year '84 would drop sharply to approximately \$800,000 (as compared with Fiscal Year '83 gross of approximately \$1,800,000) with a slow but steady upward recovery trend beginning in Fiscal Year '85.

In an effort to compensate for this projected reduction, a strong, aggressive marketing program was undertaken to substantively increase the Office's technology transfer program both domestically and, to an even greater extent, internationally.

Royalty income for Fiscal Year '84 was \$1,894,000, representing a number of new licenses to a greater variety of clients. Future value of these licenses to MIT is estimated to be in the high seven figure category once programs are fully implemented and sales of products commence. More important, however, is the fact that a firm groundwork continues to be laid for a continuously expanding licensing base in future years. (Of course, there is no guarantee that an executed license will actually result in sales or products. Hence, the need for broadening the licensing base.)

The program has spread our licensed portfolio over small and medium businesses as well as larger multinationals, domestic and foreign, in keeping with the general mandate of the US Uniform Patent Act and the Institute's goal of a diversified technology transfer effort to the public sector.

The significant actual increase in royalty income over projected figures was achieved without an unduly significant increase in operating costs, and despite the unexpected and sudden loss of a traditionally major income producing license during this fiscal year on which the original projections relied.

The use of selected outside agents and consultants to complement the marketing effort provided commercial and financial expertise in the international sector. By contract, the agents are on a commission basis directly related to income earned, and thus absorb all initial overhead, travel and marketing expenses.

During Fiscal Year '84, a total of 119 new invention disclosures were reviewed (106 from campus and 13 from Lincoln Laboratory); 62 patent applications were filed in the US; corresponding foreign applications were filed on 7 US cases in an average of 12 countries per case; and 50 new patents issued in MIT's name. Almost 50 percent of new disclosures resulted in a patent application.

New license/option agreements were reached with 15 companies, representing firms primarily in America and Europe.

PERSONNEL

The Office of Patent, Copyright and Licensing is authorized five operational staff personnel and one staff administrator.

During Fiscal Year '84 a new staff attorney was hired to fill one of the staff vacancies, while another attorney resigned, leaving the actual number of legal operational staff at three.

Of the three positions, one is being transferred to OSP effective August 1, 1984, to handle the negotiating of the intellectual property clauses in sponsored research agreements.

Interviews are now in process for hiring an Assistant Director for the Office to strengthen the overall program, particularly in the area of faculty communications and administration. Ideally this person, who will be responsible for the Office in the absence of the Director, will have a broad background in administration and client interaction and relations, with experience in intellectual property matters. It is planned that once the Assistant Director has been hired, the remaining authorized operating position will be reviewed as to its necessity and possible functions.

ARTHUR A. SMITH, JR.

Plasma Fusion Center

During the past year there has been significant technical progress in Plasma Fusion Center (PFC) research programs. The Plasma Fusion Center is recognized as one of the leading university research laboratories in the physics and engineering aspects of magnetic confinement fusion. Its research programs have produced significant results on four fronts: (a) the basic physics of high-temperature plasmas (plasma theory, RF heating, development of advanced diagnostics and small-scale experiments on the Versator tokamak and Constance mirror devices), (b) major confinement results on the Alcator C tokamak, including pioneering investigations of the stability, heating, and confinement properties of plasmas at high densities, temperatures and magnetic fields, (c) development of an innovative design for axisymmetric tandem mirrors with inboard thermal barriers, with initial operation of the TARA tandem mirror experiment beginning in February, 1984, and (d) a broad program of fusion technology and engineering development that addresses problems in several critical subsystem areas (e.g., magnet systems, superconducting materials development, environmental and safety studies, advanced millimeter wave source development, and system studies of fusion reactor design, operation, and technology requirements). The Plasma Fusion Center technical programs are principally supported by the Department of Energy's Office of Fusion Energy. During the past year, the funding level has been approximately \$25 million. There are approximately 342 personnel associated with PFC research activities. These include: 25 faculty and senior academic staff, 75 graduate students, and 15 undergraduate students, with participating faculty and students from Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, and Physics; 115 research scientists and engineers, and 10 visiting scientists; 60 technical support personnel, and 42 administrative and support staff.

ALCATOR CONFINEMENT EXPERIMENTS

The Alcator experimental program continues to be one of the most successful and prominent tokamak confinement programs within the international fusion research community. The primary objective of the Alcator experimental program, headed by Ronald Parker, is to develop the basic physics understanding of the stability, transport and radiation properties of high-temperature plasmas at near-reactor conditions and to develop radio-frequency methods for heating and driving currents in plasmas at thermonuclear temperatures. The main Alcator experimental areas include: device operations (David Gwinn); confinement studies (Steve Wolfe); plasmawall interactions (Earl Marmor); radio frequency heating (Miklos Porkolab); and data acquisition and computations (Martin Greenwald). Design efforts on a follow-up device to the Alcator C experiment have been intensified during the past year by the toroidal systems development group (Peter Politzer and D. Bruce Montgomery). These efforts are now focused on a superconducting high-field tokamak, Alcator DCT, capable of very long pulse length or steady-state operation. Ronald Parker and Bruno Coppi are overall Alcator program principal investigators.

Ohmic Confinement Studies: During the past year we have carried out a major program of optimized ohmic studies on Alcator C, intended to enhance the basic understanding of energy and particle transport at high plasma densities, and to improve plasma performance by exploiting the high field and current capabilities of Alcator C. This experimental effort featured operation at toroidal currents between 600-800 kA, toroidal fields of 10-11 tesla, and densities above $5 \times 10^{14} \text{cm}^{-3}$. Fueling by injection of frozen hydrogen and deuterium pellets from a pneumatic injector developed at Oak Ridge National Laboratory was used to produce high densities with peaked profiles. Line-average densities approaching 10^{15}cm^{-3} were produced using this technique.

The confinement properties of high-density pellet-fueled discharges have shown considerable improvement relative to gas-fueled plasmas. Confinement times of approximately 50 ms are observed at densities above $5 \times 10^{14} \text{cm}^{-3}$ and the saturation in confinement previously encountered at densities above $2 \times 10^{14} \text{cm}^{-3}$ is ameliorated. At the highest densities, the measured energy confinement is consistent with neoclassical ion transport and the electron losses are consistent with neo-Alcator scaling.

Values of the Lawson parameter $n_0 \tau_E$ approaching $0.8 \times 10^{14} \text{s-cm}^{-3}$ were achieved. These results clearly exceeded, for the first time, the minimum requirements for energy breakeven (in D-T plasma at higher temperature) and correspond to a doubling of the best value of $n_0 \tau_E$ achieved previously on Alcator C with gas-puff fueling. Record values of plasma pressure (1.6 atmospheres) and $n_0 \tau_E T_i$ were also obtained. Thermonuclear neutron rates (D-D) in excess of $10^{13}/\text{s}$ were measured. These results, particularly the achievement of Lawson $n_0 \tau_E$ values in the range required for thermalized breakeven, represent a major milestone in the history of fusion research.

RF Heating and Current Drive: In 1983-1984, substantial progress was also made in the Alcator C RF heating program. High power radio frequency (RF) waves were used to raise the plasma temperature in both

the lower hybrid range of frequencies (LHRF) and in the ion cyclotron range of frequencies (ICRF). Using lower hybrid waves, the concept of RF current drive was demonstrated at average densities $\bar{n} \approx 1 \times 10^{14} \text{cm}^{-3}$. In experiments carried out through the summer of 1983, two sixteen-waveguide-array antennae were used to couple over 1 MW of RF power at 4.6 GHz (LHRF) into Alcator C over a wide range of densities. In the density range $10^{13} \text{cm}^{-3} \lesssim \bar{n} \lesssim 10^{14} \text{cm}^{-3}$, RF-generated toroidal currents of the order of $I \approx 200 \text{ kA}$ have been observed for time durations of up to half a second. RF current generation in Alcator C is achieved at record density levels (about an order-of-magnitude higher than in any other current-drive experiment) because of the high frequency chosen for the microwave sources and the high-field capability of Alcator C.

When the plasma density is raised to the range $10^{14} \text{cm}^{-3} \lesssim \bar{n} \lesssim 2 \times 10^{14} \text{cm}^{-3}$, and the waveguide arrays are phased so as to produce a standing wave at the waveguide mouth, significant plasma heating is observed. By injecting 850 kW of RF power at plasma densities of $\bar{n} \approx 1.5 \times 10^{14} \text{cm}^{-3}$, the electron temperature was raised from $T_e \approx 2.0 \text{ keV}$ to values $T_e \lesssim 3.0 \text{ keV}$, and the ion temperature was raised from $T_i \approx 1.1 \text{ keV}$ to 1.9 keV. These results, which were obtained by using SiC-coated carbon limiters, correspond to a heating rate of $\delta(\Sigma_i n_i T_i)/P \approx 22 \text{ eV} \times 10^{13} \text{cm}^{-3}/\text{kW}$, a record value. There is also observed a concomitant significant increase in the plasma impurity level. However, these experiments operate at surface power flux levels which approach (within a factor of two) the expected equivalent thermal flux in a reactor. These results, therefore, indicate the necessity of active impurity control in future reactor-grade plasma devices.

The LHRF experiments were resumed in April, 1984, with 3 MW available at the source, and the full capabilities of this system will be exploited during the second half of 1984. Of considerable interest at present is to study RF current ramping and also RF start-up, both of which require the high power levels now available. With the additional RF power, it is also planned to drive currents at plasma densities exceeding $1 \times 10^{14} \text{cm}^{-3}$. By increasing the RF power, the temperatures in the heating mode of operation will also be raised to higher values than previously obtained. With the delivery in December, 1983, of the fourth 16-waveguide array, the full 4 MW LHRF system has been completed and is ready for operation on Alcator C when conditions warrant. Particularly important will be the control of R injected impurities.

An ICRF experiment was successfully tested on Alcator C during the first three months of 1984. RF power up to 400 kW has been coupled to the plasma at 180 MHz. The ion temperature was raised by 500–600 eV at a density of $\bar{n} \approx 1.8 \times 10^{14} \text{cm}^{-3}$ when a few percent of hydrogen minority species was injected into a deuterium plasma at magnetic fields of 12 tesla. The electron temperature remained the same, or decreased slightly due to impurities. ICRF heating at the harmonic of the ion cyclotron frequency has been performed at a power level of 200 kW, and to date no temperature rise has been observed. The conclusion is that more RF power will be needed to demonstrate harmonic ion cyclotron heating at densities $\bar{n} > 1 \times 10^{14} \text{cm}^{-3}$. Present plans call for resuming the ICRF experiments early in 1985 at the 1 MW level, including a two-port antenna system. Meanwhile, calculations are underway to determine the feasibility of more advanced ion heating techniques, such as ion Bernstein wave heating.

Alcator DCT: As discussed in last year's report, a successor to Alcator C has been designed which would carry on the tradition of highfield tokamak research at MIT. The Alcator DCT (Driven-Current Tokamak) is a tokamak in which the toroidal and poloidal field coils are entirely superconducting. The primary mission of the device is to extend the pulse length to a duration of at least 100 seconds at reactor-level plasma conditions. The device would also allow continuation of research on RF current drive, with the objective of demonstrating efficient steady-state tokamak operation. The specific objectives include plasma shape and profile control for pulse times in excess of the skin time, further development and optimization of RF current drive and heating methods, exploration of various methods of impurity control, and integration of the superconducting magnet systems into an operating tokamak environment.

While Alcator DCT is well suited to explore those issues of tokamak operation associated with pulse-length extension at reactor-level plasma parameters, a major role as a facility for tokamak innovation is also foreseen. In particular, the development of efficient current drive techniques under plasma conditions which are favorable for achieving high beta (e.g., appropriate shaping, low values of safety factor, and moderate density) would greatly enhance the potential of the tokamak concept as a reactor. Thus, the design is presently being optimized in order to assure that proper emphasis is given to these capabilities. In the meantime, work is proceeding in the area of Nb_3Sn conductor development, since the design is predicated on achieving optimum performance from the Nb_3Sn conductor.

Graduate Student Training: At present, there are twenty graduate students in the Alcator program, most of whom are doing experimental PhD work associated with Alcator C. Three new students will begin research in September, 1984.

MIRROR CONFINEMENT EXPERIMENTS

The Mirror Confinement Systems Division, headed by Richard S. Post, is involved in the design, construction, and operation of a medium-scale tandem mirror research facility called TARA. With the completion of the experimental facility and the initiation of experiments, TARA represents a major step forward within the national fusion program. The primary objective of TARA operation during the initial

phase is to use high-power RF waves to explore the basic stability and transport properties as well as to increase the understanding of the important physics issues inherent in high-power RF heating. In the longer term, experimental studies will include microstability properties, thermal barrier formation, and alternative potential enhancement schemes. The main areas of activity include: TARA operations (Richard Post and Don Smith); computations and advanced concepts (Jay Kesner); and TARA engineering (Richard Post).

TARA Tandem Mirror Experiment: The TARA device began operation in March, 1984. The TARA facility is the outcome of a three-year design and fabrication effort at the Plasma Fusion Center which will be completed in the fall of 1984 with the installation of a six megawatt neutral beam injection system. Present operation with high-power RF heating will continue until September, 1984.

The configuration of the TARA tandem mirror is unique in that it uses an axisymmetric confining plug with an outboard minimum-B anchor. This has been identified as a very desirable tandem mirror configuration for potential reactor applications. The primary objectives of the TARA experiment are to investigate trapped-particle mode stability properties, overall MHD stability limits, central cell radial transport, and enhanced potential formation.

The following is a brief summary of the TARA design. The TARA central cell is a 15 cm radius, 10 m long solenoid with upgrade capabilities to 15 m. When a thermal barrier is present, the projected plasma temperature is $T_e \sim T_i \sim 400$ eV and density $n \approx 4 \times 10^{12} \text{cm}^{-3}$. Ions are confined by axisymmetric inboard plugs which eliminate the possibility of enhanced radial transport that is driven by the quadrupole moments of the plugs (so-called resonant transport).

The central solenoid is bounded by high-mirror-ratio inboard plugs ($R = 5$ to 10) with peak fields of up to 5 tesla. Neutral beams (20 keV extractor energy) with 150 A current are injected at a 40° angle into the plugs to create a sloshing-ion distribution which is expected to exhibit improved microstability properties and provide a partial thermal barrier. Gyrotrons at 28 GHz are available with a capability of 400 kW per plug. These are required for creating the hot mirror-trapped thermal barrier electron species and the suprathermal ($T \sim 700$ eV) warm electron species required to produce a thermal barrier at the midplane of the plugs.

Initial operation has been aimed at producing a stable start-up plasma suitable for neutral beam injection experiments in the fall of 1984. In the present experiments, electron cyclotron heating is used to produce a high-pressure, low-density plasma in the quadrupole anchor cells located at the ends of the device. Typical anchor plasmas have betas approaching 15%, density $n \approx 3 \times 10^{11} \text{cm}^{-3}$, and average electron energies approaching 300 keV. Subsequently, a central cell plasma is produced from a gas feed by RF heating in the ion cyclotron frequency range in the central solenoid. Using up to 500 kW of ICRF power, the following plasma parameters have been obtained: beta $\approx 2\%$, density $\approx 2 \times 10^{12} \text{cm}^{-3}$, plasma volume ≈ 700 liters, and average ion energy ≈ 2 keV. ICRF has also been used in the anchors to trap and heat the plasma streaming out of the central cell, increasing the anchor density to 10^{12}cm^{-3} .

ICRF experiments are being carried out over a range of frequencies from 0.8 to 4 times the ion cyclotron frequency. In addition, comparison is being made with a theoretical model of antenna coupling and observed ion and electron heating.

Plasma particle and power balance, and stability properties are being studied using various probes, optical diagnostics, interferometers, and end-loss analysis. The decay time of the hot ions after RF heating is about 2 ms, consistent with charge exchange and electron drag estimates. The present central cell plasma is mirror confined with an energy confinement time of about 1 ms. (Electrostatically confined plasmas with longer confinement time will not be obtained until the neutral beam injection experiments are carried out.) Substantial fluctuation levels are observed in the central cell, but these do not appear to strongly affect confinement. The central cell is, if anything, more stable than expected and can be operated at the present parameters without the high-beta anchor cells.

We anticipate that TARA fabrication will be completed in the fall of 1984 with installation of the neutral beam injection systems. Experiments will then begin to test thermal barrier operation of the full TARA tandem mirror configuration.

Computations and Advanced Concepts: The TARA research program has a combined theoretical and experimental effort which permits a close collaboration between experiment, theory, computations, and reactor design.

Areas of emphasis in mirror theory include low-frequency stability properties (trapped-particle and MHD theory) and microstability properties. Several important computational codes have been developed, including the McVey antenna coupling code, Monte-Carlo RF heating codes, and a multiregion Fokker-Planck code including electron cyclotron resonance heating (ECRH). Additionally, the reactor implications of the TARA geometry are being assessed. The goal of this latter effort is both to evaluate the reactor extrapolability of the TARA geometry and to uncover and evaluate possible new conceptual advances.

Detailed Monte-Carlo studies of electron pumping as a potential enhancement scheme have been performed. This approach, first proposed by Smith and McVey, could substitute for a thermal barrier or, in conjunction with a thermal barrier, result in reduced requirements on ion pumping and ECRH power. Initial results indicate a power requirement of approximately 70 kW/plug for maintaining a 600 eV plug potential barrier in TARA. At these levels, the central cell has a density of $4 \times 10^{12} \text{cm}^{-3}$ and an electron temperature of 400 eV.

A theoretical analysis of potential enhancement by bounce frequency electron pumping is also in progress. One approach would make use of frequency modulation (FM) of waves having a higher phase velocity than the trapped electrons. For the appropriate choice of FM modulation index, it is found that a stochastic diffusion of trapped electrons can result from an intrinsically nonlinear coupling. The transition from regular to stochastic motion has been investigated numerically and analytically. Only a weak dependence on the phase velocity is found.

Parametric studies of central cell heating have been performed for TARA parameters using the McVey antenna coupling code. These studies focused on the two antennae that will be located in the TARA central cell: (a) an aperture antenna which produces primarily a fluctuating magnetic field perpendicular to the central cell axis, and (b) two half-turn loops which produce a fluctuating parallel field and can be operated as either an $m = 0$ or an $m = \pm 1$ antenna.

A multiregion Fokker-Planck code has also been developed. During the design of the high-power ECRH system for TARA, the plasma conditions consistent with ECRH were estimated, and the design parameters for the plug and barrier antennae were specified. Most importantly, TARA's large power to volume ratio gives considerable confidence that the major ECRH requirements for potential enhancement can be met.

Trapped-particle analytic theory at finite azimuthal mode numbers and rotation velocity has been extended to permit a cell-to-cell variation in equilibrium potential. Since the passing particles (electrons in TARA) have a different average equilibrium drift than the trapped ions, the differential drift can lead to charge separation. This can produce a strong stabilizing effect when, for example, the central cell has a positive potential gradient and the anchor has a negative gradient. Evaluation of this effect will complete the study of rotation on trapped-particle modes.

The effects of particle collisions on trapped-particle modes in tandem mirrors have also been analyzed. Both low-collisionality and higher collisionality regimes are considered. The magnetic geometry of the equilibrium is arbitrary, and a pitch-angle scattering operator is used to model the effects of collisions. For low collisionality, electron collisions are found to destabilize an otherwise stable negative-energy mode. At higher collisionality, two modes are obtained: (a) a flute mode with stability determined by the flux tube integral of the beta-weighted curvature drive, and (b) a dissipative trapped-ion mode driven unstable by the difference in collisionality between electrons and ions. It is found that the flute mode persists with increasing ion collisionality, whereas the dissipative trapped-ion mode is damped by increasing ion collisionality.

Finally, the reactor implications of the recent work of Berk et al. on wall stabilization of high-beta mirror confined plasmas have been investigated for an axisymmetric configuration similar to the TARA geometry. It is found that the central cell can be stabilized by finite Larmor radius kinetic effects for modes with azimuthal mode number m greater than unity. Since the central cell has isotropic pressure, the wall stabilization proposed by Berk et al. for the $m = 1$ mode is weak and cannot, by itself, provide stability. If the stability of the $m = 1$ mode derives from wall stabilization within the axicell, then modes with $m > 1$ can be stabilized by finite Larmor radius effects in the central cell. Such an approach would greatly simplify end-plug design and enhance tandem mirror reactor economics and Q values. Specifically, a high-beta axicell would have a very small volume compared with existing reactor designs, and would provide a simple magnetic field configuration. A more detailed analysis of this approach is in progress.

APPLIED PHYSICS RESEARCH

The primary objective of the Plasma Fusion Center Applied Plasma Physics Research Division, headed by Ronald Davidson, is to develop the basic experimental and theoretical understanding of plasma heating and confinement properties. Present applied physics research activities include: experimental research on the Versator II tokamak (George Bekefi, Miklos Porkolab and Stan Luckhardt); experimental research on the Constance mirror device (Richard Post and Donna Smatlak); fusion theory and computations (Abraham Bers, Bruno Coppi, Ronald Davidson, Thomas Dupree, Jeffrey Freidberg, Jay Kesner and Kim Molvig); spin-polarized fuel source development (Thomas Greytak and Daniel Kleppner); plasma diagnostics and laser development (Daniel Cohn and Paul Woskoboinkow); and basic experimental and theoretical research on radiation generation by intense charged particle beams (George Bekefi and Ronald Davidson).

We summarize here the significant progress made during the past year in selected applied plasma physics research areas.

Versator II is a medium-size research tokamak (major radius = 40.5 cm, minor radius = 13 cm, toroidal field = 15 kG) with primary emphasis on basic investigations on RF plasma heating and current drive. During the past year, several important experimental activities were completed. First, experiments on plasma confinement and transport during RF current-drive operation were completed. Second, initial experiments were carried out comparing the current-drive efficiency of coupling structures mounted on the side and top of the torus. The results of these initial experiments appear to be consistent with theoretical predictions of the effects of toroidal geometry on propagation of the lower hybrid waves. Third, preliminary tokamak plasma start-up experiments were carried out in which the plasma was formed solely by the injection of RF power.

In addition to the experimental activities, two major construction projects have been completed, including an upgrade of the ohmic heating system, and fabrication of a new high-frequency ($f = 2.45$ GHz) RF power system. The upgraded ohmic heating system allows operation at higher toroidal plasma currents (100 kA), and longer pulse duration (60 ms) in ohmic operation. The upgraded Versator II also has the capability of fully RF-driven operation. In fully RF-driven operation, the system will provide improved plasma conditions for more precise RF current-drive experiments. In ohmic operation, the improved plasma temperature and confinement will be advantageous for RF heating experiments.

The newly completed lower hybrid RF power system operates at a frequency of 2.45 GHz, which is approximately three times higher than the 800 MHz system used in previous Versator II experiments. This system will be used to test the conjecture that RF power at higher frequency will drive currents at higher density (e.g., $\bar{n} > 10^{13} \text{ cm}^{-3}$) than is possible with the present 800 MHz system. The system has been tested at power levels up to 80 kW and initial experiments have begun.

In May, 1984, a new RF experiment was proposed for Versator II in which plasma heating at the electron cyclotron frequency (ECRH) will be investigated. The ECRH experiment, which is a collaborative effort with the Naval Research Laboratory, will employ a gyrotron power source operating at a frequency of 35 GHz and a power level of 150 kW. The aim of these experiments is to test the heating and current-drive processes using combined RF power near the lower hybrid frequency and the electron cyclotron frequency. Such experiments may result in reduced power requirements for RF start-up of tokamak discharges and for steady-state RF-driven plasmas.

Constance B is a quadrupole mirror device of moderate size in which high-beta (beta is the ratio of plasma pressure to magnetic field pressure), hot electron plasmas are created using electron cyclotron resonance heating (ECRH). The major objective of the Constance program is to contribute to the basic physics understanding of the equilibrium and stability properties of mirror-confined hot electron plasmas. Investigations of radial potential control and radial ion pumping in hot electron plasmas are a fundamental part of the research program.

The construction of Constance B was completed in September, 1983, with initial experimental operation in October, 1983. Plasma betas of 30%, hot electron temperatures in excess of 200 keV electrostatic potentials up to 500 volts, and densities of $2 \times 10^{11} \text{ cm}^{-3}$ have been achieved. Several new diagnostics have been added to the device. In progress are the basic parameter measurements and scaling studies which are necessary to develop an understanding of the self-consistent formation, particle and power balance, and the MHD equilibrium properties of the hot electron plasma.

Evidence of a microinstability driven by the hot electrons has been observed in Constance B. Bursts of RF emission near the electron cyclotron frequency occur which correlate with bursts of ion and electron end loss, ion radial loss, X-rays, diamagnetic fluctuations, and potential fluctuations. Work is in progress to identify the source of this instability and to evaluate the effect on plasma confinement.

The radial potential control experiments began in January, 1984, using a biased plate at one end of the device. A second end plate was installed in June, 1984, along with a segmented radial limiter. Experiments are now in progress which indicate that the density and the potential profiles are changed when the end plates are biased. The next phase of this work will require the construction of trim coils to reduce the plasma ellipticity at the end walls. The design of these coils is now in progress.

During the past year, the analysis and design of the radial ion pumping experiments were completed. Theoretical work has indicated that it will be possible to induce stochasticity using a few kilowatts of ion cyclotron resonance heating (ICRH) power. The construction of the drift pumping and ICRH antenna has begun and the design of the feedline, matchbox, and transmitter is now in progress.

In the plasma theory and computations area, recent studies include: (a) the continued development of self-consistent plasma models which simultaneously include the effects of neoclassical transport and plasma turbulence, (b) the formulation of a nonlinear kinetic theory of tearing modes, to explain the MHD density limit in Alcator C, (c) the investigation of the stabilizing effects of limiters on external kink-mode stability, (d) the continued development of self-consistent theoretical models describing anomalous electron energy transport in tokamaks, (e) basic investigations of the MHD stability properties of tokamak plasmas and the determination of stable operating regimes at moderate values of plasma beta

(the ratio of plasma pressure to magnetic pressure), (f) the development of a self-consistent kinetic description of the free electron laser instability including the important influence of novel magnetic field configurations and finite radial geometry, (g) continued basic theoretical investigations of RF heating, including studies of steady RF current drive and computational studies of the nonlinear coupling of microwave power to the plasma from waveguide arrays, (h) fundamental investigations of triggered emission of whistler waves in the ionosphere, (i) development of a 2-D self-consistent model of RF current drive with lower hybrid waves that shows a large (one to two orders-of-magnitude) enhancement of perpendicular temperature of the current carrying electrons, (j) studies of the thermal stability of ignited plasmas, (k) fundamental nonlinear studies of the influence of stochastic magnetic fields on turbulent transport in high-temperature plasmas, and (l) basic studies relating to the equilibrium, stability and transport properties of high-field tokamak configurations using advanced fuels.

In the plasma diagnostic development area, a 140 GHz gyrotron is being fabricated with output power levels of 1 to 10 kW in 30 ms pulses and with narrow linewidth (< 1 MHz) for collective Thomson scattering diagnostics on the TARA tandem mirror experiment. The main goal of this diagnostic will be to study scattering from instability-driven ion density fluctuations in the TARA end plugs. The instabilities of interest are the drift cyclotron loss cone (DCLC), the axial loss cone (ALC), harmonics of the DCLC and ALC, and the ion two-stream instability. Moreover, scattering from electron plasma waves will be attempted to determine if this diagnostic technique can be used to locate the position of the potential dip in the thermal barrier region of a tandem mirror. Density fluctuation levels will be measured as a function of wave vector, position, and time. This scattering diagnostic will have the capability of detecting thermal-level fluctuations in order to investigate fully the growth of microinstabilities. Future goals will be to demonstrate high-power gyrotron operation at frequencies above 600 GHz for diagnostic applications in tokamaks.

Free Electron Lasers: As a result of extensive experimental work, computer simulation, and theoretical studies, free electron laser research has reached a high level of maturity. At MIT, efforts have been concentrated on free electron lasers operating in the high-current (Raman) regime. Particular success has been achieved in the construction and operation of a circular free electron laser in which the electrons orbit in an azimuthally periodic magnetic field.

Recently, a very promising free electron laser has been put into operation. It uses a bifilar helical wiggler and a guiding axial magnetic field. This versatile instrument exhibits very narrow-band radiation which is tunable over a very wide frequency range. The power output is 100 kW with an efficiency of 12% in converting electron beam energy into radiation. Excellent agreement with theory is obtained.

FUSION TECHNOLOGY AND ENGINEERING

The Fusion Technology and Engineering Division, headed by D. Bruce Montgomery, provides critical engineering analysis for the advanced design projects, and develops advanced superconducting magnet technology for the national fusion program. Research activities include: engineering support for the Alcator DCT advanced design (D. Bruce Montgomery); advanced magnet design in support of the Tokamak Fusion Core Experiment (TFCX) and the INTOR International Tokamak Reactor study (Richard Thome and Joel Schultz); concept development for improved magnetic divertors for tokamak and mirror upgrades and next-generation test reactors (Ted Yang); development of forced-flow superconductors for application to advanced fusion devices (Mitchell Hoenig); basic research on the development of ductile superconducting materials (Simon Foner, Robert Rose and Brian Schwartz); advanced magnet design in support of DOE programs in MHD and high energy physics (Peter Marston and John Tarrh). Recent research activities in these technology and engineering areas are summarized briefly.

A significant national effort is underway in the preconceptual design of a long-pulse ignition experiment called the Tokamak Fusion Core Experiment (TFCX). This effort is led by the Princeton Plasma Physics Laboratory (PPPL), and the Plasma Fusion Center provides major technical support to that activity, with responsibility for a number of magnetic systems and critical design areas. Analysis of critical magnet design issues for the international INTOR project is also carried out.

The Plasma Fusion Center has been active in developing improved magnetic divertor concepts. A long-burning fusion reactor must deal with the buildup and removal of helium "ash" and impurities, and magnetic or mechanical divertors are considered to be an extremely demanding but necessary component. Conceptual designs for reactor-scale bundle divertors are being investigated, and powerful numerical methods have been developed to study the recycle and exhaust for various divertor concepts. This group has provided strong technical support in designing the TARA transition region and the poloidal field and divertor systems for TFCX.

Critical experiments using subsize internally-cooled cable superconductors have demonstrated a 50% increase in current density for cables sheathed in Incoloy tubing. Incoloy alloys have a low coefficient of thermal expansion which, unlike stainless steels do not degrade the superconductor (Nb_3Sn) used in high-field (8-12 tesla) coils. Work is progressing in the development of full-scale conductor sheathing

using Incolloys as well as in the testing of advanced Nb₃Sn superconductors. The fabrication of the 40 cm bore, 12 tesla insert coil has been completed. The 600 pound coil, made from three double pancakes of a full-size internally-cooled cable superconductor, has been delivered to the Lawrence Livermore National Laboratory, where it is to be installed in the high-field test facility. It is designed to operate at 15 to 20 kA in fields of 10 to 12 tesla. Advanced conductor test coils with 50 to 100% higher current ratings are being fabricated.

Basic research on advanced superconducting materials is also a major fusion engineering activity performed in conjunction with the Materials Science and Engineering Department. The objective is to develop materials and techniques for producing superconductors capable of generating 15 tesla magnetic fields and sufficiently ductile to be suitable for advanced fusion devices. Materials developed by this group show considerable improvements in mechanical properties and offer significant possible reduction in production costs over conventional industrial preparations.

Advanced magnet design for the national MHD program, and for selected national high energy physics projects is also carried out. While the MHD program is greatly reduced from previous levels, there are several utility/ industrially-based activities which show promise of growth. The design group is presently supporting activities at Southern California Edison for an MHD disk generator upgrade of an existing plant. An analysis of conductor cost and its dependence on current density has been carried out. Research by the MIT magnet design group in the high energy physics area has been directed at an analysis of the iron structure for Professor S. Ting's large L3 detector for installation at CERN. In addition, a conceptual design has been developed for the SLAC large detectors.

In addition to these fusion and related technology areas, the engineering group is involved in the design and construction of the PFC confinement experiments. Advanced design activities during the past year have emphasized design studies and conductor development for a superconducting long-pulse tokamak, Alcator DCT, as a follow-on to the Alcator C experiment.

FUSION SYSTEMS

The Fusion Systems Division, headed by Daniel Cohn, investigates several aspects of fusion reactor design and develops advanced millimeter and submillimeter wave technology for plasma heating and diagnostics. Research activities include: safety and environmental studies (Mujiid Kazimi); reactor system studies (Leslie Bromberg and Dan Cohn); blanket and first wall structural design studies (John Meyer); gyrotron and advanced millimeter source development (Richard Temkin); millimeter and submillimeter detector development (Peter Tannenwald, Lincoln Laboratory).

Safety and Environmental Studies: Modifications of the LITFIRE code have been made to increase its utility in modeling fires in fusion reactor containments. The ability to monitor lithium-lead alloy reactions in air has been incorporated into the LITFIRE code. Also, the geometry has been made more flexible and the available options made compatible. Comparisons indicate that lithium-lead alloys are much less reactive than pure lithium. Work on a new code FULIB has been initiated to model lithium-water reactions in confined geometry.

Rapid numerical techniques have been developed for computing the 1-D structural response to eddy current loading in a torus such as may occur after a plasma disruption. Since the currents are directed toroidally, the structure and the driving currents are modeled as a set of circular loops which couple through mutual inductances. The resulting circuit equations are solved, and the structural response depends on the characteristics of the driving current.

Small-scale experiments have been conducted to measure the strain due to simulated plasma disruptions. The results indicate that the induced strains are about an order-of-magnitude higher in the regions of structural discontinuities.

Reactor System Studies: A preconceptual design has been developed for a superconducting tokamak reactor that is inductively driven by an ohmic heating transformer and capable of four-hour pulse lengths. The tokamak design has a major radius of 7.5 m. The model includes the effects of fatigue due to thermal stresses on the first wall, the fatigue on the superconducting coils (crack growth of the structure at 4 K) and the effects of fatigue due to thermal cycling of the turbine. The study is a continuation of research carried out last year, when the requirements for pulsed operation were analyzed. It was found that the pulse length could be as short as a few minutes and still satisfy the lifetime requirements of the superconducting magnets, the first wall and the turbine. However, if continuous power production is required, or the steam flow through the turbine cannot be choked, then some degree of thermal storage is required and pulse lengths as long as 4-6 hours would be necessary to satisfy the turbine lifetime requirements. The conclusion of the study is that it is possible to design a pulsed tokamak reactor with inductive current drive (from a transformer) that is about the same physical size as steady-state tokamak reactor designs that use RF current-drive mechanisms.

Resistive-coil experimental devices offer the opportunity to explore the physics and engineering aspects of ignited plasmas at moderate cost. The design of a Long-Pulse Ignition Test Experiment device has been developed in order to minimize cost and technical risk. The main objectives of LITE are to demonstrate ignition (where the heating of the plasma is provided entirely by the fusion reaction products) and to study the effects of long-pulse operation on plasma performance. The LITE design uses high-performance copper-plate magnets. The size is smaller than that of the TFTR tokamak at the Princeton Plasma Physics Laboratory. Operation at liquid nitrogen temperatures and at stress levels similar to those in Alcator C minimize the machine size and the associated power supply equipment, therefore reducing the cost of the experimental facility.

In the past, tokamak reactor designs with normal resistive coils have received considerably less emphasis than designs with superconducting coils. The main disadvantage of resistive coils is the power consumption, which in a reactor would increase the recirculating power fraction. However, resistive coils have some significant advantages over superconducting coils. In particular, resistive magnets require less neutron shielding and offer the possibility of easy demounting. This allows the positioning of poloidal field coils in the bore of the toroidal field magnet. High-beta reactors could be possible using this approach. The reactor designs would be smaller than superconducting reactors with the same output power, and the toroidal field magnet system would be considerably reduced in complexity and cost.

A scoping study of the extrapolation to a commercial reactor of the TARA tandem mirror configuration has been performed. The overall length of the reactor is similar to other tandem mirror reactor designs with the same power rating, but the end cell design is much simpler. The end cell is technologically the most complex component in a mirror reactor and therefore the most expensive. The efficiency of using low-frequency electromagnetic waves to establish the thermal barrier in the plug of a TARA-like reactor has been calculated. Larger powers are required, but the lower frequency may result in higher overall efficiency. Finally, a preliminary study of a high-beta wall-stabilized reactors is being carried out. If feasible, it will result in tandem mirror reactor designs that are even more attractive. There is strong interaction between the TARA experimental group and reactor system studies group.

Blanket and First Wall Studies: The thermal fatigue of the first wall of a tokamak reactor has been analyzed. This has been considered a fundamental constraint on tokamak reactor operation. The analysis indicates that for a stainless steel first wall and for thermal wall loadings of the order of 0.5 MW/m^2 (corresponding to neutron wall loadings of 2 MW/m^2), the pulse length could be as short as 100 s. If a better material is used for the first wall (such as vanadium), the thermal wall loading can be increased to 2 MW/m^2 for the same pulse length. Furthermore, it is found that thermal wall loading is a much more important limitation than the pulse length, and that very large gains in lifetime are obtained by relatively small decreases in the wall loading.

The decreased lifetime of the turbine due to pulsed operation has also been analyzed. It is found that short-pulse operation is possible if the flow of steam through the turbine can be stopped during the dwell phase of the reactor, and if the conditions in the turbine during that time are similar to those of the condenser. Longer pulses would be required, together with some form of thermal storage, if the flow is not to be choked or there is a need for continuous power production.

Gyrotron and Advanced Millimeter Source Development: Improved power levels and efficiency have been obtained in operation of the gyrotron device (electron cyclotron maser) developed at the Plasma Fusion Center. Output powers of 100 kW at a frequency near 140 GHz have been achieved at an efficiency of 36%. To our knowledge, this is the highest efficiency ever achieved at any frequency above 60 GHz by a high-power coherent radiation source, including masers or lasers. Output powers of up to 175 kW at 28% efficiency have also been achieved. Operation is short-pulse (1 μs), but the device appears scalable to long-pulse or even CW operation. The output bandwidth has recently been measured on a single pulse basis and is found to be less than 3 MHz. Second harmonic emission (25 kW at 241 GHz) in the $\text{TE}_{11,2}$ mode with 7% efficiency has recently been observed. The gyrotron group has also developed a tunable far infrared laser based on stimulated Raman scattering of CO_2 laser radiation in CH_3F gas. Continuous tuning between 32 and 40 cm^{-1} (250 to 300 μm) has been achieved.

APPOINTMENTS AND PROMOTIONS

During the past year, there have been several important appointments and promotions in Plasma Fusion Center program areas.

Appointments include: Joseph Bosco (Princeton Plasma Physics Laboratory), appointed Electronics/Systems Engineer in the Toroidal Confinement Division; Dr. Kevin Brau (Association Euratom-CEA sur la Fusion), appointed experimental Research Scientist in the Mirror Confinement Division; Dr. Bruce Danly (Massachusetts Institute of Technology), appointed Research Scientist in the Fusion Systems Division; Kenneth George (Sala Magnetics), appointed Technical Supervisor in the Mirror Confinement Division; Dr. Stephen Horne (University of Wisconsin), appointed experimental Research Scientist in the Mirror Confinement Division; Dr. George Johnston (Massachusetts Institute of Technology), appointed theoretical Research

Scientist in the Intense Charged Particle Beam Research Group; Dr. Stephen Knowlton (Massachusetts Institute of Technology), appointed experimental Research Scientist in the Toroidal Confinement Division; Dr. Xing-Zhong Li (University of Wisconsin), appointed Postdoctoral Associate in both the Mirror Confinement and the Fusion Systems Divisions; Ilene McCool (University of Texas at Austin), appointed Applications Programmer in the Toroidal Confinement Division; Dr. Joseph Minervini (National Bureau of Standards), appointed Design Engineer in the Technology and Engineering Division; Peter Mitchell (Sperry Research Center), appointed RF Engineer in the Toroidal Confinement Division; Dr. Richard Petrasco (American Science and Engineering), appointed experimental Research Scientist in the Toroidal Confinement Division; Dr. Evelio Sevilano (University of Washington), appointed experimental Research Scientist in the Mirror Confinement Division; Dr. Yuichi Takase (Massachusetts Institute of Technology), appointed experimental Research Scientist in the Toroidal Confinement Division; Dr. Itzhak Weiss (Courant Institute of Mathematical Sciences), appointed Postdoctoral Associate in the Theory and Computations Research Group; and Dorothea Williams (Smithsonian Astrophysical Observatory), appointed Applications Programmer in the Mirror Confinement Division.

During the past year, promotions in the Plasma Fusion Center include: Dr. Marcel Gaudreau, promoted to Manager of TARA Operations; Dr. Jay Kesner promoted to Associate Leader for Computations and Advanced Concepts of the TARA Physics Coordination Group; Dr. Barton Lane promoted to theoretical Research Scientist in the Mirror Confinement Division; Michael Olmstead promoted to Leader of Mechanical Engineering for the Mirror Confinement Division; Dr. Abhay Ram promoted to theoretical Research Scientist in the Theory and Computations Research Group; Dr. Donald K. Smith promoted to Associate Leader for TARA Experimental Studies; Paul Thomas promoted to Operations Technical Supervisor for the Mirror Confinement Division; and Dr. Stephen Wolfe promoted to Principal Research Scientist.

The Plasma Fusion Center has also hosted several Visiting Scientists in the various research programs. They are: Dr. Gerhard Berge (University of Bergen, Norway), fusion theory and computations; Dr. Franklin Chang (NASA), plasma propulsion; Dr. John Davies (Clark University), theory of free electron lasers; Dr. Vladimir Fuchs (IREQ), fusion theory and computations; Dr. Zengji Guo (Academia Sinica, PRC), fusion technology and engineering; Dr. Elisabeth Källne (Joint European Torus) soft X-ray emissions from Alcator C; Dr. Jan Källne (Joint European Torus), soft X-ray emissions from Alcator C; Dr. Fredrick Seguin (American Science and Engineering), impurity transport and MHD phenomena in Alcator C; Dr. Richard Slusher (Bell Laboratories), CO₂ laser scattering from lower hybrid waves in Alcator C; Dr. Clifford Surko (Bell Laboratories), CO₂ laser scattering driven lower hybrid waves in Alcator C; Dr. Jan Trulsen (University of Tromsø, Norway), ICRF and ECR heating in TARA; Dr. Han S. Uhm (Naval Surface Weapons Center), theory of beam-plasma systems with intense self fields; Dr. Yuan-Zhao Yin (Academia Sinica, PRC), millimeter and submillimeter wave radiation generation; and Dr. Fei-Ming Zhao (Harbin University, PRC), plasma-wall interactions in Alcator C.

GRADUATE DEGREES

During the past year, the following students graduated with theses in fusion-related areas: Geoffrey Crew, PhD in Physics; Kurt Cogswell, PhD in Nuclear Engineering; Bruce Danly, PhD in Physics; Alan Fisher, PhD in Physics; Paul Gierszewski, PhD in Nuclear Engineering; Kurk Hackett, PhD in Physics; Joseph Johnson, PhD in Nuclear Engineering; Si-Young Lee, PhD in Nuclear Engineering; Peter Roemer, PhD in Nuclear Engineering; Yuichi Takase, PhD in Physics; Mark Tillack, PhD in Nuclear Engineering; Kenneth Jacob, S.M. in Mechanical Engineering; Beth Koester, S.M. in Electrical Engineering and Computer Science; Thomas Morizio, S.M. in Mechanical Engineering; Jean Nolley, S.M. in Nuclear Engineering; Roger Richardson, S.M. in Electrical Engineering and Computer Science; Edward Yachimiak, S.M. in Nuclear Engineering; and Daniel Yates, S.M. in Electrical Engineering and Computer Science.

We take this opportunity to wish these graduates success in their future professional endeavors.

RONALD C. DAVIDSON

Research Laboratory of Electronics

INTRODUCTION

The Research Laboratory of Electronics (RLE) is the Institute's oldest interdisciplinary research laboratory, founded in 1945 as the natural continuation of the war time Radiation Laboratory. Initially, the Laboratory was formed to bring together interests in Physics and Electrical Engineering to work on problems in electromagnetic radiation, circuits, and specialized vacuum tubes. Over the years, however, the Laboratory has branched out into a number of directions, and in fact has been the root from which many other laboratories at MIT have grown. Research in the Laboratory is conducted by approximately 75 members of the faculty who are affiliated with the Departments of Electrical Engineering and Computer Science, Physics, Chemistry, Material Science and Engineering, Aeronautics and Astronautics, Nuclear Engineering, and Linguistics. During the past year there have been approximately 250 graduate students together with 100 undergraduates working on research projects within the Laboratory. Major support for the research is derived through the Joint Services Electronics Program (JSEP) of the Army, Navy and Air force, as well as other agencies of the Department of Defense, the Department of Energy (DOE) the National Science Foundation (NSF), the National Institutes of Health, (NIH) and the National Aeronautics and Space Administration (NASA), together with substantial contributions from industry and private foundations. While the Laboratory is very heterogeneous in character, it can be seen as organized into two major thrusts focused around electronics and optics, and language speech and hearing. In addition there are seven smaller focus areas, as well as some individual activities, which have a small amount of coupling to other projects within the Laboratory.

ELECTRONICS AND OPTICS

Research in this area ranges all the way from underlying device physics, materials technology, and processing techniques, through the utilization of devices in high performance circuits and on to systems and architectural considerations. The Laboratory brings together in this area experts from physical chemistry, condensed matter physics, electronic materials, device design and characterization, processing innovation, design techniques for complex high performance integrated circuits, and overall system and architectural strategies for a variety of application areas including digital signal processing and image processing.

Professor Sylvia T. Ceyer is constructing an apparatus for the determination of chemical processes at the surface of a semiconductor during plasma etching. A molecular beam of neutral species is directed against the semiconductor surface and reactive products are measured with respect to both angular distribution and energy, thus providing an unambiguous characterization of the surface chemistry during such practical processes. Professor Keith Nelson has introduced a novel time domain stimulated light scattering method for the investigation of lattice vibrations and other condensed-phase excitations. For the first time this provides time-resolved observations of cooperative motion near phase transitions in a variety of crystals, and has been successful in characterizing photochemical effects at time resolutions less than 100 femtoseconds. In addition to providing effective experimental probes, these techniques are being extended for satellite and terrestrial optical communications as well as signal processing.

In the Submicron Structures Laboratory, under the direction of Professor Henry I. Smith and Principal Research Scientist John Melngailis, many fabrication techniques have been introduced including various forms of lithography, etching, growth and deposition. The research projects fall into four major categories including submicron structure fabrication techniques, submicrometer electronics, crystalline films on amorphous substrates, and periodic structures and applications. New lithographic processes provide the capability of generating structures of 1/10 micron line width, and new techniques have been developed for forming crystalline films on amorphous substrates adequate for device fabrication. The ability to accurately tailor devices is being enhanced through the acquisition of a focused ion beam fabrication facility. Professor Carl Thompson, in addition to collaborating on the research directed toward the forming of crystalline films on amorphous substrates, is also investigating techniques to both characterize and minimize the effects of electromigration.

Professors Hermann Haus and Erich Ippen have been developing novel waveguide optic devices for ultra high speed signal processing, and new lasers for studies of material processes on a subpicosecond time

scale. The goal of this research is to develop prototype optical waveguide devices that operate at rates of many tens of Gigahertz. This work couples together a variety of theoretical studies, such as the theory of a new soliton laser and the theory of surface acoustic wave grating couplers with very high performance experimental techniques utilizing nonlinear optical fiber pulse compression techniques to generate pulses as short as 16 femtoseconds, setting a new world record. Consideration has also been given to the integration of optical techniques with more conventional electronic systems, exploiting the best properties of each.

In the condensed matter physics area, a coordinated set of experimental and theoretical investigations has been yielding new insight into a variety of novel states of matter. Professor A.N. Berker has developed the theory for several systems undergoing phase transitions using the renormalization-group technique and other methods of statistical mechanics. These techniques have led to the accurate solution of several systems including the prediction of new phases in the epitaxial absorption of Oxygen onto Nickel (100). Professor Robert Birgeneau has utilized high resolution synchrotron x-ray techniques at the Stanford Synchrotron Radiation Laboratory to study and confirm theories of order in two dimensional matter. Synchrotron-generated x-rays are also being used by Professors Birgeneau and Litster as a probe technique for the study of surface order. This experimental work is complemented by studies by Professor John Joannopoulos on the study of surfaces of real material systems. This theoretical work has focused on elucidating the nature of chemisorption processes in structural phase transitions so as to predict surface binding accurately at atomic dimensions. Professor Marc Kastner has collaborated with Dr. Melngailis to study electron conduction in very narrow silicon field effect transistors. At low temperature, the conductance of these devices, fabricated in the Submicron Structures Laboratory, shows large non-monotonic variation with electron concentration. Professor Patrick Lee has provided a theoretical explanation of these phenomena in terms of tunneling processes in a one dimensional disordered system. Professor Kastner has additionally been studying defects in amorphous silicon dioxide by means of the creation of new electronic states with ultraviolet light. These experiments may provide new probes of defects in optical fibers as well as in the insulating silicon dioxide used on silicon devices.

In the area of VLSI circuit design, Professor Lance Glasser has focused on the development of timing optimization strategies for the sizing of integrated circuit devices. Professor John Wyatt has introduced new techniques for the modelling of MOS transistors and MOS logic gates leading to additional sizing optimization techniques as well as extensions to previous work by Professor Paul Penfield on waveform bounding for fast timing analysis. It is expected that the waveform bounding techniques can be combined with new techniques for relaxation simulation to provide highly accurate but cost effective simulation techniques that will be useful for very large VLSI circuits. Professor Jonathan Allen has been focusing on techniques for combining architectural performance in terms of parallelism with circuit performance in terms of area, speed, and power. High accuracy circuit extraction techniques have been developed, along with a number of flexible module generators and a computational framework for efficiently exploring architectural tradeoffs in a task-invariant way.

LANGUAGE SPEECH AND HEARING

In the speech communication area, studies range from fundamental characterization of acoustic speech generation and perception, through phonetic and linguistic studies of second language learning, to applied systems of speech synthesis and recognition. Dr. Dennis Klatt has extended his work in phonemic speech synthesis to include appropriate rules for the Japanese language, and Professor Victor Zue and his students have been working on several aspects of speech recognition, including the recognition of continuous digit strings and the utilization of linguistic and phonotactic constraints for large vocabulary speech recognition systems. Very sophisticated research facilities based on Lisp machines have also been utilized extensively in this area.

In the Sensory Communication Group, Professor Louis Braid, Senior Research Scientist Nathaniel Durlach, Principal Research Scientist Steven Colburn and Research Scientists William Rabinowitz, Charlotte Reed, and Patrick Zurek have conducted a range of studies focusing on human perception in the senses of hearing and touch. These studies have provided new quantitative understanding of pitch and loudness perception, as well as binaural interaction, short term memory effects, and speech intelligibility. Much of this work is now being focused on the development of improved hearing aids including the introduction of signal processing schemes that improve intelligibility for subjects with sensory-neural hearing impairments. It has also been shown that it is possible to perceive speech through use of tactile stimulation, such as the use of a human hand placed against the face of the speaker. A model of the human face has been constructed which can be controlled by computer to investigate the ways in which information can be transmitted by this tactile means. Additional

projects in the tactile area focus upon hand function in the manipulation of objects and are directed toward the development of improved robotic systems and hand rehabilitation procedures.

In cooperation with the Eaton-Peabody Laboratory at the Massachusetts Eye and Ear Infirmary, many long term studies on the mechanism of hearing are being pursued. In one project, the acoustic reflex, in which muscles of the middle ear contract in response to intense sound and thereby decrease signal transmission through the ear, has been studied by Dr. John Guinan and his students, who have shown that the neural input to these muscles does not follow the usual view of skeletal muscles. Professor N.Y.S. Kiang and Dr. Bertrand Delgutte have recently summarized several coding features of speech sounds found in the auditory nerve of cat, thus providing some of the first quantitative understanding of the way in which human-like speech sounds are encoded at the peripheral level. Under the direction of Dr. Donald Eddington, work is beginning on the implantation of electrodes attached to the bony exterior of the cochlea as a technique for improving impaired hearing in humans. Professor William Peake has been studying the signal transmission properties of the middle and inner ear both experimentally and theoretically together with Dr. John Rosowski. Professor Thomas Weiss has developed a theoretical analysis of the processes of hair cell stimulation in the inner ear, while Professor Lawrence Frishkopf has demonstrated experimentally that the micro mechanical processes of the hairs of receptor cells provide band pass filtering.

FOCUS AREAS

Atomic and Molecular Physics

Professor Daniel Kleppner and his students have been studying spontaneous radiation from excited atoms, discovering that these fluctuations can be reduced and the spontaneous radiation inhibited by placing the atoms between conductors whose separation is less than one half the atom decay wavelength. This has led to the discovery of a unique class of atomic states, and the ability to control spontaneous emission which is the fundamental source of noise in quantum electronic devices. Professor David Pritchard has been building new facilities for trapping experiments, but has also developed a new technique using supersonic expansion to study collisions at low temperatures. Professor Shaoul Ezekiel has also been concentrating on techniques for minimizing noise in optical systems, particularly those utilizing fiber optic coils and the Sagnac effect, that can be used for navigational purposes and the detection of the earth's rotation.

Plasma Physics

In the Plasma area, Professor George Bekefi has developed a variety of techniques involving free electron lasers for the production of high intensity radiation. Recently a very promising free electron laser using a bifilar helical wiggler and a guiding axial magnetic field has been developed and shows to produce radiation in a very narrow band which is tunable over a very wide frequency range. Together with Professor Bekefi, Professor Miklos Porkolab has continued a varied experimental program using the Versator II medium sized research tokamak. Studies of plasma confinement and transport during RF current drive as well as studies of current drive efficiency through coupling structures on the outside of the torus has recently been completed. Two major construction projects have allowed for upgraded ohmic heating and a new high frequency RF power system, thus extending the capability of Versator. Additional experiments are planned to test the heating in current drive processes over several frequency regimes.

Theoretical study of plasmas in thermonuclear regimes has been conducted by Professor Bruno Coppi and his collaborators, providing theoretical guidance for the Alcator and Versator experimental programs. In addition, theoretical explanations have been derived for enhanced electron and ion thermal conductivity with particular relevance to future experiments in which heating due to fusion reaction products will prevail.

Radio Astronomy

Professor Bernard Burke has been pursuing a program of studying extragalactic radio sources with emphasis on the search for "dark matter", the non-luminous component of the universe that is manifest in galaxies and clusters of galaxies only through its gravitational effects. In this program, a new example of gravitational lensing was discovered during this last year whereby a quasar can be split into multiple images by the gravitational field of intervening matter. These effects can now be

deliberately demonstrated through use of the Very Large Array of the National Radio Astronomy Observatory. Professor Alan Barrett has been investigating mechanisms of star formation in several galaxies. Galaxies undergoing extensive star formation provide interesting radio properties including a bright nucleus, infra-red color excess, and optical emission lines that are characteristic of young, hot stars. Also during 1983, the Mark II Astrometric Interferometer at Mount Wilson in California tracked stellar interference fringes in two colors for the first time. This result was obtained by Professor David Staelin together with Dr. Michael Shao and their students.

Digital Signal Processing

Professors Alan Oppenheim and Jae Lim have been concentrating on the restoration of images from various forms of degraded information. They are also developing a technique for very low bit rate video conferencing by transforming an image into a bi-level image and then coding the difference between consecutive image frames. Artificial Intelligence techniques are being introduced for object detection in visual pattern recognition, as well as in new approaches to such classical problems as pitch detection. Professor Arthur Baggeroer is continuing his series of geophysical and acoustic experiments in the marginal ice zone of the Arctic, characterizing acoustic reflections from the ocean bottom in these environments. Professor Bruce Musicus has been studying techniques for architectural transformations in signal processing systems, including ways to manipulate signal flow graphs into a variety of task invariant architectural forms.

Image Processing

Professors William Schreiber and Donald Troxel have been investigating a variety of problems in image processing including image sampling and reconstruction, automated engraving of gravure printing and new architectures for computer graphics. The careful modelling of human perceptual performance together with the use of high performance computer techniques has allowed techniques of picture editing to be introduced into practical systems for image generation. In addition, a project in advanced television research has been initiated to provide new scientific and technological findings for improved television systems. This work is supported by a broad industry consortium and brings together a number of research groups in RLE as well as efforts in the Media Laboratory and the Communications Policy Research Program. Professor David Staelin has been studying video bandwidth compression techniques by demonstrating full motion monochrome head and shoulders video sequences at 56 kilobits per second using 128x120 pixel resolution. Motion compensated interpolation techniques to 15 frames per second have also been demonstrated successfully for video sequences of people talking and moving.

Electromagnetics

Professor Jin Kong has undertaken a wide variety of studies in electromagnetic waves with applications to microstrip antennas, microelectronic integrated circuit problems, geophysical subsurface probing, microwave remote sensing, and optical beam refraction by periodic structures. Increased understanding of electromagnetic, magnetostatic, and magnetoelastic wave phenomena has been utilized by Professor Frederic R. Morgenthaler to create novel device concepts useful for microwave signal processing applications. New forms of microwave delay lines have been developed as well as RF and microwave applicators and techniques useful for the production of hyperthermia in biological tissue for the treatment of certain cancers.

Communications

Professor Jeffrey Shapiro and Dr. Prem Kumar have undertaken a variety of studies in the areas of optical frequency physics, devices, and systems. These include experiments with atmospheric optical communications links, including protocol issues, the study of coherent CO₂ laser doppler radars, and the novel experimental generation of "squeezed state" light beams that introduce non-classical quantum states of the radiation field with superior fluctuation properties for a variety of communication and precision measurement applications. Dr. Robert Rediker has succeeded in controlling five diode lasers so as to operate coherently with each other, thus leading to the possibility of the use of as many as a thousand diode lasers with coherent output for high energy radiation applications.

The neurophysiology Laboratory led by Professor Jerome Lettvin has continued to study a wide variety of physiological phenomena involving nervous transmission and the physiological basis for visual

perception in animals and man.

Dr. Joseph Jarrell and Professor John King have been utilizing their scanning micropipette molecule microscopy system to study the water transport at the cellular level across hormonally responsive tissues that model the distal tubules of mammalian kidney. This technique, providing very fine resolution, has given new insight into the specific sites of fluid transport in a way not previously possible.

JONATHAN ALLEN

Vice President, Resource Development

INTRODUCTION

For the second consecutive year, income from gifts, grants, and bequests, and from memberships in the Industrial Liaison Program (ILP), exceeded \$55 million. Pressures on Institute resources, however, remained severe. Funds for core needs--faculty support, student aid, seed research, and unrestricted purposes--remained well below the levels necessary to maintain MIT as a leading private educational institution.

To begin to address this problem, members of MIT's development staff embarked on a national program aimed at expanding the Institute's pool of prospective donors. Initial efforts concentrated on identifying those individuals who have the capacity to make major philanthropic contributions to MIT, and determining ways to interest them in the Institute's goals and activities. This program will continue during the coming years, along with efforts to expand corporate and foundation contacts.

PRIVATE SUPPORT

Private support for 1983-84 totaled \$55.7 million, including the following: \$49.1 million in gifts, grants, and bequests, and \$6.6 million in support through membership in the ILP. The total compares with \$56.4 million in 1983, \$46.6 million in 1982, \$47.5 million in 1981, and \$38.1 million in 1980. Gifts-in-kind for the past year (principally gifts of equipment) were valued at \$7.3 million. Payments on Leadership Campaign pledges had only a residual effect on cash flow in 1984.

Sources of gifts for fiscal year 1984 were: alumni, \$12.9 million; non-alumni friends, \$6.5 million; corporations, corporate foundations, and trade associations, \$14.2 million; foundations and charitable trusts, \$15.1 million; others, \$0.4 million. Included in the totals for alumni and friends are gifts of \$1.1 million made to the Rogers, Maclaurin, and Compton Pooled Income Funds. The total income of \$6.6 million for corporate liaison programs represented a 3.1 percent increase over the total for fiscal year 1983.

Donors designated expendable and endowed funds as follows: unrestricted, \$6.6 million; departments, \$20.1 million; faculty salaries, \$5.3 million; graduate scholarships and fellowships, \$3.2 million; undergraduate grants, awards, and loan funds, \$3.4 million; building construction funds, \$6.3 million; other funds, \$4.2 million.

Included in the totals above was support for three new endowed chairs--two full professorships and one assistant professorship--as well as one term chair.

CORPORATION DEVELOPMENT COMMITTEE

Members of the Corporation Development Committee (CDC) assisted with fund-raising to support a variety of projects over the year. Primary among these were Project Athena, renovation of the chemistry teaching laboratories, the economics department, and core needs for the Institute.

The annual meeting of the CDC was held on November 3, with David Saxon, new chairman of the MIT Corporation, presiding, and with 62 members attending. Mr. Saxon reported that MIT ranks fifth in private support among peer institutions, and that total private support for the Institute topped \$50 million for the first time in fiscal year 1983. Budgetary matters and a discussion of core funding needs were followed by a presentation on Project Athena--an Institute-wide experiment in the use of computers in education.

The luncheon program in the Bush Room featured Professor Emilio Bizzi, director of the Whitaker College of Health Sciences, Technology, and Management, who described the new

interdisciplinary approach to research at Whitaker, and the four divisions and intellectual foci of the college. The 1983 Dalton award for service to MIT was presented in absentia to Denman K. McNear '48, corporation member, former president of the Alumni Association, and a tireless and effective worker in the San Francisco area.

Following the luncheon program, CDC members visited with faculty and students at four on-campus sites: the Center for Engineering Design, the Media Technology Laboratory, the Department of Economics, and the Eric P. ('32) and Evelyn E. Newman Laboratory for Biomechanics and Human Rehabilitation. The meeting closed with a reception at the President's House.

We note with deep regret the loss of committee member John Fluke, Sr. '36, whose good counsel and leadership in the Northwest contributed so much to strengthening MIT over many years; and honorary member Leo Loeb '08, whose eight decades of caring and generosity placed him among our special friends.

ORGANIZATION

Resource Development engaged in a major reorganization at mid-year. The specific goal was to place more staff members "in the field" (that is, actively seeking gifts from prospective donors) in the most efficient manner. The various changes are described in more detail in the following sections.

In addition to several personnel shifts, the reorganization involved the creation of a new Office of Special Gifts, designed to place increased attention on fund-raising from individuals; and an Office of Foundations and Corporations. The Office of Planned Giving and Legal Affairs was transferred to the office of the MIT Treasurer as a means of increasing efficiency in the legal and financial areas.

SPECIAL GIFTS

Effective January 1, 1984, a new Office of Special Gifts was created to provide a special impetus to the solicitation of individuals, under the direction of Nelson C. Lees. The new office has two groups, Major Gifts and Leadership Gifts, both described below.

Major Gifts

The Major Gifts group will have particular responsibility for gifts in the range of \$100,000 or more. Two new staff positions and one support position were authorized for this area.

The office, which will work closely with the Alumni Fund (particularly reunion gift efforts) and the Office of Planned Giving and Legal Affairs, will focus on identifying, cultivating, and soliciting major gifts from a substantially increased number of alumni and friends of MIT.

Leadership Gifts

Director Donald P. Severance and the Leadership Gifts staff continued to work closely with volunteers in the identification, cultivation, and solicitation of potential donors.

Plans for a comprehensive national screening program were developed under the leadership of Associate Director Edith E. Nelson. The program is designed to carry out a review of names by alumni volunteers to re-evaluate existing prospects, identify new prospects, and define mechanisms that can involve individuals more closely with the Institute. It also provides an opportunity for MIT to present its financial needs and concerns to a large group of alumni and friends, in a comprehensive and consistent fashion.

Planning and testing of the new program was time consuming, but rewarding. The first session was hosted in Los Angeles on June 28 by CDC member Duwayne Peterson, Jr. '55, executive vice president of Security Pacific National Bank. Response from alumni participants was most enthusiastic.

Staff have also continued to work closely with the Alumni Fund class reunion gift programs and with the Office of Planned Giving and Legal Affairs in the solicitation of leadership gifts.

In June, Leadership Gifts hosted a one-day workshop on major gifts for representatives of the Ivy-MIT-Stanford fund-raising staffs, to discuss issues of mutual concern in assuring increased gift flow from individuals.

DEVELOPMENT OFFICE

Under the leadership of Vincent C. DeBaun and G. Rodger Crowe, the Development Office continued its staff support of major fund-raising priorities, including the Microsystems (VLSI) program and laboratory; arts and media technology; health sciences; Project Athena; undergraduate chemistry laboratories; Department of Economics; REMERGENCE; Engineering Design Center; Sloan School; School of Architecture and Planning; and the Chemical Engineering Unit Process Laboratory. Staff worked closely with Eric C. Johnson, assistant dean of engineering, in coordinating fund-raising approaches.

The office continued to maintain and operate various management information systems in support of all Institute development activities. Utilization of several on-campus data bases for both planning and operations was improved. Plans were also developed to use on-line commercial data bases for identifying new prospects, particularly individual entrepreneurs.

HEALTH SCIENCES

The Institute's health sciences development effort continued to expand during the year. Significant new grants were received for graduate fellowships in the biological sciences, and to support the work of faculty members involved in biomedical engineering, brain sciences, and cancer research.

Increased involvement from the faculty was instrumental in securing gifts from corporations, foundations, and individuals. Barbara Gunderson Stowe, development officer for the health sciences, worked closely with Kenneth A. Smith, associate provost and vice president for research, in assessing Institute funding priorities for a range of health-related projects and programs. Irwin W. Sizer, former head of the Department of Biology and former dean of the Graduate School, continued to work closely with Ms. Stowe.

COMMUNICATIONS

The Office of Communications, under the direction of Deborah J. Cohen, produced a number of new fund-raising publications and began several new projects in the area of donor relations. In addition, a large number of proposals were issued for Institute priorities ranging from curriculum development funds for Project Athena to fellowship and faculty endowment funds for the brain sciences.

New publications included: the 1984 Factual Profile; the third edition of Endowed Professorships at MIT: A History (publication scheduled August 1984); Institute Priorities, remarks by President Gray; Gift Opportunities 1984; a revamped newsletter for members of the Corporation Development Committee; and a brochure for the new MIT Economics Forum. Staff members also consulted with groups throughout the Institute on various departmental publications.

Donor relations activities concentrated on improving contacts with donors through reports and campus visits. A system for monitoring these contacts, incorporating information from throughout the Institute, began operation. Reporting on endowed professorships was stepped up, and a well-received program of campus visits was begun. In conjunction with the Student Financial Aid Office, staff members carried out a study of reporting to financial aid donors.

FOUNDATIONS AND CORPORATIONS

A new unit within Resource Development, the Office of Foundations and Corporations, was established on January 1, with Vincent C. DeBaun as director. Robert Hagopian is associate director, in addition to his ongoing assignment as administrator of the National Business Committee (NBC). The Committee continues under the chairmanship of Robert L. Mitchell '47.

In broad terms, the objective of the new unit is to continue to attract support for Institute priorities from private foundations and corporations in increasing amounts. Staff are enlisting the aid of members of the CDC and NBC; increasing the involvement of deans, department heads, and senior faculty; and expanding cultivational and stewardship

activities. A major effort will be directed toward identifying and developing relationships with entrepreneurial companies, especially those in which MIT alumni are key figures.

Principal fund-raising areas are: professorships, student aid, Project Athena, the engineering design center, and chemistry laboratory renovations, as well as encouraging corporate membership in the Industrial Liaison Program.

MIT SUSTAINING FELLOWS

Starting its fifth year, the MIT Sustaining Fellows continued its mission of recognition, involvement, and cultivation of major benefactors of the Institute. Membership totaled 766: 501 life members and 265 annual members.

This year the Sustaining Fellows fund (which comprises Sustaining Fellows' unrestricted gifts to MIT) totaled \$332,517, and is pending designation by President Gray. In past years, Sustaining Fellows funds have been used for the renewal of equipment in undergraduate teaching laboratories (1979-80); automation of the MIT Libraries' circulation system (1980-81 and 1981-82); and for the rebuilding and landscaping of a portion of Amherst Alley (1982-83).

The MIT Sustaining Fellows' third major event, originally scheduled for the spring, was rescheduled for December 11, 1984, with White House correspondent Lesley Stahl as the featured speaker. Ms. Stahl is the daughter of Mr. and Mrs. Louis E. Stahl. Mr. Stahl is a member of the CDC and the Class of 1936.

Corporation member Breene M. Kerr '51 continued his energetic leadership as Sustaining Fellows chairman, and Professor Elias P. Gyftopoulos continued as faculty chairman.

INDUSTRIAL LIAISON

During the past year the Industrial Liaison Program continued to grow in strength and quality, with new services provided to member companies and to MIT faculty and departments. Directed by Professor James M. Utterback, the program showed a net gain of 20 paying members, and cash flow exceeded \$6.6 million. Total membership now stands at 296, of which 270 are paying members, and 26 are affiliate members based on major gifts to the Institute.

Member Services

Figures for the past year included: over 1,500 visits by member companies to MIT, in which more than 2,300 visitors met with faculty and staff; 650 visits to member companies by faculty, and 350 by Liaison Officers; 500 telephone conversations between member company personnel and MIT faculty; a 50 percent increase in the number of publications sent out (75,000 items in response to 18,000 requests); and a 25 percent increase in library use (more than 1,800 cards distributed).

Fifteen symposia were presented in the U.S. for member companies, with attendance of more than 2,000. Most popular were "Networked Computer Systems," "Organizational Transformations: A Symposium in Honor of Professor Richard Beckhard," "Marketing Strategy and Models in the Information Age," and "Frontiers in Medical Technology." Six seminars and four short courses were presented in Europe with total attendance of more than 400. In Japan, 25 conferences had a total attendance of nearly 800.

MIT continued to attract attention through the MIT Report. Monthly mailings total 15,000; 1,500 within MIT. An article from the May 1984 issue about Professor Alan Nelson's research on electron microscopy was condensed by the Associated Press and United Press International and reprinted in newspapers throughout the country.

Eleven departmental or interdepartmental collegia are jointly sponsored through the Liaison Program.

New Services

A new series of dinner meetings was instituted to strengthen ties between MIT and chief executives of member and prospective member firms. Four were held at Endicott House; two featured Professor Jay W. Forrester, and two Professor Paul A. Samuelson. In the coming year, six meetings will be held at Endicott House, and the service will be expanded to eight major U.S. cities where there are concentrations of member firms.

An intensive laboratory course entitled, "VLSI Design" was held in June. An additional course entitled, "Advanced VLSI Design" will be held in July in conjunction with the Summer Session Office. During the year the Liaison Program began production of video-taped research briefings highlighting research in different parts of the Institute. Recent topics have included the Design Center, materials, and robotics vision. The respective research programs, Educational Video Services, and the Alumni Association are co-sponsoring this work and also using the briefings.

ORGANIZATIONAL AND PERSONNEL CHANGES

Nelson C. Lees, who continues as director of Resource Development, became director of the new Office of Special Gifts, with its line responsibility as his principal assignment. Thomas W. Boyden will join the Special Gifts office staff in July. A second major gifts officer is still being sought.

Donald P. Severance, director of Leadership Gifts, retired June 30, and will become a consultant to the Office of Special Gifts for the coming year. Edith E. Nelson succeeds Mr. Severance as director of Leadership Gifts. Robert H. Bliss, district director for the Midwest and the Los Angeles region, also retired from the Institute on June 30, and Steven D. Immerman, formerly assistant dean for student affairs, joined the staff on May 1 as district director for the South and Southwest region. E. Barbara Lewis, executive director of the Sustaining Fellows, continues to head that program, but will also assist with Leadership Gifts' national screening program.

Personnel changes in the Development Office included the promotion of G. Rodger Crowe to director. This followed the appointment of former director Vincent C. DeBaun to the new position of director of the Office of Foundations and Corporations on January 1, 1984. Carol A. Hubert resigned as assistant director, and will be replaced by Karen A. Engelbourg on July 30, 1984. In October 1983, Lindsey V. Humes was promoted to the new position of manager, development research.

During the year, Stacy E. Hynes was promoted to donor relations coordinator in the Office of Communications.

Akemi Saito was promoted to assistant director of the ILP Japan Office, Susan I. Shansky to manager of communications, and John W. Leech and Jennifer Knapp-Stumpp were appointed liaison officers. Liaison Officers James P. Carpenter and Robert R. Lockett resigned; Mr. Carpenter took a position as manager, Business Development Marketing, Precision Products Division, Northrop Corporation, Norwood, and Mr. Lockett is pursuing a master's degree in the Sloan School of Management. ILP Analyst Carmela R. Sciandra left the Institute and is now working at Nixdorf Computer Corporation in North Reading. In addition, John T. Preston, associate director, is taking a six-month leave of absence through October 1984.

CONCLUSION

As noted earlier, on June 30 Donald P. Severance retired from full-time service, after serving the Institute in various capacities since 1938. Over the years, Mr. Severance has held the positions of registrar, executive vice president of the Alumni Association, and instructor in the Department of Mathematics, as well as director of Leadership Gifts. We are very pleased that he will continue part-time as a special consultant in development for the coming year.

It is also a pleasure to acknowledge the help from the new chairman of the corporation, Dr. David S. Saxon. Dr. Saxon has devoted a great deal of effort to the Corporation Development Committee, and has visited with a number of its members and with a number of potential MIT donors.

No report from the vice president for Resource Development at MIT could be complete without acknowledging the splendid cooperation, help, and travel by President Paul E. Gray; the assistance, help, and guidance of Senior Vice President William R. Dickson; and the cooperation and advice of our Treasurer, Glenn P. Strehle.

SAMUEL A. GOLDBLITH

Lincoln Laboratory

Lincoln Laboratory is operated by MIT as a Federal Contract Research Center for performing research and development in advanced electronics. During the past year, agencies of the Department of Defense (DoD) -- the Air Force, Army, Navy, and the Defense Advanced Research Projects Agency (DARPA) -- supplied 96 percent of the Laboratory's budgetary support. The Federal Aviation Administration provided most of the non-DoD support. In fiscal year 1984 the operating budget was \$258 million, supporting the efforts of 792 professional staff, 78 percent of whom hold advanced degrees.

Several administrative changes at the Laboratory Steering Committee level occurred during the year. Henry W. Fitzpatrick retired on June 30, 1984 after 31 years of service to MIT, 28 years at Lincoln Laboratory as Assistant Director with financial and administrative responsibilities. He will be succeeded by John A. McCook. Dr. John Rheinstein succeeded William Z. Lemnios as Associate Head of the Radar Measurements Division when Mr. Lemnios became Division Head as reported last year. Ernest Stern was appointed as an Associate Head of the Solid State Division. Dr. Theodore Bially resigned to take an industrial position, and was succeeded as Associate Head of the Data Systems Division by Peter E. Blankenship.

Technical work areas at the Laboratory include radar and optical sensors, measurements, and systems; satellite communications; signal design and processing; lasers; solid-state devices; digital technology, circuitry, and data systems; tactical and strategic systems and countermeasures; and air traffic control systems. Unclassified highlights of several accomplishments during the past year are summarized below.

CUSTOMIZATION AND RESTRUCTURING OF VLSI CIRCUITS

A technique for customization and restructuring of whole wafer, very large-scale integrated circuits was described last year. The procedure employed a laser to cut or make connections to improve process yield and to customize the circuit after fabrication. During the past year this process has been developed further, and two new techniques have been demonstrated, one using an electron beam and the other using a laser to induce metal deposition from a vapor phase medium.

Applications of Laser Restructuring

Using the new technology and design methodology described last year, called restructurable VLSI (RVLSI), the Laboratory recently fabricated and tested the first wafer-scale random logic chip, a digital integrator intended to extract communication signals from high-noise backgrounds. The chip has an area of 20 square centimeters compared with the usual 0.5 square centimeter of modern chips. It contains 130,000 working transistors and accepts data at a rate of 25 MHz. Two other applications of the technology, each containing about 300,000 transistors, are in development, a fast Fourier transform (FFT) processor, of broad value in signal processing, and a "dynamic time warping" system for speech recognition.

In RVLSI the wafer contains an array of logic cells embedded in a matrix of programmable interconnect. The cells and interconnect are all tested, and the results are input to a program which assigns each part of the logical system to a specific usable cell or wire. The chip is mounted in its package, and the laser micro-welding technique is used to connect the assigned parts and bypass defective ones to build the system. In the FFT design the laser is also used to customize the cells. As the system is wired it can be tested incrementally, and if a new defect is discovered it can either be corrected or a new assignment can be made which avoids the defect.

Several Laboratory developments make this technology possible. In the design stage the assignment software is used to determine the system partitioning and the level of redundancy based on expected defect density. Each individual wafer is then processed as described above. The laser programming is used in conjunction with a new device, a sandwich of two aluminum alloy conductors separated by an insulator of amorphous silicon. The yield and reliability of these links are very good, their off-impedance is high and on-resistance is very low. An optical probing technique was also developed which allows testing of links and cuts as the chip is programmed so that any remaining defects can be corrected.

Electron Beam Restructuring

A new technique for testing and restructuring wafer-scale systems by means of an electron beam has also been demonstrated. Restructuring is accomplished by the use of floating-gate NMOS transistors as nonvolatile switches which can be selectively turned on or off with an electron beam to provide customizing or fault-avoiding connections. A wafer-scale 128K-bit read-only NMOS memory with about 200,000 electron-beam programmable switches has been successfully fabricated. An electron beam has also been used to test integrated circuits by selectively altering and sensing logic states. This technique will enable the testing of wafer-scale systems without mechanical probing. Current work includes extension of the electron beam techniques to CMOS technology.

Laser-Microchemical Techniques

A third technology, originated at the Laboratory, complements the above two approaches. It is based on the use of a focused laser beam to initiate a localized chemical reaction in a gaseous medium above a semiconductor surface to produce low-temperature selective deposition, doping or etching. A resolution of 0.2 micrometer (i.e., below the diffraction limit of the laser beam) has been achieved by use of nonlinearities in the chemical kinetics at the surface. The technique uses programmed scanning of the beam to alter circuit connections for restructuring or customization without the use of prefabricated link or switch structures. Logic routings for circuit substructures have been demonstrated using commercial CMOS gate-array circuits. Laser microchemical techniques have also been successfully used in the fabrication of fragile x-ray membrane masks and for in situ modification of integrated-optical and surface acoustic wave devices that are under development at the Laboratory.

PARALLEL, FAULT-TOLERANT PULSE-DOPPLER PROCESSOR

Under an Army-sponsored program, a high-performance, fault-tolerant, parallel pulse-doppler processor has been developed to accommodate stressing radar system requirements of high bandwidth, long-range windows and high burst rate. Each processor in the parallel architecture contains an analog-to-digital (A/D) converter as well as a fast Fourier transform (FFT) subsystem for Doppler processing. High bandwidth is achieved by interleaving the A/D converter sampling epochs so that the effective system sampling rate is equal to the product of the individual A/D sampling rate and the number of active processors. The problem of precisely matching A/D converter calibrations is alleviated by careful choice of the relationship between the radar pulse repetition interval and the individual A/D sampling period, so that for any given FFT computation all of the input data originate from the same A/D converter.

As a demonstration of the architectural concept an experimental system comprising four processors has been developed which achieves a system bandwidth of 48 MHz. On a rotating assignment basis, three processors are active while the fourth is designated as a spare which performs self-test functions during the idle period. This experimental configuration provides a processor throughput of three million 16 point fast Fourier operations per second (equivalent to 600 million instructions per second).

The basic architecture when augmented with advanced electro-optic sample and hold devices, currently under development at the Laboratory, will be able to accommodate waveforms with bandwidths approaching one GHz. A significant size reduction for the Doppler processors can be achieved by replacing the current design, which comprises 1192 integrated circuits, with four wafer-scale integrated circuits which are also currently under development at the Laboratory (see the previous section on Restructuring of VLSI Circuits).

BINARY GRATING OPTICS

In the past few years three independent new developments, in electro-magnetic-optics theory, in pattern generation and substrate deposition, and in dry reactive ion-beam etching techniques, have made it feasible to generate binary holographic gratings with blaze-like characteristics (grating diffraction angle along the specular reflection direction for a strong diffraction line) and near-perfect efficiency.

Highly efficient binary diffraction gratings with 94 percent first-order diffraction efficiency measured in the infrared (10.6 micrometers) on straight gratings and on holographic off-axis lenses have been fabricated at Lincoln. The observed point-spread functions of these lenses (F/10, f=25 cm) were limited only by diffraction. Using oxygen reactive ion-etching techniques, grating patterns on glass, silicon, and plastic substrates have been produced. Large scale integration production techniques were adopted to fabricate these gratings. This work, therefore, merges development in theories of binary diffraction gratings operating in the electromagnetic domain with advances in very large-scale integration fabrication techniques.

OPTICAL SIGNAL PROCESSING

The Laboratory has been developing several different solid-state optical devices for high-speed processing of electrical and optical signals. Work has continued on an electrooptic analog-to-digital converter which has achieved a higher speed (500 MHz bandwidth, one gigasample/sec) than any other type of A/D converter, on a photoconductive optoelectronic switch for high-speed optical mixing and sampling applications, and on a new type of fast, electrically addressable spatial light modulator for two-dimensional optical processing.

In addition to these efforts, a unique electrooptic frequency translator has recently been demonstrated which uses an electrical signal to shift the frequency of an optical carrier. By appropriate drive to the electrodes of an array deposited on the surface of an electrooptic material (lithium niobate), light propagating in the material is modulated and deflected at a constant angle independent of the modulating frequency, thus allowing single-sideband operation over a wide frequency range. A frequency shift up to 100 MHz has been achieved with initial devices. Applications include optical radar systems, frequency standards, and heterodyne fiber-optic communications.

The technology of integrated optics has been applied to the development of a new type of wavefront measurement sensor. The device couples spatially separated samples of an incoming optical wavefront into an array of optical waveguides formed by titanium diffusion into lithium niobate. The output intensities of the waveguide circuit provide a direct measure of the phase distortions in an optical wavefront incident on the measurement sensor. An initial device consisting of a 20-element array operating at a wavelength of 0.85 micrometers exhibited near-theoretical performance. This is the forerunner of a new class of devices in which microwave phased-array techniques are translated to optical frequencies.

CCD DETECTOR ARRAYS IN SPACE SURVEILLANCE

The Ground-based Electro-Optical Deep Space Surveillance (GEODSS) program has been a part of the Laboratory's optical space surveillance activities since our initial technology development and successful concept demonstration of tracking deep space satellites with optical telescopes and high sensitivity television-type cameras. This program has continued with technical support to the Air Force in the deployment of five operational GEODSS sites (three now completed) as well as the development of advanced technologies and surveillance techniques as improvements in performance and reliability for the GEODSS network.

Early investigations at the Laboratory into the technologies and applications of visible band charge coupled device (CCD) solid-state imagers has led to a project to develop a CCD retrofit camera prototype for improvements in satellite detection sensitivity, search rate, and accuracy for GEODSS.

The imaging sensor in the GEODSS system now deployed is an intensified silicon target vidicon. It does not meet the sensitivity requirements over its entire field of view and exhibits other undesirable performance characteristics. To achieve desired performance improvements the Laboratory is developing mosaic focal plane cameras using coherent fiber optic image reducers and CCD imagers suitable for complete retrofit to the GEODSS sensors. Work to date has demonstrated that a mosaic focal plane can be assembled with satisfactory characteristics. Development of custom CCDs has been required to advance the state of the art in solid state imagers to meet GEODSS requirements. Development work at the Laboratory and through subcontract with Texas Instruments is aimed primarily at making exceptionally large area image CCDs with high-quantum efficiency and low noise with reasonable production yield.

The CCD imagers, focal planes, camera systems, and signal processing technology being developed in these programs emphasize high sensitivity and high resolution with direct application to improving the observation capability for many important projects in the field of astronomy. The Laboratory is applying these CCD sensor developments to the discovery and measurement of asteroids and other space objects in support of several NASA space and astronomy programs.

WEATHER RADAR

Severe weather, especially the turbulence and low-altitude wind shear associated with thunderstorms, is a significant hazard to both en route and terminal aircraft operations. Under sponsorship of the Federal Aviation Administration, the Laboratory is developing techniques to automatically interpret the output of Doppler weather radars to alert air traffic controllers to the location and severity of such hazardous weather phenomena.

In a program jointly undertaken by the National Weather Service, the Air Weather Service, and the Federal Aviation Administration, a next-generation Doppler weather radar (NEXRAD) is being developed and a nationwide network of these radars will be installed. In order to make the output of these radars useful in the air traffic control process, a continuously operating, real-time processing system is required to translate the radar returns into information on the location and severity of the turbulence and precipitation associated with thunderstorms, and to display this information in a form easily interpretable by an air traffic controller.

In addition to this national network, the FAA plans to install NEXRAD-like radars at a number of major air terminals to provide information to the terminal controllers on low-altitude weather phenomena in the vicinity of the airport. Principal focus is on the detection and characterization of low-altitude wind shear associated with thunderstorm-induced microbursts. As in the case of en route weather observations, it is necessary to develop techniques for automated weather data processing and interpretation to avoid the need for a trained meteorologist to be continuously on duty to interpret each radar output. Among the principal technical issues are the separation of the radar return due to low-altitude weather phenomena from that caused by ground clutter, and the characterization of weather phenomena based on radar observations of returned signal intensity, Doppler shift, and Doppler spread. An important element of this effort is the validation of techniques for relating turbulence to the radar observables by the use of aircraft penetrating the storm activity simultaneously with the radar measurements. Also of importance is the development of techniques for presentation of the three-dimensional weather picture on the controller's plan-position-indicator radar display in a way which is easily interpretable and does not interfere with the controller's ability to separate aircraft.

W.E. MORROW, JR.

Secretary of the Institute and Secretary of the Corporation

The Secretary of the Corporation serves as the Corporation's annually elected Recording Officer and joint signatory with the President in the awarding of the academic degrees of the Institute. The Officers and Committees of the Corporation rely upon the Secretary of the Institute to provide a range of support for the operation of the Corporation and its Committees. This report summarizes the work of the Institute's governing body.

CORPORATION MEMBERSHIP

At the year's end the reduced total of 96 members of the Corporation included 72 Active Members, 23 Life Members Emeriti, and one Member-Elect due to assume office at the October 5, 1984 Annual Meeting of the Corporation. This compared with a record 101 Members at the close of the previous year. There were 26 individuals whose membership status changed during 1983-84 in a year of extensive efforts by the Membership Committee to engage in five-year planning, to moderate the annual fluctuation in Corporation nominations, and to maintain the strength of women and minorities in the Institute's governing body.

On July 1, 1983, David S. Saxon, Class of 1941, retired President of the University of California, relinquished his Life Membership to assume the Chairmanship of the Corporation, succeeding Howard W. Johnson. Mr. Saxon's fundamental concern for the quality of education and his lifetime of experience in building the quality of the University of California and in speaking out on issues of basic concern to higher education have brought major advantages to MIT as he addressed his new responsibilities at the Institute. We have all learned from him during the year.

At its June 4, 1984 Meeting, the Corporation elected the following Members to Life Membership, effective July 1, 1984: Frank T. Cary, Chairman of the Executive Committee, International Business Machines Corporation; and Edward E. David, Jr., Class of 1947, President, Exxon Research and Engineering Company, both of whom had served two previous consecutive five-year terms.

At its June 4, 1984 Meeting, the Corporation further elected the following Members to five-year terms, effective July 1, 1984: Donald J. Atwood, Class of 1948, Executive Vice President and Director, General Motors Corporation; E. R. Kane, Class of 1943, Director and Former President, E. I. du Pont de Nemours & Company, Inc.; Margaret E. Mahoney, President, The Commonwealth Fund; Robert L. Mitchell, Class of 1947, Vice Chairman, Celanese Corporation; Mitchell W. Spellman, Dean for Medical Services and Professor of Surgery, Harvard Medical School, and Executive Vice President, Harvard Medical Center; Raymond S. Stata, Class of 1958, President and Chairman of the Board, Analog Devices; Clifton R. Wharton, Jr., Chancellor, State University of New York System; and Thornton A. Wilson, Class of 1953, Chairman and Chief Executive Officer, The Boeing Company. At the same Meeting, Arlene F. Roane, Class of 1983, a recent graduate of the Alfred P. Sloan School of Management, was elected a Member for a five-year term, effective October 5, 1984.

In addition, Mary Frances Wagley, Class of 1947, retiring Executive Director, Episcopal Social Ministries of the Diocese of Maryland, Inc., assumed an additional ex-officio position on the Corporation by virtue of her selection as the 1984-85 President of the Alumni Association. In that position, she succeeds Robert W. Mann, Whitaker Professor of Biomedical Engineering, effective July 1, 1984. The Corporation expresses its deep and abiding appreciation to Professor Mann for the added responsibility he has carried this past year. His participation in the quarterly Meetings of the Corporation and his spirited contributions to the Corporation Joint Advisory Committee on Institute-Wide Affairs (CJAC) are particularly appreciated. He has been a superb Alumni Association President.

The Corporation was saddened by the deaths of our Life Members Emeriti, David A. Shepard, Class of 1926, Former Executive Vice President and Director of Exxon Corporation, in Greenwich, Connecticut on July 10, 1983, at the age of 80; and George J. Leness, also of the Class of 1926, Former Chairman and Chief Executive Officer of Merrill, Lynch, Pierce, Fenner & Smith, in Southampton, Long Island on August 17, 1983, at the age of 80.

Mr. Shepard served as a Member of the Corporation for 32 years, including 28 years as a Life Member and long service on the Executive Committee. In his passing, the nation has lost a distinguished leader of the petroleum industry and an articulate statesman of the business community. We at MIT have lost a beloved friend who participated in extraordinary measure in the affairs of the Corporation, the Institute, and the Alumni Association for more than 60 years.

Mr. Leness served as a Member of the Corporation for 27 years, including 22 years as a Life Member and long service on the Investment Committee. In his passing, the nation has lost a distinguished leader of the investment banking industry and a statesman of the financial community. We at MIT have lost a great and good friend and invaluable counsellor.

During a year of profound losses, the Corporation was further saddened by the deaths of two active Members. W. Van Alan Clark, Jr., Class of 1942, retired Founder and Chairman of the Sippican Corporation of Marion, Massachusetts died in Boston after a long illness on July 16, 1983 at the age of 63. He had served as a Corporation Member for 11 years, including one year as a Life Member beginning in 1982. He had earlier been a faculty member and a member of the Dean's staff of the Alfred P. Sloan School of Management. In his passing, the nation has lost a vital management educator, philanthropist, and leader of technology-based companies. We at M.I.T. have lost a distinguished alumnus, staunch friend who served in the Corporation Development Committee for the last 18 years of his life, and former colleague who participated in MIT affairs as student, teacher, administrator, corporate neighbor, and member of the governing body in a career spanning 40 years. I can still see him vividly, lecturing in his animated way to students in MIT courses on production management 35 years ago. It was a privilege to have him as an instructor.

Our fellow Member, E. Kirkbride Miller, Class of 1941, retired Chairman of the Board of T. Rowe Price Associates, Inc., died in London suddenly while on a visit there on June 12, 1984 at the age of 66. He had served as a Corporation Member for two years since 1982 after serving in an extensive range of resource development activities of the Institute and the Alumni Association. In 1982 the National Selection Committee expressed to him its hope that he might serve as President of the Alumni Association when his health permitted. He was a major figure in the support of cultural and civic organizations in Baltimore, Maryland, and he was a strong and willing rallying point for MIT in that area. In his passing, the nation has lost another distinguished leader of the investment banking industry, and we at MIT have lost a devoted, caring alumnus.

Expiration of term membership has cost the Corporation the formal services of Herman R. Branson, President, Lincoln University of the Commonwealth System of Higher Education, Pennsylvania; Paulette Coleman, Class of 1977, Division Manager and Senior Scientist, Lawrence Johnson & Associates, Inc., Washington, D.C.; S. James Goldstein, Class of 1946, Founding Partner, James Goldstein & Partners, Millburn, New Jersey; Maurice F. Granville, Class of 1939, Former Chairman and Chief Executive Officer, Texaco, Inc.; Joe F. Moore, Class of 1952, President, Bonner & Moore Associates, Inc., Houston, Texas; Barbara W. Newell, Chancellor, State University System of Florida; J. Paul Sticht, Chairman of the Board, R. J. Reynolds Industries, Inc.; and Emily V. Wade, Class of 1945, Chairman of the Boston Zoological Society. These retiring Corporation Members continue their association with the Corporation in many ways as members of various alumni, Corporation, and Institute committees. Their combined service as Corporation Members is a total of 46 years of trusteeship, and they will be sorely missed.

Under the Bylaws of the Boston Museum of Fine Arts (MFA), the President of MIT annually appoints a representative from MIT to serve on the MFA Board of Trustees. During the past year, the Institute's representative has been Dean Jean P. de Monchaux of the School of Architecture and Planning. Several Corporation Members also serve as MFA Trustees. Howard W. Johnson continued his service as Chairman of the Overseers of the Museum of Fine Arts.

CORPORATION JOINT ADVISORY COMMITTEE ON INSTITUTE-WIDE AFFAIRS

The Corporation Joint Advisory Committee on Institute-Wide Affairs (CJAC) devoted the year to a study of the cluster of issues resulting from bias and imbalance in students' enrollment decisions and career choices at the undergraduate level.

CJAC held an afternoon meeting with the senior officers on October 20, 1983 and then met for two hours in monthly 7 a.m. meetings for the next seven months. The final report of the Committee on its deliberations dealt with long term efforts to augment and improve student perceptions about the richness and variety of undergraduate education, both before they come to MIT and after they arrive to undertake their common freshman year, but prior to their choice of undergraduate major.

I wish to acknowledge the brilliant leadership of our Corporation Member, Claude W. Brenner, who served as Chairman throughout the year, and the voluntary assistance given to CJAC by Iris E. Lazarus of this office, who also served as voluntary Secretary of CJAC through much of the year. At the close of the year, CJAC was saddened by the tragic death of one of its able, contributing, graduate student members, Asit Sarkar, an international student from India.

DEDICATIONS AND SPECIAL FUNCTIONS

The Corporation continued to carry prime responsibility for dedications of major facilities and many special functions. Notable ceremonies this year included the dedication of the EG&G Education Center on October 7, 1983--named in honor of the principal donors, Esther M. and Harold E. Edgerton, Pauline S. and Kenneth J. Germeshausen, and Dorothy J. and Herbert E. Grier. That happy day included the formal designation of subsidiary facilities in the Center--the Pauline S. and Kenneth J. Germeshausen Undergraduate Teaching Laboratory on the fifth floor; the Dorothy J. and Herbert E. Grier Conference Room on the fourth floor; an acknowledgement plaque to EG&G, Inc. on the second floor in recognition of a corporate grant from the Company; and the 325 seat Esther M. and Harold E. Edgerton Lecture Hall on the first floor.

The EG&G Education Center provides a much needed focus for the extensive teaching program of the Department of Electrical Engineering and Computer Science and a crucially important integration of its space.

Chairman Saxon presided at the dedication and the speakers included President Paul E. Gray, Dean Gerald L. Wilson, Professor Joel Moses representing the Department, the six principals, and Bernard J. O'Keefe, Chairman and Chief Executive Officer of EG&G, Inc. Thanks are due Professor Alvin W. Drake for his guiding hand on the dedication arrangements and for his friendship and infinite patience with details. The celebrations during the year included the Ida Green Fellows Tenth Anniversary Luncheon on October 5, 1983, honoring our Life Member Emerita, Ida M. Green, on the occasion of the completion of the first decade of the prestigious Ida Green Fellows Program for first year graduate student women. The Greens and President and Mrs. Gray joined in serving as hosts at the President's House.

Other honors to Corporation Members included the dedication of the Jerome B. Wiesner Student Art Gallery in the Stratton Student Center at a gala black tie evening of dancing on April 7; and the dedication of a plaque honoring Luis A. Ferre, also in the Stratton Student Center, in connection with a student-organized weekend of Puerto Rican culture on April 29. President and Mrs. Gray were hosts at the former and Chairman Saxon presided at the latter.

The Corporation honored some 70 faculty members who are members of the National Academy of Engineering at the December 2, 1983 Corporation Luncheon. Our alumnus, Robert M. White, President of the Academy, spoke at the Luncheon. At the March 2, 1984 Corporation Luncheon, the Corporation honored 42 new recipients of its Corporate Leadership Award, bringing to a grand total of over 260 the number of Institute alumni who have been so honored since the establishment of the Award in 1976. To be eligible, an alumnus must be Chairman, Vice Chairman, or President of a major firm. Professor Robert W. Mann spoke at the Luncheon.

Finally, the Treasurer's Office took the lead in arranging for the dedication on March 15, 1983 of the Nabisco Laboratory and the 84 foot long TARA Tandem Mirror Experiment at the Plasma Fusion Center on Albany Street. President Gray presided at the ceremony which heralded a new era in the research capabilities of the Center. Speakers included Professor Ronald C. Davidson, Director of the Center; Robert M. Schaeberle, Chairman and Chief Executive Officer of Nabisco Brands, Inc.; Alvin W. Trivelpiece, Director of the Office of Energy Research, Department of Energy; and Richard C. Post, Senior Research Scientist and head of the Plasma Fusion Center's Mirror Confinement Experiment.

I wish to recognize the selfless dedication of Mary L. Morrissey, Director of the Information Center, in the planning and execution of major facilities dedications. She is a joy and an indefatigable ally.

CORPORATION DEVELOPMENT COMMITTEE

The report of the staff organization to support the resource development activities of the Institute is included elsewhere. At the same time, no account of trusteeship can be complete without recognizing the participation of Members of the Corporation in the Council on Resources of the Institute, Corporation Development Committee, and Alumni Fund Board. In addition, many Members of the Corporation have headed or are serving as members of National Sponsoring Committees for professorship and scholarship projects or departmental facilities.

Breene M. Kerr continued his role as Chairman of the MIT Sustaining Fellows. Several Corporation Members served as hosts at regional luncheons for the Sustaining Fellows. One-third of the 35 members of the National Business Committee seeking major grants from U.S. and foreign corporations were Members of the MIT Corporation. The National Business Committee is chaired by Robert L. Mitchell, newly elected Corporation Member. E. R. Kane played a key role in soliciting funds for the renovation of undergraduate teaching laboratories in the Department of Chemistry. Jerry McAfee led the funding effort on behalf of the Chemical Engineering Practice School. Jerome B. Wiesner continued as Chairman of the Council of the Arts at MIT; Gregory Smith continued as Chairman of the Arts Council's Development Committee; and the Arts and Media Technology Facilities Sponsoring Committee includes a number of Corporation Members. In Japan,

Yaichi Ayukawa continued to serve as a central figure in organizing support by the Japanese government and Japanese companies. Denman K. McNear, President and Chief Executive Officer of Southern Pacific Transportation Company, and long time Corporation Development Committee member, was named the recipient of the 1983 Marshall B. Dalton Award of the Corporation Development Committee at its annual meeting "in recognition of conspicuous and sustained service in the enhancing of MIT's financial independence." Altogether, these leadership responsibilities and actions by the Corporation represent a renewed sense of institutional purpose. They constitute a clear demonstration by the Institute's governing body of its commitment to secure the necessary resources for MIT's continued independence and strength in the years following the successful completion of the MIT Leadership Campaign. The Institute will always be grateful to the above-named and to the Corporation as a whole.

This year's achievements included an encouraging total of cash gifts, grants, and bequests receipts from the private sector. It was the Institute's second best gift year on record, and the second consecutive year in which the grant total exceeded \$50 million. Not included in these totals are several million dollars worth of equipment gifts, including computers donated as part of Project Athena, and other vital equipment donations.

MEETINGS

As a matter of record, the Corporation held four meetings during the year. At a time of continued financial stringency, Chairman Saxon, President Gray, and Provost Low called upon all segments of the Institute community to continue the budget limitations needed to pull together in planning for a future balanced budget. In addition, through its various committees, the Corporation played a key role in communication with students, faculty, alumni, and the general public on the range of questions and issues before MIT.

Special thanks are due to the Ad Hoc Committee on Shareholder Responsibility, under the chairmanship of D. Reid Weedon, Jr., for its continuing assistance to the Executive Committee of the Corporation. Walter L. Milne, Assistant to the President and the Chairman of the Corporation, served again as Secretary to the Committee on Shareholder Responsibility.

Additional thanks are due the Corporation Screening Committee, under the chairmanship of David R. Wilson and the staff of the Alumni Association for the effort required to conduct the special alumni election needed to fill a vacancy in the category of younger Member of the Corporation.

In notable actions, the Corporation voted at its Annual Meeting on October 7, 1983 to endorse and support President Paul E. Gray and the administration of MIT in their opposition to the proposed restriction on the freedom to conduct research and inquiry embodied in the proposed Nuclear Free Cambridge Act in the City of Cambridge. At its March 2, 1984 Meeting, the Corporation approved the establishment of a new S.M. Degree in Real Estate Development in the School of Architecture and Planning. At the same Meeting, the Corporation approved the change in the designation of the undergraduate degree in the Alfred P. Sloan School of Management from Bachelor of Science in Management to Bachelor of Science in Management Science. At its June 4, 1984 Meeting, the Corporation voted to change the designation of the Bachelor's Degree in the merged Department of Earth, Atmospheric and Planetary Sciences from S.B. in Earth and Planetary Sciences to S.B. in Earth, Atmospheric and Planetary Sciences to conform the Degree to the new Department name. The merger permits students to engage in the study of atmospheric sciences for their Bachelor's Degree for the first time since the founding of the Department of Meteorology in 1946 as a graduate degree program exclusively.

At the June 4 Commencement Exercises, under sunny skies in Killian Court, Chairman Saxon welcomed Dr. Shirley A. Chisholm, former U.S. Congresswoman and now Purrington Professor, Department of Sociology and Anthropology, Mount Holyoke College, the third outside invited speaker to address the graduating class in 20 years.

At its Breakfast Meeting prior to Commencement, the Corporation adopted a set of Resolutions on the Eightieth Birthday of our Life Member Emeritus, former President, Chairman and Honorary Chairman, James R. Killian, Jr. In these Resolutions, the Corporation noted that Dr. Killian's continuous service to MIT extends over more than half of the Institute's total history in the more than 60 years he has been at MIT.

CORPORATION VISITING COMMITTEES

The 1983-84 year was a year of new activity for the Corporation Visiting Committees. Eight meetings were held in the first semester and seven meetings were scheduled in the second semester. One of the seven, Whitaker College, was cancelled due to a snowstorm but rescheduled in spring. Compared with 14 of the 28 Committees which met during 1982-83, the following total of 15 Committees held meetings in 1983-84:

Aeronautics and Astronautics
Architecture and Planning
Athletics
Biology
Chemistry
Civil Engineering
Earth Sciences
Economics

Humanities
Linguistics and Philosophy
Alfred P. Sloan School of Management
Medical
Mechanical Engineering
Political Science
Whitaker College of Health Sciences, Technology,
and Management

Three of the above Committees met for two days and four met for one and one-half days, for a cumulative total of 20 meeting days.

Under Chairman Saxon's leadership, the Corporation undertook an in-depth study of Visiting Committee procedures. A number of interesting changes have been made as a direct result of Mr. Saxon's determination to improve the effectiveness of these vital Corporation Committees:

1. Membership in the average Visiting Committee has grown steadily through past efforts to diversify the composition of membership. Many of the Committees are now in excess of 20 members each. A multiple-year effort to reduce the size of each Committee to 15 or 16 members is underway.
2. Frequency of meetings, after a series of well intentioned efforts to slow down the frequency during the MIT Leadership Campaign and then to speed it up again, has returned to the 18 to 24 month interval. This frequency is unequivocally the optimum time interval which nicely balances the need to hold meetings to carry out the Corporation's mandate and the need to allow enough time for organizational changes, plans, and progress to mature in academic departments. The cumulative translation to overall activity is approximately 15 Visiting Committee meetings per year in the steady state.
3. Length of meetings has been increased from a modular evening dinner followed by a full meeting day to at least a day and longer session in the interest of covering the agenda more thoughtfully and of allowing more time for individual discussions with component parts of departments being visited. This elongation has been universally welcomed despite the added meeting time and administrative effort involved. There have always been several Committees which have required two full days to accomplish their goals. The others are now gravitating toward day-and-a-half meetings, and we are watching carefully for strains on attendance due to the longer meetings.
4. Length of terms has been kept at three years to encourage rotation, but the additional rule has been instituted that no Visiting Committee member shall be terminated unless the individual has at least two opportunities to attend scheduled meetings.
5. Oral and written reports have been decoupled for the first time in 15 years in the interest of making these reports more dynamic and relevant. We have discarded the requirement introduced in the late 1960's that a Visiting Committee chairman must first submit a written report to the Executive Committee before being permitted to make his or her oral report to the Corporation. Under the revised reporting scheme, we have returned to the earlier and original standard, viz., an oral report is due at the next Corporation Meeting after the Visiting Committee meeting is held, and a written report is due as soon as it is practical and possible to prepare but not later than the semester following the semester in which the Visiting Committee meeting was held. To assist the Visiting Committee chairmen in preparing their reports, the Committees are now asked to meet privately in executive session, then meet with the senior officers at the end of the day to report their findings, and a prompt, confidential interim record of what they reported is furnished to them and to the senior officers by the Office of the Secretary. Despite the added administrative burden of preparing this interim record, the new reporting arrangement has been well received by the Corporation. We have had only a partial year of experience with it, but the results so far appear to justify the added effort in terms of more timely reporting.

President Gray has observed that the obvious fact that the Corporation has been engaged and involved in these efforts to improve the effectiveness of Visiting Committees has reaffirmed the importance of the

Committees and has had a noticeable effect on the quality of their performance. While it seems fair to say that nothing is cast in concrete at a dynamic institution like MIT, this writer has been astonished at the painless transition to new operating assumptions reached under Mr. Saxon's leadership. As part of this transition, Mr. Saxon has instituted a systematic, biannual evaluation of Visiting Committee performance with the President, Provost, and Secretary. This effort is continuing.

I want to recognize the exceptional performance of Mary S. Miller, Administrative Secretary in the Corporation Visiting Committee Office, in improving the planning and staffing of these meetings during the past three years. From her roots on an Iowa farm and from her innate, wide angle vision, Ms. Miller has brought renewed strength and quality to the management of Visiting Committee activity. She has cheerfully shouldered the extra workload involved in longer meetings and more timely reporting. It is a privilege to work with her.

Several features of the meetings which have proved successful in the past were continued by the Visiting Committees this year. All of the 15 meetings included dinner at which the Committee members were brought together informally with members of the faculty and administration. I wish to thank Jerilyn K. Edmondson, formerly of this office, for her volunteer assistance at several of these dinners. Also, the Committees made effective use of private sessions with students on their agenda, further formalizing this additional and valuable means of gaining insight into departmental activities. A number of the Committees for larger Departments included similar separate sessions with younger, untenured faculty. Discussions with each of the Departments had many common interests, including systematic follow-up of previous Committee recommendations and reviews of departmental progress in recruitment of minorities and women as students and faculty members.

During 1983-84, we continued an earlier, two-year effort initiated by President in 1981 to increase the number of highly qualified women and minorities serving on the Corporation Visiting Committees. Women now represent 20 percent and American minorities now represent 12 percent of the total number of 575 positions in the Visiting Committees. These percentages far exceed the national participation of women and minorities in advanced fields of science and engineering, and they exceed the participation of women and minorities in the MIT faculty. They approximately equal the current percentage of women and minorities earning MIT degrees. I wish to acknowledge the continuing assistance given this worthwhile project by several Members of the Corporation, the deans and department heads, the Nominating Committee for Visiting Committees of the Alumni Association, under the chairmanship of our Corporation Member, Joseph G. Gavin, Jr., a number of internal groups at MIT, and most importantly, President Gray.

The participation in this year's series of meetings by the senior officers and deans of the Institute continued at a high level. The presence of these officers at the various meetings enhances the interchange between the Committee and the Department and often provides a welcome catalytic effect which contributes to the success of the meeting. Enduring thanks are due Provost Francis E. Low for his diligent participation in all of the meetings, and to the more than 300 faculty members who participated in the sessions of the Visiting Committees.

Of the Committees meeting in the 1982-83 year, all of the Chairmen have now reported orally to the Corporation. These reports to the Corporation are important to the successful operation of the Committees, and they provide a broadened forum in which to consider the plans and progress of each Department. They are invaluable to the functioning of trusteeship at MIT. The Academic Council systematically receives copies of the written reports when they are approved for distribution by the Executive Committee, and the Council also hears oral reports from the Provost and the responsible Dean or Vice President as Visiting Committee meetings occur.

An interesting development is continuing in the growth of "advisory boards" and committees affiliated with some of the major research laboratories and centers of the Institute. These advisory boards are not formally a part of the Corporation Visiting Committee system. They have been organized by the offices of the Vice President for Research and the Dean of the School of Engineering to serve the need of specific centers for an advisory body reporting to the Dean or the Vice President and providing advice to the research program director. At the same time, a number of Corporation Members chair or serve on these advisory boards and have found them worthwhile and useful for the purposes intended. External advisory boards or committees have now been established for some 10 centers or laboratories. It is hoped that an annual compilation of these boards can be made in the future to give greater recognition to the nearly 200 people serving as members and to encourage the increased appointment of women and minorities to these boards.

The Office of the Secretary of the Institute has encouraged the directors of laboratories who have sought advice in establishing the various advisory boards. There is still some residual confusion between the functions of the advisory boards and the Corporation Visiting Committees, but I believe some progress has been made in distinguishing between the two. This aspect continues to be studied. The Membership Committee of the Corporation has tried to take account of Corporation Member participation in these advisory boards in planning Visiting Committee assignments in recent years.

Acknowledgements

I wish to thank Dorothy G. Adler of the MIT Alumni Association for her strong support of the nomination of alumni to the Visiting Committee and for the assistance to the Corporation Screening Committee for younger alumni. In March 1984 Elizabeth A. Gerber transferred from her position in the Industrial Liaison Program to become Administrative Secretary in the Office of the Secretary to succeed Iris E. Lazarus. Ms. Gerber has proved to be a quick and ready learner. I am permanently indebted to Iris E. Lazarus for her heroic performance in handling the quarterly meetings of the Corporation and related affairs during a period of three and more years until her departure on April 1, 1984. She stands alone among others with whom I have worked in her ability to innovate and absorb sustained workload cheerfully and efficiently. She has made a permanent difference in this Office, and she will be missed.

Priscilla K. Gray once again heads the list of MIT volunteers for the quality and character of her manifold contributions. Students, faculty, staff, alumni, and friends all stand in her debt for the warmhearted manner in which she has welcomed and encouraged every program and person at the Institute and afar. She exemplifies an army of talented spouses of MIT staff and employees who contribute every day to the Institute's mission. One of the unique constituencies she symbolizes is the group of spouses of our Presidents and Chairmen, now happily augmented by Shirley G. Saxon, and including Elizabeth P. Killian, Catherine N. Stratton, Elizabeth W. Johnson, and Laya Wiesner. What university in America has been comparably blessed and bolstered by such a complement of modern day spouses who carry on in the great tradition of our founding first lady, Emma Rogers?

This year has been punctuated with so many truly outstanding events and accomplishments that it is difficult to single out any one of them. For the writer, the arrival of David S. Saxon has had particular meaning. Elizabeth J. Whittaker, able, wise and always devoted Assistant Secretary of the Corporation, has been a tower of strength in providing continuity between the Chairman's Office and other, closely associated offices. The spirit of renewal which has accompanied David Saxon's chairmanship of the Corporation has brought home time and time again M.I.T.'s remarkable ability to move gracefully from one period to the next under new leaders, seemingly without missing a beat in its corporate and academic life.

VINCENT A. FULMER

Alumni Association

We have concluded another record-breaking year. In alumni programs special note must be made of the meteoric growth of the MIT Enterprise ForumSM. In the Alumni Fund \$9.4 million was raised from over 27,600 donors with significant upgrading in gift levels by many alumni. A new Alumni Register was begun with a consequent significant improvement in the quality of information about our fellow alumni. Great success has been achieved in programs by The Black Alumni of MIT (BAMIT) and the Association of MIT Alumnae (AMITA). Technology Review gained national stature by again winning the "Magazine of the Year" award from the Council for the Advancement and Support of Education. An offer to purchase the magazine was considered and, ultimately, was not accepted.

Each of these significant achievements rests on people. The Alumni Association has benefitted from enlightened, energetic, committed and thoughtful volunteer alumni leadership coupled with an equally vigorous, hard-working and remarkable staff. This mixture of first-rate people, dedicated to the support of MIT, their fellow alumni and, each other will continue to enrich, enliven and stimulate MIT.

Special note must be made of the following four volunteers. First, Robert W. Mann '50, Whitaker Professor of Biomedical Engineering and the 89th President of the Alumni Association. Bob, the first faculty member to serve in fifty years as President, set new standards of performance, leadership and energy. He, his wife Margaret '56, and their son and daughter (also MIT alumni) truly became the Association's first family. While many other volunteers served in outstanding ways the exceptional service by James K. Littwitz '42, as Chairman of the Alumni Fund Board, Claude Brenner '47, as Chairman of the Technology Review Advisory Committee, Joe F. Moore '52, as Chairman of the National Selection Committee, must be noted.

Finally, a special note of thanks to the members of the Alumni Association Board of Directors who served with diligence and distinction in this most active year.

Alumni Relations

The annual National Alumni Conference was held this year on the MIT campus on September 22 and 23, 1983. The goal of this conference was to help alumni in their roles as fundraisers, educational counselors and leaders of classes and clubs. Three hundred fifty alumni and guests attended the conference. Workshops were held on the admissions selection process, interviewing, class programs, course programs, the MIT Enterprise Forum, and the Alumni Fund. A reception and banquet were held at the MIT Athletic Center at which President Paul E. Gray, Class of 1954, was the keynote speaker on the topic, "Project Athena" and was joined in the question and answer period by Dean Gerald L. Wilson, Class of 1961, Dean of the School of Engineering. Saturday morning breakfast workshops focused on the Alumni Fund and on the different Alumni Association regions. The Alumni Association business meeting was followed by an awards luncheon and then an afternoon symposium which focused on the Undergraduate Research Opportunities Program. That symposium was chaired by Professor Margaret L. A. MacVicar, Class of 1965, and featured presentations by three UROP students on their research. Next year in 1984, we will continue the tradition of alternate year off-campus NAC's by going to Toronto on September 21 and 22 and Dallas on October 12 and 13.

The Alumni Council series this year was an outstanding success with large audiences (average attendance was 120). Featured speakers included Professor Royce N. Flippin, Jr., Professor Woodie C. Flowers, Class of 1973, Professor Jack L. Kerrebrock, Professor Margaret L. A. MacVicar, Class of 1965, Professor John M. Deutch, Class of 1961, and Dr. David S. Saxon, Class of 1941.

Student/alumni programs continue to be an area of strong commitment for the Association. The Alumni Host Family Program matched up 72 incoming freshmen with alumni residing in the Boston area, for social as well as career mentorship purposes. The Senior Dinner Program was held again this year, with Dr. and Mrs. Gray (Honorary Alumna) hosting ten dinners at the President's house during the month of February 1984. Each dinner featured a brief presentation about the Association's organization and activities, alumni described their professional careers and history of service on behalf of MIT, and students described their plans for the future. Five hundred fifty students attended these dinners—41% of the senior class. The Alumni Association assisted student groups looking for speakers and continues to encourage this kind of activity. International alumni continue to perform a very important role, offering support and advice to newly admitted students. Many MIT clubs invite admitted freshmen and their parents to club events held in the spring, and continue to invite all students from their respective areas to holiday and summer events. A number of MIT clubs continue to sponsor summer job programs for students from their respective areas.

The Black Alumni of MIT (BAMIT) sponsored the eleventh annual "MIT Black Students' Conference on Science and Technology" on October 21 and 22, 1983, and attendance was 225. BAMIT also sponsored their annual welcoming reception for incoming minority students on October 8, 1983, and their exit reception for graduating minority students on June 3, 1984.

The Association of MIT Alumnae (AMITA), in conjunction with the Boston section of the Society of Women Engineers, sponsored their fourth annual conference, "Anatomy of a Career: An Inside View of Technical Professions for Women," on March 30 and 31, 1984 at MIT. Attendance was approximately 290. AMITA also sponsored for the eighth successive Independent Activities Period the workshop, "Getting the Job You Want in Industry: A Woman's Guide to the Pinstriped World," a recurring event which draws from 30 to 50 participants each year. AMITA also continued its high school visiting program, where approximately 100 alumnae volunteers visited 68 high schools to talk to groups of women students about how important it is to continue to study mathematics and science so they can preserve a wide variety of career options. More than 3,000 high school students were reached with this very important message.

The MIT Enterprise Forum has expanded both locally and nationally this year and its list of subscribers has increased to approximately 2,000 people. The Boston area forum's annual workshop, this year held on October 29, 1983 and entitled "Buying and Selling Technology-Based Companies," drew an audience of 470 people. Their IAP Seminar on "Management of the High Technology Company: The Engineer as Entrepreneur," drew 75 attendees at each of four sessions. The newly established program for "start-up" ventures was held five times with audiences made up of bankers, venture capitalists, and other professional counselors. Other active Enterprise Forums exist in Chicago, Fairfield, CT, Houston, Los Angeles, South Florida, New York City, Seattle, and Washington DC/Baltimore. The group in Washington held a highly successful workshop on March 24, 1984 entitled "Entrepreneurial Marketing: Getting and Holding a Competitive Edge" with an attendance of 300.

The Boston Seminar Series this past year consisted of six meetings on the topic "World Diversity: How Do We Co-Exist?" with an audience of approximately 95 at each meeting. The Washington DC area also held a seminar series this year, consisting of six meetings on the topic "How Risky is Safe Enough?" with an attendance of approximately 125 at this series' second year.

The Cardinal and Gray Society, established formally in 1980 for alumni residing in the mid-New England region who have celebrated at least their 50th class reunion, held two very well attended meetings this year at Endicott House. The first meeting featured Professor Ernest G. Cravalho who spoke on October 16, 1983 about the Whittaker School and Dean Gerald L. Wilson, Class of 1961, who spoke on May 27, 1984 about "Engineering Challenges Facing Us In the Eighties and Nineties."

Technology Day on June 8, 1984 focused on the topic "Introduction to Success." Four alumni examined the process of advancement from their real life situations of success. Attendance at the symposium was approximately 850 with a turnout of 2,000 alumni and guests at the pre-Technology Day festivity, "Tech Night at the Pops," held on June 7, 1984 at Symphony Hall. Thirteen reunions, held between the dates of June 6 through 10, 1984, brought back to campus a total of 1,150 alumni and their guests.

In the regional area, the five regional Directors, the President of the Alumni Association, as well as senior Association and Institute staff, travelled extensively on behalf of the Institute drawing large and enthusiastic audiences at each engagement. Some Regional events are especially worthy of note. Among them: the reception for Dr. and Mrs. David S. Saxon, Class of 1941, held in New York on April 24, 1984 with 475 people attending; the dinner meeting for Dr. and Mrs. Paul E. Gray, Class of 1954, at West Palm Beach, Florida on March 8, 1984 with 110 people attending; the joint meeting of the Boston Seminar Series and Graduate Management Association featuring the Vice Chairman of Citicorp, John S. Reed, Class of 1961, on September 20, 1983 with 100 people attending; and a gala cocktail party and reception with MIT alumni members of Congress. Drs. Saxon, Gray and Mann were all in attendance at that meeting. The Mexican Fiesta took place in Mexico City, Morelia, and Guadalajara on March 17-24, 1984 and 90 people attended, with Provost Francis E. Low the guest of honor. Equally noteworthy were two events held on the West Coast. On June 8, 1984, the Sloan Fellows held a Convocation in Los Angeles, CA inviting MIT alumni of all departments for the first time. Eighty-five alumni and guests attended. On February 19, 1984, the Club of Northern California held a special Vatican Art Exhibit Tour jointly with the Wellesley Club. It attracted 329 attendees. The Medical Science Lecture Series, an increasingly popular program that appeals to a specialized group based in New York, had Dr. Robert Mann as the start-off lecturer this past season. The MIT alumni clubs continue to demonstrate their diverse and versatile interests by organizing throughout the country various ski trips, Embassy visits, symposia, concerts featuring Pops or the MIT Chorallaries, performances by the MIT Shakespeare Ensemble, museum, vineyard and industrial tours and a host of imaginative and innovative programs. We are grateful to all the members of MIT's staff and faculty who gave of their time to attend and lecture at so many important events. We especially wish to express our gratitude to Alumni Association President Robert W. Mann, Class of 1950, and his wife, Margaret, Class of 1946, for their presence at so many events across the country.

The Committee on Alumni Nominations for Corporation Visiting Committees recommended to the Corporation that 27 members whose terms had expired be ended, that 32 terms be extended, and that 30 new alumni members be appointed to visiting committees.

The Board of Directors appointed 18 new alumni members and seven chairmen to serve on the seven national boards and committees of the Association. The Board also approved the following recommendations of the Awards Committee:

Bronze Beaver Awards: E. Milton Bevington, Class of 1949; Thomas F. Creamer, Class of 1940; Elisabeth M. Drake, Class of 1958; Alice H. Kimball, Class of 1936; Peter M. Saint Germain, Class of 1948; and Florence and Walter J. Smith, Class of 1928.

The Harold E. Lobdell, Class of 1917, Distinguished Service Awards: Edwin F. Brush, Jr., Class of 1963; Samuel E. Denard, Class of 1974; Paul H. Fricke, Class of 1961; Robert P. Fried, Class of 1946; Vincent A. Fulmer, Class of 1953; J. Lee Gagan, Class of 1961; David R. Wadleigh, Class of 1938; Harris Weinstein, Class of 1956; and Sandra G. Yulke, Class of 1974.

The George B. Morgan, Class of 1920, Awards: Charles M. Griffiths, Class of 1937; Matthew N. Hayes, Class of 1936; Rockwell Hereford, Class of 1924; Thomas C. Thompson, Class of 1957 (deceased); and Louis Young, Class of 1950.

Presidential Citations: MIT Chemists Club; MIT Club of Hartford Spring Telethon; MIT Club of Northern California; and San Diego Personal Solicitation (Telephone).

Honorary Membership in the Alumni Association: Dorothy L. Bowe, Loretta H. Mannix, and Elizabeth A. Pigott.

The following alumni were elected by national ballot to serve three year terms on the National Selection Committee: Virginia Grammer, Class of 1947, District #1; Kenneth F. Gordon, Class of 1960, District #5; Paul H. Fricke, Class of 1961, District #6; and Donald E. Robison, Class of 1946, District #7.

The Association supports the Corporation Screening Committee ballot process through which degree recipients 1982/1983/1984 elected Arlene F. Roane, Class of 1983, to serve a five year term on the Corporation.

The National Selection Committee made the following selections for terms starting July 1, 1984:

Terms on the Corporation: Donald J. Atwood, Class of 1948; Robert L. Mitchell, Class of 1947; and Raymond S. Stata, Class of 1957 (all five year terms).

President of the Alumni Association: Mary Frances Wagley, Class of 1947 (one year term).

Vice Presidents of the Association: E. Rudge Allen, Jr., Class of 1948 and Kenneth F. Gordon, Class of 1960 (two year terms).

Directors of the Association: Russell N. Cox, Class of 1949, District #1; Christina H. Jansen, Class of 1963, District #2; Maria Luise Bentel, Class of 1951, District #4; and Ernest U. Buckman, Class of 1946, District #5 (two year terms).

There were no changes in the Alumni Relations staff this year, but over the summer of 1984, the newly created position of National Director of the MIT Enterprise Forum will be filled by Paul E. Johnson, currently Regional Director for the Gulf/Atlantic region. He will be succeeded in the Gulf/Atlantic region by Louis E. Alexander, who will be promoted from the position of Administrative Assistant in our New York office. A major new initiative for our future is the MIT Enterprise Forum and these personnel changes are a reflection of that importance.

Alumni Fund

The Alumni Fund, chaired by James K. Littwitz, Class of 1942, reported record levels of support of the Institute by its alumni. With a total of 9.4 million contributed by 27,637 alumni, the Fund marked its sixth consecutive year of dollar and donor increases. Further, it was the fifth year in the last six that the total dollars represented a new million dollar giving plateau.

The breadth and depth of alumni support is evident from both the alumni participation rate and substantial gift upgrading. Undergraduate alumni achieved a record rate of 51 percent participation in the Fund, while graduate alumni participation was 33 percent, equalling last year's impressive figure. In terms of upgraded levels of giving, 8,055 alumni, representing 29 percent of the contributors, made a contribution of \$100 or more to the Fund. Further, there were 3,000 alumni, whose gift was \$250 or greater, an impressive 11 percent of the total participation in the Fund. Measured against a base year of 1979, the number of alumni giving at the \$100 or more level has nearly doubled, while those contributing a minimum of \$250 has increased by 130 percent.

Fund solicitation programs, including Direct Mail, Major Reunion Gift, Matching Gift, Personal Solicitation (P.S.), Senior Gift, Telethon, and Young Alumni were conducted in the established format. A newly initiated Course Program, aimed at graduate alumni, and organized around the Institute's academic departments was launched successfully. Activities included departmentally based fund-raising efforts, telethons, and a variety of alumni relations programs.

Alumni also conducted solicitation programs throughout the United States. In both fall and spring, telethons were conducted in 14 cities. Additionally, volunteers participated as solicitors in the Personal Solicitation Program, held in eight major metropolitan areas. These alumni made personal appeals to some 400 individuals, seeking upgraded gifts for the Alumni Fund. Of the 300 alumni who pledged, 66 percent increased their level of support for MIT, meeting the objectives of this key solicitation program.

Telethons continue to be the primary means of contacting large numbers of alumni for increased levels of support from regular contributors, and adding new participants to the Fund. Overall, 950 volunteers, both student and alumni, contacted more than 16,000 individuals in the 1984 Fund. A total of 11,000 pledges in the amount of \$650,000 was raised in this effort, a 12 percent dollar increase over 1983. Further, the dollars raised per caller was \$683, a dramatic 46 percent increase over the prior year.

Strong support of the Fund by young alumni is continuing. A total of 610 alumni from the five most recently graduated classes made a first time gift to the Fund. The overall percentage of participation by recent graduates is impressive. A good example is provided by the achievement of the Class of 1979, which celebrated its 5th Reunion. Since graduation, some 700 members, 70 percent of the class, have made at least one contribution to the Fund.

Major reunion gifts of more than \$8.2 million were announced on Technology Day 1984. Included in the totals were gifts received in the prior five years and pledges projected through 1989. The 50th Reunion Class of 1934 announced a total gift of \$2,300,000, with 77.5 percent class participation, a record level for a 50 year class. In addition, plans for future gifts from members of the class total \$1.2 million. The Class of 1944, celebrating its 40th Reunion, announced a class gift of \$1,030,500. This gift included \$430,000 to endow a Class of 1944 Scholarship Fund; 64 percent of the Class participated in the 40th Reunion Gift.

The Class of 1959 presented a 25th Reunion Gift of \$790,000, which included \$291,000 to endow a scholarship fund as part of the gift; 67 percent of the class participated in the reunion gift effort, a record level for a 25th Reunion class.

Reunion gift presentations also included a 60th Reunion Gift from the Class of 1924 in the amount of \$4.1 million; the Class of 1979 presented a 5th Reunion Gift part of which was \$31,300 toward the endowment of a Student Aid Fund, including matching contributions from the Class of 1929; and, in an unprecedented gesture for 10th reunion classes, a gift of \$35,500 from the Class of 1974, including an endowed Student Aid Fund.

Of special note in Fund Year 1984 was the alumni response to President Gray's request for increased levels of support for student financial aid. As stated above, four of this year's reunion classes established endowed scholarship funds as class projects. When fully funded, these projects - combined with the Class of 1946 effort - will add nearly \$1 million in new endowment for student aid.

Finally, the staff of the Alumni Fund increased by one with the promotion of Lauren T. Norton to Assistant to the Director. The achievements of the Fund this year were substantial and are due to the efforts of thousands of alumni volunteers, backed by outstanding staff support.

TECHNOLOGY REVIEW

Technology Review's year was punctuated by a number of unusual events, and 1983-84 turned out to be a landmark year.

During the first half of the year, while the search for a successor to Steven C. Marcus as Managing Editor continued, two Senior Editors served successively as Acting Managing Editors—Thomas Burroughs and Jonathan Schlefer. Both made important contributions to the magazine under circumstances that were far from ideal.

The search for a new Managing Editor concluded late in the fall with the appointment of Peter Gwynne, whose qualifications as a science writer, journalism teacher, and magazine manager are very high. Peter first came to the U.S. (from England) in 1966 to work at Technology Review. Two years later he joined the Boston Herald as Science Editor and then for more than 12 years was science writer and later (1972-81) Science Editor of Newsweek. Peter's return is an expression of confidence in the Review and interest in the Institute that gave us a great lift.

Meanwhile, even before our search for a Managing Editor was resolved, Marjorie Lyon, who as Senior Editor has been in charge of the MIT news in the Review for nearly a decade, resigned to accept an editorial assignment in the computer field. Ms. Lyon's departure was taken as the opportunity to restudy the handling of MIT news in the Review, and only in March, 1984, were we ready to select a successor. We're fortunate in the choice—Susan Lewis, formerly a member of the Department of Public Relations and Information at the University of New Brunswick, Fredericton, Canada.

Nancy Cahners, Design Director, began a maternity leave in December and remains on a part-time status, adding significantly to the responsibilities of Kathleen B. Sayre, Design/Production Manager. To help, Elizabeth Motzkin, Assistant to the Editors, is spending part of her time as production assistant.

While all this was going on, the business department of the magazine had its share of changes, too. Evelyn Milardo, Circulation/Marketing Director, resigned in the fall, and she has been succeeded—also with great success—by Julie Zuckman, formerly of the MIT Press. Finally, Deborah I. Gallagher joined us as Circulation/Marketing Assistant and has expanded the scope of that assignment with imagination and enthusiasm.

These changes were put in place against a background of two other developments—the effort to improve the Review's marketplace performance spearheaded by consultant Robert Cohen, and negotiations for participation in the Review by the publishers of the American edition of The Economist.

Mr. Cohen's work focused chiefly in the circulation promotion and marketing area, where he was instrumental in developing new sales materials and techniques that improved our circulation promotion efforts and increased our rates of both response and acceptance. He urged the editors to sharpen the magazine's focus on the implications of new technologies—the policy issues that represent an editorial "niche" in which the Review is unique among magazines. Thanks in large part to his efforts, the Review is finishing 1983-84 with a very acceptable marketplace performance.

Suggestions of a possible joint venture involving the Review, the National Academy of Engineering, and The Economist were first made in mid-1983, and they reached the stage of discussion by the Advisory Board to Technology Review late in November and the Board of Directors of the Alumni Association in December. Both groups at those meetings found the proposal unlikely of acceptance but intriguing, thus agreed that the Publisher should continue negotiations to develop additional details and alternatives that would better serve MIT's and the Alumni Association's interests.

The result by early in 1984 was a formal proposal from The Economist for acquisition of Technology Review from the Alumni Association. The new magazine would be provided to the Association for use as its "alumni" magazine and would similarly be offered to other educational institutions. The Association would retain an advisory role to The Economist in the editing of the new magazine, but the latter would have full editorial responsibility and control.

Brought first to the Advisory Board to Technology Review and then to a special meeting of the Board of Directors of the Alumni Association, this proposal was decisively rejected. The Board resolved to maintain the Association's role as sponsor of Technology Review and the magazine's unique dual role as an "alumni" magazine and a public ("paid circulation") magazine. The arguments for The Economist proposal centered on the reduction to the Institute of exposure to marketplace risk; both groups judged this benefit to be of less value to MIT than the loss to MIT of its role as sponsor and venue of a widely respected magazine on the policy issues surrounding technological change.

The fact that the decisions by both bodies were essentially unanimous masks the intensive consideration given to The Economist's proposal by the staff—especially the Publisher—and by the two boards involved. As Chairman of the Advisory Board to the Review, Claude W. Brenner '47, made a unique and indispensable contribution, and we deeply regret his decision to retire from this board as of July 1, 1984.

Technology Review's issues of 1983-84 were good ones; the magazine continues to mature as a quality editorial product targeted to an important audience. Outstanding among our editorial features during the year were a number of articles on the implications of the nation's growing emphasis on "high-technology," waste-disposal problems, national technology policy and technology transfer, climate change, and offshore engineering. We published a landmark article by Professor Lawrence Lidsky on "The Trouble with Fusion," an important series on nuclear reactors for the future, and a timely debate on space defense.

During the year Technology Review was honored for its design and illustration by acceptances in a number of graphic exhibitions, and at the end of the year we were designated the "Magazine of the Year," winner of the Robert Sibley Award, by the Council for the Advancement and Support of Education. But, perhaps, the most important accomplishment of the year was the confirmation, through the lengthy deliberations occasioned by The Economist's offer, of the Review's role with respect to the Alumni Association and MIT. The environment of an educational institution will not likely ever provide the spectacular capital support that is required to build large circulation; but it is a uniquely valuable environment in which to edit a thoughtful magazine that can contribute to an essential national and international dialogue on the impact of science and technology in the service of and disservice to the U.S. and world communities.

RECORDS/ADMINISTRATION

The administrative functions of the Association continued with no major changes in staff or operating procedures.

Work on the 1984 Alumni Register began in September 1983. This required conversion of the database fields to upper/lower case. Questionnaires were mailed in October to 68,500 alumni with addresses; the response was 46%. A second mailing was sent out in January 1984 to the 37,200 who had not responded to the first mailing. Total response to both mailings was 65%.

The processing of questionnaire data required more time than anticipated due to the size of our database and the high response rate.

Over 12,000 registers were ordered by alumni and members of the MIT community. Sales are expected to cover all costs of converting the database to upper/lower case for future use with word processing applications, adding new data and updating existing data as well as the cost of producing the 1984 **Alumni Register**.

Progress continued on the gift history project so that the new gift history file was completed and ready to accept records from the FY84 year end for gift records maintenance. Documentation of the task list for completion of the Master File project was completed but no further work was undertaken during FY84. Work on the Activities File was suspended waiting further specifications from users for applications use of the file.

The Sloan School stopped maintaining their system for Sloan graduate alumni in March 1984 and now maintain all Sloan records on the Alumni Association database. Creation of a new company file and transfer of unique Sloan data was accomplished by year end so that Sloan could produce directories of their alumni early in FY85.

In October 1983 John Bidwell left as a result of layoff and the position of Database Manager was left vacant. Carol Roberts resigned in February 1984 and Candace Hopkins was appointed to the position of Database Production Coordinator in April to fill the vacancy.

WILLIAM J. HECHT