Report of the President and the Chancellor
1977–78
Massachusetts Institute of Technology
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Massachusetts Institute of Technology
Corporation

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Over the past seven years, our annual reports to the Corporation have traced the evolution of the Institute as an academic enterprise: an evolution characterized by sustained attention to educational needs and opportunities, by significant growth of research in the face of tight constraints on resources, and by continuous innovation in the institutional forms which serve our academic programs.

This evolution has emphasized the interdependence of education and research at M. I. T. The research interests of our faculty constitute a framework which organizes and sustains essentially all of the intellectual activities that occur here. Research is the basis for the professional life and growth of all teachers, as well as for the Institute's contributions to the expansion of knowledge and to the ways in which that knowledge can be applied to the solution of problems of importance to society. And research has a pervasive influence on education. During their years at M. I. T., all of our graduate students and most of the undergraduates take a direct part in research, which helps them develop intellectual independence and the ability to deal creatively with the unknown. For them, research is a most important element of their educational experience. Beyond such direct involvement, and because of it, the perspective and the attitudes that develop in the course of research have an important influence on the formal educational program as it appears in the lecture hall, the classroom, and the teaching laboratory.

On the other side of the coin, the vitality of the Institute's educational programs and the extraordinary talent of our students enhance our research and strengthen our ability to sustain a faculty and research staff of exceptional quality. It is often said that students come to M. I. T. to study because of the opportunity to associate with senior colleagues of high distinction. It is equally true that faculty and staff come here and stay here because of the satisfaction of association with such able learners.

In this review of our seventh year of stewardship of the Institute, we report on events which affect the posture and vitality of M. I. T. as a major international center of research and education. While most of the events we report reflect internal needs and initiatives, some reflect our role in the larger community and some are conditioned by the economic and governmental climate in which we operate.

The progress and plans described in this report underscore the extraordinary importance to the Institute of the Leadership Campaign, which continues to move toward achievement of its objectives. The success of this major fund-raising drive will ensure both the sustained quality of existing programs and the birth and nurturing of new programs and ventures. Our objective in the Campaign is not just to reach the $225 million goal by April 1980, but to press beyond and to raise annual support in the years to come to a significantly higher level.

At the close of the academic year in June, the Campaign total, measured in terms of gifts received and pledges made, stood at $187 million, an increase of $35 million over the corresponding figure a year earlier. As we write this report, the total stands at $172 million. This change during the year signals important progress in several areas: essential completion of the gift support required for the new health sciences and health services facility; substantial additions to the funds pledged in support of the much-needed athletics and special events facility;
an important start on the funding of a visual arts facility on the East Campus; and near completion of the funding of the Alumni Center-Huntington Hall project in the Maclaurin Building.

The Campaign is also having a major influence on the annual level of gifts to the Institute. During the 1977-78 year this level was $34.3 million, compared with $29.4 million in the prior year and an average of $26.4 million during the previous five-year period (1971-72 through 1975-76). This increase of nearly 30 percent in the level of giving is most encouraging, for a sustained increase in this figure must be regarded as a critical objective for the Institute in future years.

While there have been significant achievements in the Leadership Campaign to date, there are also areas in which we must redouble our efforts if we are to achieve our goals in the next two years. Foremost among these is the objective of increased endowment for professorships, student aid, seed funds for research, and general uses, including the maintenance of a competitive level of salaries for faculty and staff. While we have reached almost 75 percent of the total dollar amount sought in the Campaign, at year end we had received just 38 percent of the goal sought specifically for endowment. In order to ensure the future health of M.I.T., we must make strenuous efforts during the remainder of the Campaign to reach the endowment objectives which we set in 1973 in the course of planning for the Campaign. In the long run there is no more important funding need at the Institute, whose endowment is substantially smaller than it needs to be.

Other areas in which we have made little progress include undergraduate housing, the special development fund for the School of Engineering, and resources to support the physical expansion of the Sloan School of Management -- an expansion which will permit a significant increase in the scale of the Master's degree programs of the School. It seems clear that efforts in support of these important needs must continue beyond the formal end of the Campaign.

Notable Developments in Research and Education

The health of the Institute is dependent in large measure on its capacity for self-renewal: our ability not only to grow, but, even more important, to recognize, to adjust to, and to influence changing conditions in the intellectual universe and in the society at large. This past year saw important evidences of this continued vitality in our research and educational programs, in a revised career structure for our research staff, in the renewal of a number of significant research facilities, and in the Institute's ability to evolve institutional forms in response to new problems.

During the year there were notable developments in research programs and educational activities in each of the five Schools and in the other academic units. A brief account of some of these developments follows.

The Institute strengthened its ability to engage in health-related research and education with the inauguration of the Whitaker College of Health Sciences, Technology, and Management. We reported last year on the evolution of this program and of the concept of a college within M.I.T. to serve as a locus and anchor for the Harvard-M.I.T. Division of Health Sciences and Technology (now eight years old) and as a focus for our other activities in these areas. The College is named for two benefactors -- Helen F. Whitaker and her late husband and industrialist, U. A. Whitaker -- whose support over two decades has spurred unprecedented growth in the life sciences and in health-related teaching and research at M.I.T.
President and Chancellor

Dr. Irving M. London, Grover M. Hermann Professor of Health Sciences and Technology, professor of biology at M.I.T., and professor of medicine at Harvard Medical School, is the first director of the College. We believe that Whitaker College will foster productive interaction among engineers, natural scientists, and social scientists in a broad range of disciplines basic to the health sciences and medicine. As a multidisciplinary organization, the College is not organized along departmental lines, but rather, faculty members in the College will hold joint appointments in departments of the Institute. This concept of faculty from all Schools joining together to collaborate on research and education in as challenging a field as health represents the beginning of a new organizational form in American higher education. In Whitaker College, the programs will emphasize those areas in which the Institute's special strengths can contribute to medical needs and health-related problems -- such as human biology, environmental biology and toxicology, experimental medicine, and health care policy and management.

The establishment of Whitaker College is seen by many as the exciting beginning of a new venture at M.I.T. This is true, but such a view misses the point in some important respects. While the College will be a new home for many of the health-related science and engineering activities at M.I.T., such pursuits have long been a significant part of the professional lives of many professors and students. The Whitaker College program is therefore more than a beginning: it is a reflection of the long-time efforts of M.I.T. engineers, natural and social scientists and managers. And it represents M.I.T.'s readiness to reshape organizational forms to serve the basic intellectual drives of its faculty and the changing structure of knowledge.

Development of another new, multidisciplinary program -- in Science, Technology, and Society -- continued during the year as well. This program will provide a supportive structure in which faculty from several disciplines can develop teaching and research programs which bear on the relations between technological and societal problems, and on the ways in which social conditions and values are shaped by the interplay of scientific, technological, and humanistic concerns. An example of the already active interest and inquiry into these issues is the faculty seminar in which natural scientists, social scientists, and humanists from several institutions met together for over a year. The impressive results of that seminar have been published as "Limits of Scientific Inquiry," a volume which appeared as the spring 1978 issue of Daedalus, the journal of the American Academy of Arts and Sciences. From these kinds of beginnings has come inspiration for a second new college at M.I.T. and the vigorous development of an educational and research program to serve as the experimental phase of that college. Support for initiation of the Program has been received from three foundations -- The Alfred P. Sloan Foundation, the Andrew P. Mellon Foundation, and the William and Flora Hewlett Foundation. The Program is currently affiliated with the School of Humanities and Social Science but as it develops, we expect that it will have strong connections with the faculty and students of the other Schools as well. In order to help guide its growth and to develop working relations with the rest of the Institute, Dr. Donald L. M. Blackmer, Associate Dean of the School of Humanities and Social Science and Professor of Political Science, has been appointed the first director of the Program, and a broad-based Faculty Advisory Council has been established.

Such a new intellectual grouping holds more risks than a new venture in an established discipline and it therefore needs more nurturing. In recent years, these two programs have received special attention as new developments which combine research and education under a coherent group of faculty who share broad interests across many disciplines. In many respects the five academic Schools of M.I.T. reflect similar tensions between cohesion and diversification, as they periodically examine their intellectual foundations and the prospective roles and careers of their graduates.
The School of Architecture and Planning has been engaged in recent years in such a reexamination of its intellectual strengths and needs, and it has undertaken a rethinking of its commitment to its students, its faculty, and the professions they serve. It is an objective of the School to provide students with a rigorous educational experience that will prepare them for influential roles on the frontiers of several professions concerned with public policies and with the quality of the physical, aesthetic, and sociopolitical environment. Toward this end, the School has drawn on well-established educational approaches developed by previous generations of architects and planners, and has sought novel techniques for experiments in planning and design.

During the past year the Department of Architecture revised, with the approval of the faculty and of the M.I.T. Corporation, its graduate degree structure. The revisions serve two purposes. First, they recognize the existence and attractiveness of a broad spectrum of interests and disciplines which have developed in the Department but which are not normally contained within the traditional, professional architectural programs. Second, the revisions respond to the need for a graduate-level program for the study of architecture and its related fields with a focus on scholarly research to complement the Department's continuing commitments to design and professional practice. These changes will enable the Department to engage a broader range of students, including applicants from other related fields as well as those already educated to be architects, who will broaden the intellectual scope of the Department.

In the School of Engineering, program developments and increased enrollments reflect a growing interest in technology related to public policy and societal needs. For example, the US Department of Energy has called upon the School to aid in developing energy contingency plans in the event of an oil shortage. In the future, we can anticipate an increase in the number of projects of this kind, in which engineering faculty and students address not only the basic technology of engineering problems, but the legal, regulatory, and societal aspects of problems and their solutions. Awareness of this kind of need and of our institutional response to it may account, in part, for the extraordinary increases in student enrollments in the School during the past five years. More than 60 percent of the undergraduate majors now choose one of the engineering fields, with an increase of 12 percent in the 1977-78 year alone.

An example of the School's response to increased interest by students in engineering study and careers is the Engineering Internship Program. In June of this year, the first class of 32 sophomore engineering students started summer work assignments at 12 participating companies. Modeled after the successful Course VI-A program, the internship program has been established in seven of the School's departments and extends the student's learning experience beyond the classroom and laboratory to situations and problems not available in an academic setting. Students in this program will typically spend three summers and one graduate term in residence at a participating company or government agency, and receive academic credit while earning a salary to help pay for their educational expenses. By the end of the program, most students will have earned a combined bachelor's and master's degree, with the graduate thesis on a topic related to their work experience.

Other educational concerns and developments in the School are reflected in the agenda of the Committee on Engineering Education: ways in which the social, ethical, political, and economic context of professional engineering activities can be woven into the educational programs; the interface between the Engineering School and the School of Humanities and Social Science; physics teaching as it affects engineering programs; the use of computers in engineering education; the relation of departmental graduate education to opportunities in interdepartmental centers; and the relation of traditional graduate education to new patterns in continuing education.

Efforts to meet the increased and changing expectations of students in engineering have placed great demands on the faculty and staff of the School. Recognizing the long-term pattern of enrollments and the continuing pressures on faculty and staff, we have approved substantial increases in the School's academic budget for the coming year.
Faculty from several engineering departments and from the Sloan School of Management collaborated during the year on the development of the Laboratory for Manufacturing and Productivity. This new interdepartmental enterprise provides a focus for research and education and will explore the complex interactions between design and production in a manner which takes into account non-technical aspects of these problems. This objective requires the combined involvement of industry and government as well as of academic institutions.

Much of the impetus and leadership for these new programs has come from Professor Alfred A. H. Keil, who retired as Dean of the School in August of 1977 after six years of extraordinary leadership in engineering education and of dedicated counsel to faculty and students alike. Professor Keil will continue to serve the Institute as an advisor for several major research activities. During the last year, the leadership for the School was assumed by Associate Dean James D. Bruce, who served as Dean during this period of transition. We are grateful to Dean Bruce for having accepted yet another responsibility on behalf of the Institute. On July 1, 1978 we welcomed Dr. Robert C. Seamans, Jr.--a distinguished engineer and a national leader in technology policy--as the new Dean of Engineering.

The Institute has been involved for many years in academic programs which bear on the sources, conversion, and uses of energy. These activities have grown in scale and in importance in the past five years as the nation--indeed the entire world--has struggled to come to terms with large increases in petroleum prices and with the prospect of fossil fuel depletion.

Many of our efforts that bear on energy issues are centered in the Energy Laboratory, which has been a subject of these reports in previous years. The Energy Laboratory continues to develop as a national resource and as a focus for collaborative efforts of faculty and students from all five Schools.

Within the Energy Laboratory, the Center for Energy Policy Research is making important contributions to the national debate about energy policy. The frustrating lack of progress toward creation and adoption of a national energy policy results, in part, from a lack of understanding of current conditions and of the implications of changes in energy policy. There is uncertainty about the effects of possible policy alternatives on jobs, inflation, and the environment--or even on energy supply, demand, and imports. Even where there is knowledge about social impacts, we seem to lack the knowledge or the political consensus to moderate the effects of policy changes.

The result is stalemate and indecision in key areas such as oil and gas price administration, controls on fuel choice and end-use technology, the government's role in the development and commercialization of new energy technologies, and the bounds of socially acceptable trade-offs between energy development and environmental protection.

The Center for Energy Policy Research is an effort to increase the nation's capacity to make effective energy policy by building a fundamental research base in the economic, technological, and management aspects of energy issues and by conducting major studies on specific problems, and communicating the results of those studies to people in policy-making positions.

To increase its effectiveness the Center is building a network of sponsoring organizations which covers the full spectrum of public and private agencies and organizations that are actively involved in the energy area. Diversity in sponsorship and participation will increase both the quality and the credibility of the work of the Center. Professor Henry D. Jacoby of the Sloan School of Management, whose research has centered on energy policy studies and technology evaluation, and especially on analysis of the world oil market, is the Center's first director.
In the spring construction of a new combustion research facility was completed. This facility, which is unique in the United States, is now being commissioned for work on reaction conditions and pollutant formation relevant to practical combusters burning any hydrocarbon and particularly the new synthetically derived fuels. A new fluidized bed combustion chamber was also constructed and will be used to explore the removal of sulfur and other pollutants during the combustion of solid fuels. In addition, substantial work has been completed on renewal of the physical facilities of the Sloan Automotive Laboratory, the Gas Turbine Laboratory, and the Fuels Laboratory, encouraging research on a number of other energy-related technological problems.

The health effects of fossil fuel combustion are the focus of a new activity being established by the Energy Laboratory and the Harvard-M.I.T. Division of Health Sciences and Technology. The new Environmental Health Sciences Center for the study of potential health effects of combustion of present and potential fossil fuels and an associated long-term interdisciplinary research program is being formed under a grant from the National Institute of Environmental Health Sciences. Primary objectives of the Center's program are the development of a database with which to assess potentially mutagenic and/or carcinogenic species from combustion of fossil fuels, and the identification of possible alternative combustion methods and fuel utilization strategies that could reduce or eliminate health hazards.

Another energy-related effort which has grown greatly during the past several years has been in plasma fusion research, where scientists and engineers have been trying to find ways to confine the nuclei of hydrogen atoms close enough together at high enough temperatures for a long enough time so that they fuse, creating heavier nuclei and, in the process, releasing enormous amounts of energy. The advantages of this process are that it produces few long-lived radioactive byproducts, such as the heavy radioactive isotopes which are produced in fission reactors, and that the natural resources used are available in a virtually unlimited supply. This past year has seen important progress in the Institute's program in plasma fusion and physics, and in the growth of the new Plasma Fusion Center. Two developments will contribute greatly to the future of this work.

First, the Plasma Fusion Center has received and is installing a 200-megawatt alternator to be used as the source of pulsed power for provision of the extremely high magnetic fields required for confinement of the hot plasma in a new plasma fusion machine known as Alcator C. This machine is a successor to Alcator A which has been in operation at the Francis Bitter National Magnet Laboratory for several years and which has in recent years broken new ground in fusion experiments -- operating with a plasma-density confinement-time product of $3 \times 10^{13}$ seconds per cubic centimeter at a temperature of 10 million degrees Celsius. The alternator for Alcator C was given to the Institute by the Consolidated Edison Company of New York, which had removed the machine from use after more than two decades of service in a Manhattan generating station. This massive alternator, whose three-week train journey from New York was in itself a singular event in transportation ingenuity, will nearly double the strength of the magnetic field in the M.I.T. fusion machine and will move its performance significantly closer to the break-even point -- the point at which the plasma produces more energy than it absorbs.

The second development is the donation to M.I.T., late in the year, by Nabisco, Inc. of its Albany Street property adjacent to the National Magnet Laboratory which houses Alcator. The property consists of a 71,000 square foot building and land with a value in excess of $1.5 million. When this building becomes available to the Plasma Fusion Center in the fall of 1979, it will provide desperately needed space for the next generation of experimental plasma fusion machines.

Our activities in energy are examples of the well-established M.I.T. practice of creating new settings to support research interests which draw from many disciplines. Another new
interdepartmental venture of note is the program in submicrometer structures, a joint activity of the Research Laboratory of Electronics and the Center for Materials Science and Engineering. It is under the direction of Dr. Henry I. Smith, staff member of the Lincoln Laboratory and adjunct professor in the Department of Electrical Engineering and Computer Science. The Program is concerned with the fabrication and properties of structures in which the important dimensions are less than a micrometer -- one millionth of a meter. Such structures have many important applications -- to integrated circuits, surface acoustic wave devices, and optical components. They also can be used as tools to probe fundamental phenomena in physics, chemistry, materials science, and perhaps biology. Catalysts, crystal growth, and cell manipulation are among the processes that can be studied with such techniques. Ultimately we hope that a large, interdisciplinary research effort, involving faculty members from several departments, will develop out of the submicron program.

Research Careers and Renewal of Research Facilities

The successful interaction of research and education in these and other programs of the Institute depends, of course, on the extraordinary teachers, students, and researchers who choose to study and work here. In order to maintain the vitality of the research enterprise and its contribution to the entire spectrum of Institute activities, we have been looking into ways of encouraging full-time research careers on campus. Last year, following discussions with the Faculty Council and the faculty at large, a new structure for research staff appointments was adopted. As the new year begins, appointments are being made on the new basis, which was developed under the leadership of the Vice President for Administration and Personnel, John M. Wynne, in response to a recommendation of the Committee on M.I.T. Research Structure, chaired by Professor Frank Press, which reported two years ago. The new plan, which establishes four ranks of research staff ranging from research specialist to senior research scientist, is intended to create a work and promotion ladder which will make research staff careers at M.I.T. more attractive and viable. In a period in which the number of faculty positions is sharply constrained, we expect that the career opportunities and benefits created by this hierarchy of research staff positions will encourage the involvement of full-time professionals in research both in departments and in the centers and laboratories. We believe this will prove to be an effective and much needed way to maintain research viability, to enter new fields, and to bring young researchers to the campus in spite of increasing constraints on the number of new faculty appointments.

New research opportunities, however, depend heavily on adequate physical resources to house and support them. During the year we began a large-scale program of renewing, renovating, and rebuilding several important research facilities. This program will continue for several years. A major part of this effort relates to the care of experimental laboratory animals. As the number of animals used in research at the Institute has increased, and as Federal regulations governing the use and care of such animals have grown in number and complexity, serious questions have arisen as to whether we could continue to be certified as complying with the new regulations. In response to this problem we completed construction during the year of a new interim animal care facility on Vassar Street, which houses the Division of Laboratory Animal Medicine. In addition, we are moving ahead to renovate existing facilities in the Seeley G. Mudd, Dorrance, and Whitaker buildings to bring animal care facilities there up to current Federal standards.

At the same time, we have begun major renovations of the Suffolk Building on Main Street near Kendall Square and of the Webster Building on the East Campus for use by the Energy Laboratory, the Sea Grant Program, the Center for International Studies, and the Center for Computational Research in Economics and Management Science. We also have finished rebuilding of the Sloan Automotive Laboratory, including the installation of the large-scale combustion research facility described earlier. These renovations and new research facilities will contribute importantly to the work of the Energy Laboratory.
The improvement of these and other research facilities is crucial to our ongoing and growing research programs. Together these improvements will cost nearly $15 million over a four-year period. Of this amount, only a $1.5 million grant from the National Cancer Institute for animal care renovations has been made available directly from Federal funds. We plan to cover the balance of these costs by using several private gifts made in support of the Energy Laboratory and by committing projected operating revenues, primarily from research sources, to fund the remainder. These are large costs which impinge on the operating budget at a particularly awkward time, but the renewal of these facilities is of such great importance to the pioneering research programs of the Institute that we have moved ahead with them.

Students and the Educational Setting

The pulse of M.I.T. is quickened by the energies and talents of its students, and it can be fairly said that the quality of the institution is increased by the standards and expectations brought by these junior colleagues. The year saw many discussions and developments relating to admissions, financial aid, counseling, and student support which will affect current and future generations of learners at M.I.T.

We waited during the year to hear the decision of the United States Supreme Court in the Bakke case, in which a program intended to increase the number of minority students in the medical school at the University of California at Davis was under challenge. Early last summer we had participated, along with several other private universities, in an amicus curiae brief before the Court which argued that it was in the national interest to increase minority student access to the professions, and, further, that doing so required consideration of race in college admissions decisions.

The decision of the Supreme Court, announced in June, was complex, perhaps somewhat ambiguous, and was expressed in six separate written opinions. While the specific minority admissions program used at the medical school at Davis was found to be in violation of individual rights as guaranteed by the 14th Amendment, the Court also ruled that race could be used as a factor in admissions.

We are now engaged, in the light of the Bakke decision, in a careful review of our policies and practices with respect to admissions. On the basis of our present understanding of the Supreme Court's decision, we believe that the Institute admissions procedures are not at variance with those sanctioned by the Court. M.I.T. has neither quotas nor a fixed number of places "set aside" for minority students in each class, which is the feature of the Davis procedure that the Supreme Court found unconstitutional. If changes in our procedures seem desirable, we will, of course, make them. But such changes will in no way diminish our strong commitment to providing opportunities for an M.I.T. education for members of racial minority groups. It is our conviction that resolute movement toward the goal of a society in which race no longer matters requires consciousness of race and of the past unfair burdens which have been borne by black, hispanic, and other minorities. We must continue to make a determined effort to increase the number of minority students who graduate from the Institute. Specifically, we will continue to identify and attract able students, and will work to encourage and sustain their efforts at M.I.T.

We are pleased to report that the number of minority students admitted to the freshman class for September 1978 has reached an all-time high. The Class of 1982 includes 94 minority students, of whom 76 are black.

Because the Bakke case and decision were concerned with admissions programs for minority students, it is not clear what the legal ramifications are with regard to discrimination based
on gender, but we are confident that our efforts to increase the number of women students will meet the tests of legal and social scrutiny. The Admissions Office, as well as many individual faculty, students, and staff have been making special efforts to encourage more young women to consider careers in fields such as engineering and to regard science as an essential part of a liberal education; to recruit more young women to apply to the Institute; and to support them once they are here. As a measure of the effectiveness of these efforts, the number of women undergraduates at the Institute continues to increase. The Class of 1982 includes 232 women which, at 22 percent, is a record for the Institute, and is a strong base from which to grow.

While much attention has been given to our efforts to increase the numbers of minority and women students here, these are but part of our overall efforts to attract the brightest and most promising students to the Institute. For the past two years, the Faculty Committee on Undergraduate Admissions and Financial Aid has been engaged in a review of the Institute's admissions requirements. While the number of applicants for undergraduate admission has not changed significantly for more than a decade, that number is thought by many to be considerably smaller than one might expect it to be on the basis of national data on standardized test score distributions. The Committee has been concerned in particular that our requirements regarding high school subjects and submission of College Board Achievement Test scores, which are more stringent than those of most universities, have undesirably limited the number of students who might otherwise be qualified to apply. Consequently the Committee revised, with the concurrence of the Committee on Educational Policy, the requirement relating to achievement tests. That requirement had been that applicants must submit achievement test scores in mathematics, chemistry or physics, and English or history. Effective in the coming year, this requirement is revised to permit the submission of test scores in biology as an alternative to physics or chemistry, although applicants will still be expected to have studied both physics and chemistry in high school. This change will give increased visibility to the importance of the life sciences at M.I.T. and should enlarge the number of potential applicants since more high school students take the CEEB achievement test in biology than in either physics or chemistry, in part because physics is not usually given until the senior year in high school.

Another set of issues related to admissions has to do with the cost of a university education and with the financial aid programs available to help students and their families meet these costs. We have been much concerned this year with student financial aid, both at the undergraduate and graduate levels. This concern has two principal sources. First, students' need both for scholarships and for loans has grown to such an extent that the funds which we have available to meet these needs are not nearly adequate. In order to continue to help students meet the costs of an M.I.T. education, we have had to commit increasing amounts of unrestricted funds to scholarships, and to go outside the Institute to borrow funds to augment the Technology Loan Fund. Second, as college costs in general are driven up by inflation, there is heightened concern, both inside and outside higher education, about the costs of education; about the use of student loans to finance education; and about the problems parents face in paying college bills -- problems thought to be particularly severe for parents in the middle income range.

Our review of this last issue leaves us convinced that the relative real cost of an M.I.T. education has not increased and that there has so far been no decrease in the accessibility of the Institute to students whose families are in the middle income range. Measured as a fraction of the average starting salaries of our graduates, or as a fraction of US median family income for wage earners in the age range of parents of college students, the M.I.T. tuition has been essentially constant over the past 25 years. These measures of relative cost are, of course, subject to the criticism that they do not reflect the growing relative tax burden which accompanies the inflation-driven move into higher income tax brackets. In an effort to respond to this concern, we have recently studied the relationship of tuition to national per
President and Chancellor

capita disposable income, a measure which reflects, in some average sense, the growing tax burden. As a fraction of per capita disposable income, the M.I.T. tuition has been essentially constant since at least 1969.

Despite these facts about relative costs, most families pay a large portion of college costs out of savings rather than current income and therefore the payment of these bills is more difficult in a period in which inflation has steadily eroded the real value of savings. In an effort to assist parents we introduced a Parent Loan Plan this year. This is an insured installment loan plan which enables parents to spread a portion of the cost of four years of education over six and one-half years. Parents with income up to $60,000 per year are eligible for this plan, and while it is too early to appraise its usefulness, we are encouraged to note that 87 families made use of the Parent Loan Plan during the first year of its operation.

With regard to loans to students, we have made some changes in Institute policy, effective in September 1978. These changes came as a result of an exhaustive study of our experience with student loans. With limited exceptions, we will in the future only make student loans which are either guaranteed by Federal or other guarantors, or cosigned by a credit-worthy loan guarantor. This change should reduce the Institute's exposure to loss on loans made in the future, and may also reduce somewhat the demand for loans. For undergraduates, this policy change will have little effect on needy US students, nearly all of whom borrow under Federally guaranteed loan programs. The revised policy will probably be felt most by students from other countries, who are not eligible for these guaranteed loan programs, and who would be less likely to have a cosigner in their first year here. In order to continue our policy of helping all undergraduates meet the cost of an M.I.T. education, therefore, we will allow non-US undergraduates with financial needs to borrow some portion of their self-help without a cosigner. In these cases the Institute will serve as guarantor of these loans through an International Student Loan Fund which is being created by annual allocations of unrestricted funds and from outside contributions. Graduate students from other countries, on the other hand, may enroll at M.I.T. only with the assurance that they have full resources available to them without recourse to M.I.T. loans for their first year. Following their first year of graduate study at M.I.T., non-US graduate students may take loans if they have a credit-worthy cosigner. We are contemplating a special effort to raise support for these students from overseas donors, including our international alumni.

Neither these policy changes nor any other action short of a significant departure from our long-held policy of helping each student to the extent of his or her need will bring the students' needs for scholarships and loans in line with our available resources. This gap between needs and the resources to meet them underscores the importance of expanding endowment both for scholarships and for capital for the Technology Loan Fund.

The Admissions Office, the Financial Aid Office, and the Committee on Undergraduate Admissions and Financial Aid have monitored closely the quality of our entering classes in an effort to detect any shift in the applicant pool or entering class which might be caused by our growing costs. Although our financial aid program places a heavier self-help burden on our students than do those of many other universities, we have found no indication that costs today are more important in students' decisions to enroll than they have been for the past two decades.

At the graduate level, however, both the context and the possible consequences of constraints on financial aid are different. At M.I.T. and elsewhere, financial aid is commonly awarded on the basis of joint consideration of merit and need, and, in most fields, financial aid has traditionally made less use of loans. As externally funded fellowship programs, particularly those funded by the Federal government, have become less available, and as the pressures on our internal resources have increased, we see disturbing bits of evidence that we may be losing a disproportionate share of the best students to other universities with better-funded
graduate aid programs. During this year departments as strong and as diverse as Economics, Political Science, and Mathematics have expressed concern about signs of a decreased ability to compete successfully for the ablest graduate students.

These concerns, although new and so far isolated, are important for they may be precursors of a growing problem in which limitations on aid for graduate students have a deleterious impact both on the choices afforded prospective students and on the quality of graduate student populations in the several departments. While we are deeply concerned about this issue, we recognize that there are no easy solutions. What is required is a substantial infusion of new resources dedicated to the support of graduate students, resources which, at the present level of costs, must be in the range of $5,000 to $10,000 per aided student.

Students who are admitted and come to study here become part of a culture and academic tradition that is uniquely M.I.T. The style of an M.I.T. education -- the ways in which the academic programs and procedures are organized -- are as much a part of the educational program as the subjects studied. One such element of style -- our policy of permitting students to cancel registration in any number of subjects as late as three weeks before the end of the term -- was the focus of considerable debate among students and faculty during this past year. During recent years some members of the faculty have expressed the view that this policy has undesirable academic consequences, and have suggested that it be changed.

Following a detailed study of this issue, the Committee on Academic Performance recommended to the faculty that the Institute's policy be revised to permit the cancellation of only one subject after the midpoint of the term unless explicit prior approval of the Committee had been obtained. In recommending this change, the Committee argued that students should be encouraged to get full educational value from their subjects rather than to spread their effort over too many subjects until late in the term. The Committee felt that the "late drop date" policy allows some students to develop grade optimization strategies which may not be educationally sound and which lead to distorted academic records. The Committee also pointed out that recent experience has shown that students who drop several subjects late in the term are heavily represented among the small group of students whose overall academic performance is marginal.

The discussions of this matter in faculty meetings showed that while the number of undergraduates who use the present unlimited late cancellation mechanism is small, this practice is widely regarded as an important and valuable element of program flexibility -- as a highly desirable "safety valve" on an already intense and demanding experience. Those who favored retention of the "late drop date" argued that often more than half the term is required for students to assess the true work load in a subject and to estimate likely performance, and that other means for limiting admitted abuses of late cancellations, including more effective counseling and advising, should be found instead of adopting rule changes which would eliminate an important element of flexibility for all students.

In the end, the proposal to limit late cancellation of registration was not accepted by the faculty. The debate which led to this conclusion, however, illuminated several academic issues of concern to students and faculty alike. First among these was the widely shared concern that departmental advising and counseling of upperclass undergraduate students was not as effective as it should be. A group of faculty and staff, under the aegis of the Committee on Educational Policy (C.E.P.), has undertaken to collect information from departments about counseling and advising, and we anticipate that some review of this matter will be initiated by the C.E.P. during the coming year.

Another element of style which affects the student's learning is the Wellesley College-M.I.T. Exchange Program. The academic year 1977-78 marked the 10th anniversary of this Program. The exchange began in 1968 as an experiment in student cross-registration for the purpose of
curriculum enrichment and diversification. The exchange has now become a permanent and important feature of the educational programs of both schools, and in recent years an increased level of faculty interaction has become an equally important element of the Program.

Today, in addition to significant participation by the students of the two schools, there are a variety of programmatic linkages as well. These include faculty exchanges and team teaching in language courses and in political science; faculty participation in new multi-institutional consortia or seminars such as the Cambridge Humanities Seminar and the Center for Materials Research in Archaeology and Ethnology; development of advisory programs for Wellesley students interested in engineering; Wellesley participation in the UROP program; and overlap in spirit and arrangements between the M.I.T. Independent Activities Period and the Wellesley College Winter Term.

The Wellesley-M.I.T. Exchange Program has diversified and enriched the curricula at both schools, and has given rise to innovative opportunities for faculty development. But the unique contribution of the exchange has been that it makes it possible for each school to be more responsive to the evolving academic needs of contemporary students without depleting the resources each school has for continued growth in their respective areas of strength.

Soon after the academic year ended we were saddened by the resignation of Carola B. Eisenberg as Dean for Student Affairs, a position she has held since 1972. Her decision to accept a combined academic and administrative appointment at the Harvard Medical School leaves a gap at the Institute which will be exceedingly difficult to fill. It creates a deep personal void for each of us, for she was at once a valued colleague and an effective performer in a role which is among the most demanding, difficult, and conflict-ridden in the university.

We have decided to pause before seeking a successor in order to review the scope and responsibilities of the Office of the Dean for Student Affairs, to take a fresh look at its functions and at the relations among the various offices which support our students. Such a reappraisal has not taken place at M.I.T. for nearly two decades in spite of the fact that there has occurred, in the meantime, a shift of historic significance in the relationship of students to institutions of higher education. We expect this review to be completed in time to search for and appoint Dr. Eisenberg's successor during the coming academic year.

M.I.T. and the Community

The Institute's location in the Boston area and our involvement in issues of national and international concern have an important influence on our programs, our sense of purpose, and our sense of community.

Since 1975, the Institute has been a participant in the Phase II desegregation program for the Boston Public Schools ordered by Federal Judge W. Arthur Garrity. In partnership with the Wentworth Institute and with the Massachusetts Port Authority, we have assisted in the establishment of the new Mario Umama Harbor School of Science and Technology, a 7-12 grade school which offers a technical education to students from all parts of the city. M.I.T. people -- faculty, staff, and students -- have played a major role in shaping the new school through staff development and advising, through acquisition of specialized equipment, through planning for space renovation and improvements, and through curriculum planning and development. Fifteen M.I.T. undergraduate students served as tutors and assistants in the School last year; two of them will remain as full-time staff members next year.

It has been a gratifying result of this effort to learn that the Umama School is now the most popular of Boston's 19 magnet schools. The School Department reported recently that there were more new first-preference applications for enrollment this September at the Umama
School than for any other magnet school or magnet program in the entire Boston system. Located in East Boston, the School will enroll a twelfth grade class for the first time this fall, which will bring it to full capacity.

Now that the first phase of the Institute's involvement with the School is bearing fruit, we have initiated a study which will determine the duration, level, and type of involvement M.I.T. should have with the Umana School in the future when Judge Garrity's order is no longer in effect.

Another social issue which has had significant impact and visibility in the national scene and has received considerable attention on this campus is the question of investments in corporations doing business in the Republic of South Africa. We have looked for guidance on these matters to the Advisory Committee on Shareholder Responsibility, which has been chaired for the past five years by Dr. George W. Thorn, member of the Executive Committee of the Corporation. In the context of proxy questions about South Africa, raised with increasing frequency in the past year, the Advisory Committee has made several policy recommendations to the Executive Committee of the M.I.T. Corporation. At year end the Executive Committee prepared a statement summarizing its deliberations on the issue and outlining the following M.I.T. policies:

- The statement of principles proposed by the Reverend Leon Sullivan of Philadelphia shall be used as guidelines for voting on proxy resolutions dealing with the activities of US corporations in the Republic of South Africa. This statement espouses several basic humanistic principles, including equality in working conditions and compensation, and affirmative action in the development of the capabilities of black employees, as necessary for the operation of subsidiaries of US corporations in the Republic of South Africa.

- The Institute has joined with eight other colleges and universities in urging institutions of higher education with investments in such companies to unite behind the Sullivan principles as ethical guidelines for business activity in South Africa.

- Banks in which the Institute is a shareholder and which do business in South Africa should be discouraged from making loans to the South African government.

- While the Institute will discourage expansion in South Africa by US corporations in which M.I.T. is an investor, it will not seek to have such corporations withdraw from South Africa, believing that, on balance, US firms following substantive affirmative action guidelines, like the Sullivan principles, represent a positive and constructive force in that country.

In the course of these discussions the Executive Committee considered the question of divesting M.I.T. ownership in companies which do business in South Africa, and concluded that it would be neither desirable nor effective nor prudent for the Institute, as a general principle, to make such divestments. The Committee believes, and we share this belief fully, that divestment would have only the most transient effect on the state of human rights in South Africa. For M.I.T., however, taking such action might seriously impair our ability to invest our funds in a prudent and responsible manner in accordance with our fiduciary and other legal responsibilities.

In its review of these issues the Executive Committee affirmed the Institute's responsibility and obligation to vote its stock and to address social issues which arise in the context of its
shareholder responsibilities. At the same time it acknowledged and reaffirmed M.I.T.'s long-standing policy not to take institutional positions on political issues except in those few cases in which the issue at hand has a direct and consequential impact on M.I.T.'s function as an educational institution. In accordance with this policy, the Executive Committee concluded that it should make no formal declaration regarding apartheid, even though each member of the Committee opposes apartheid both in principle and specifically as a policy of the government of South Africa.

M.I.T. as an Institution -- Changing Patterns and Pressures

During the seven years in which we have shared the responsibility for stewardship of the Institute in the Office of the President and Chancellor, our roles have evolved and have shifted to accommodate what we have seen as the needs of M.I.T., our own personal working styles, and the complementary strengths and interests each of us brings to these jobs and to the executive group made up of ourselves, the Provost, and our other senior administrative colleagues. These roles evolved further this year when in December 1977, following discussions with the Executive Committee, we undertook a significant temporary redistribution of responsibilities. Specifically we decided that the President, while remaining formally the Institute's chief executive officer, would devote full personal efforts to the Leadership Campaign, while the Chancellor would shoulder all of the ongoing management decisions and responsibilities of the Office of the President and Chancellor concerned with the academic and administrative leadership on the campus.

During this period the President has continued his duties as an officer of the M.I.T. Corporation and as chairman of the Executive Committee, has continued to chair the meetings of the faculty, has been consulted in a number of critical decisions, and has participated in the development of the new academic and research programs described earlier. The Chancellor has chaired the meetings of the Academic Council, the Faculty Council, and the Administrative Council, and has assumed all of the internal executive responsibilities which he and the President have shared in the past.

While this arrangement was originally undertaken for a period of nine months, several considerations, including the pressing need of the Leadership Campaign for the continued involvement of the President, have persuaded us to continue in this mode until the end of the current calendar year.

This change in responsibilities underscores the Institute's need for financial stability as a support for current programs and future plans. A look at the finances for the year just completed shows good performance; a look into the future indicates some difficult challenges ahead.

We are pleased to report that once again the year ended with the operating expenses of the Institute essentially in balance with operating revenues augmented by annual unrestricted gifts. Indeed, the Report of the Treasurer shows a surplus in unrestricted funds of $68 thousand, but clearly this amount, at approximately two hundredths of one percent of expenses for the year, is no more significant than the corresponding deficit last year of $126 thousand. We are gratified with the results of these two years, following as they do three years of significant operating deficits.

These two satisfactory years, however, should not be taken as evidence that the Institute has put financial concerns behind and is moving into a new, less stringent era. We are still faced with the problem of a chronic imbalance between the rates at which expenses and revenues grow, and while we have reduced that annual difference in these rates from about $2 million per year to about $0.5 million per year, the residue has proved to be intractable. Furthermore,
in order to support current operations, we still must rely on essentially all of the annual
unrestricted gifts. A more satisfactory balance between current needs and future needs
would require that a significant fraction of these funds be capitalized as additions to the
Institute's funds functioning as endowment. Finally, there are continuing, intense pressures --
for keeping faculty and staff salaries ahead of inflation; for renovations of academic facilities;
for the replacement of equipment in the teaching laboratories; for additional on-campus
housing for students; and for expansion of academic programs in specific areas, such as the
activities in health science and technology and those engineering programs that have experienced
doubling and tripling of enrollments.

Our budget for the coming year is itself a reflection of these pressures. We anticipate a
deficit of approximately $0.5 million after application of anticipated unrestricted gifts of
$4.0 million. This projected deficit is the result of unavoidable pressures on operating
expenses, most of which are of a recurring character -- that is, they will be repeated and
will grow in future years. Consequently, we face a potential deficit of $1 million for the
1979-80 academic year even before we begin planning for that year's budget. The task of
balancing the budget in the future, therefore, will be an even more difficult undertaking.
Nevertheless, a balanced budget must continue to be a high-priority objective.

Responsible stewardship of funds is one way of assuring the future health of the Institute.
Another aspect of future planning which is just as important to an urban university is
stewardship of space. During the spring a full-scale study of land use and future development
of Institute facilities in the area east of Ames Street was started. This work, which is being
done by a joint venture established by the New York firms of Gruzen and Partners and
Mitchell/Giurgola, has been under the close supervision of the Institute's senior officers and
the M.I.T. Planning Office. The precipitating event for this study is the need to design the
health services building and the health sciences building which will be the home of Whitaker
College. Construction of these buildings may begin next winter if the necessary state and
Federal approvals for the health services building are obtained. And if gift support is
forthcoming as hoped, an early start of the first phase of the new arts facility may soon
follow. Beyond these short-term considerations, however, is the need to plan these first
steps in the context of an integrated campus plan for the entire area east of Ames Street --
a plan which explicitly recognizes that this area must effectively, economically, and
aesthetically sustain the future academic needs of the Institute for at least the remainder of
this century.

Just as the growth of the Institute is conditioned by the physical and community space it
occupies, so too is its development influenced by the legal and legislative atmosphere of our
times. Governmental actions during the past year have had a heavy impact on higher education
generally and, specifically, on the Institute. This year in particular the Institute has been
immersed in a climate of Federal laws and regulations in areas as diverse as Social Security
benefits and costs, retirement policy, immigration policy, and indirect cost reimbursements.

For example, the 1977 Financing Amendments to the Social Security Act call for increases in
both the FICA tax rate and in the wage base to which that rate applies, with a resulting increase
in personnel costs that will permanently affect our operating budgets.

In the spring, the 1978 Amendments to the Age Discrimination in Employment Act were passed
by the Congress and signed by President Carter. Under the law, effective January 1, 1979,
no employer may require a person to retire because of age prior to age 70. However, application
of the law to tenured faculty members was deferred by the Congress until July 1, 1982.
Until that date, tenured faculty may lawfully be required to retire at age 65.

We respect the basic purpose of the law to afford individuals freedom of choice in the decision
whether to continue employment between 65 and 70. Yet we know that the vitality of a university
demands the renewing energy and intellectual stimulus that those fresh from advanced study bring, and we know also that, with limited faculty and staff growth, advancing the retirement age diminishes the opportunities for such new appointments. At the same time, we reject the idea that tenured members of the faculty should be treated differently from Institute staff members and other employees in the opportunity to choose whether to continue at M. I. T. between 65 and 70.

Consequently, we have decided, following discussions with the Academic Council and the Executive Committee, that tenured faculty members now scheduled to retire during the next three years will be free to choose whether they wish to continue to age 70.

We believe that the Institute's interests are best served by continuing to regard age 65 as one's "normal retirement date" and to encourage individuals to consider early retirement, retirement at 65, or conversion to part-time service after 65 as reasonable alternatives to continuation full-time to age 70. We recognize, of course, that all persons employed at M. I. T. may choose to continue full-time service until age 70. It will be several years before new retirement patterns become clear. In the interval we intend to monitor closely the impact of these changes on the numbers of junior faculty appointments and to devise transitional measures, including temporary additions to departmental budgets, if necessary, to ensure that the burden of these changes does not fall principally on our youngest professional colleagues.

Another change in the surrounding institutional climate has to do with the international character of M. I. T. and, indeed, of science and technology. At M. I. T. and other universities, the excellence of the research and educational programs depends on the individuals who are chosen for the faculty and research staffs, and the selection process plays a critical role in maintaining the institution's standards of quality. Recently we have encountered serious and increasing problems in supporting international faculty and research staff who wish to accept positions at the Institute and who must, therefore, apply to become permanent residents of the United States. Our efforts and procedures for recruiting and hiring the best qualified faculty and staff have come into conflict with some of the technical requirements for enforcement of recent legislative changes. These procedures, however, are not contrary to the basic purposes of the Immigration and Nationality Act which was revised effective January 1, 1977. Most of the difficulties we have encountered center on the process of obtaining certification from the Department of Labor that the foreign national who is applying for an immigrant visa is better qualified than any US citizen who could be found for a particular position on our faculty or research staff.

We are concerned at this point lest the procedural difficulties become so serious as to thwart our efforts and success at recruiting faculty and researchers from an international pool of talent. This concern will require more intense monitoring of the situation and possible appeal to Congress for clarification of the legislation, which we are convinced was never intended to work against universities in this respect.

We also have been concerned throughout the year with the consequences for M. I. T. of changes in the regulations which affect the reimbursement to universities for the indirect costs incurred in the performance of research for Federal sponsors. These regulations have been under review for nearly two years by the Department of Health, Education and Welfare and by the Office of Management and Budget, which appear to be responding to narrowly based Congressional concerns about indirect costs of research -- concerns which seem to us to be based on misinformation and serious misunderstandings concerning both the nature of indirect costs and the historical antecedents of the involvement of universities in the performance of basic research on behalf of the government.
Draft revisions of these regulations published last winter by the Office of Management and Budget would have had serious consequences for M.I.T. They would cause arbitrary reductions totaling about $2 million per year in our reimbursement for necessary and proper indirect costs, and would greatly reduce important elements of operational flexibility by imposing certain uniform methods for the determination and allocation of indirect costs. More importantly, these proposed regulations insist that when research costs are determined, students must be regarded narrowly as students and not as contributors to or participants in research activities. This position is, of course, directly in conflict with the premise on which academic programs at M.I.T., involving both research and education, are based. We believe that adherence to such a position would not only impose an immediate and unwarranted financial burden on M.I.T. and other research universities, but would, in the longer term, cause institutions to adapt in ways that would be harmful to both research and education, and finally, to the national interest wherein M.I.T. is a rare asset.

We have vigorously opposed these changes and have argued that such far-reaching and harmful actions should not be undertaken on the basis of unilateral declarations by the government of policy changes, but should be based on a careful and many-sided review of the issues and the alternatives.

The outcome of this conflict is not clear as we write this report. Nevertheless, the potential financial impact on the Institute, should worse come to worst, is of such magnitude that these uncertainties represent a serious cloud over the future.

Perhaps the most appropriate summarization of the year is that it was characterized by significant accomplishments tempered by unusual and important uncertainties. Accomplishments of note are: the growth and growing strength of new academic programs and the review and reconceptualization of older ones; continuing effective admissions efforts; continuing attention of the faculty to important educational issues; steady progress of the Leadership Campaign; and the second year of balanced operating budgets. On the other hand, our optimism must be moderated by the undiminished pace of inflation, which is so corrosive to all institutions that depend on endowments and gifts, and the associated severe limitations on fiscal resources; the possibility that annual cost increases will, if unmatched by new and growing sources of student aid, diminish both choice and quality in our student body; and the influential, costly, and often incompletely considered consequences of government actions.

We decided this year to present our annual report as a chronicle of the activities and events which have given shape to the year -- a year punctuated by human actions, tries and trials, successes and failures, surprises and predictable behavior. For the pulse and character of the Institute are made up of the people here -- individuals coming from diverse backgrounds and points of view but fully engaged in the M.I.T. enterprise: education, research, and service of the highest quality. There is no more appropriate closing of our report than a salute and expression of gratitude to all of these people on behalf of M.I.T.

IN SPECIAL RECOGNITION

The individual efforts and distinctions on the part of the faculty at M.I.T. have been many during the past year. Four members of the faculty were elected to the National Academy of Engineering, bringing to 48 the total number of M.I.T. faculty in the Academy. The new members this year are: Dr. Robert L. Coble, Department of Materials Science and
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Engineering; Dr. Jack L. Kerrebrock, Department of Aeronautics and Astronautics; Walter E. Morrow, Jr., Lincoln Laboratory and Department of Electrical Engineering and Computer Science; and Dr. James Wei, Department of Chemical Engineering. In April, six M.I.T. faculty members were elected to the National Academy of Sciences, which now has 73 M.I.T. faculty among its members. Those who join the Academy this year are Dr. Robert M. Fano, Department of Electrical Engineering and Computer Science; Dr. Howard Green, Department of Biology; Dr. Bertram Kostant, Department of Mathematics; Dr. Carl I. Wunsch, Department of Earth and Planetary Sciences; Dr. George M. Whitesides, Department of Chemistry; and Dr. Daniel G. Quillen, Department of Mathematics.

In May, seven members of the M.I.T. faculty were elected fellows of the American Academy of Arts and Sciences. They are: Professors Suzanne Berger and Walter Dean Burnham, of the Department of Political Science; Professor John M. Deutch, on leave from the Department of Chemistry; Professor Peter A. Diamond, associate head of the Department of Economics; Professor Richard Leacock of the Department of Architecture; Professor Roman Jackiw of the Department of Physics; and Professor Peter A. Wolff, of the Department of Physics, director of the Research Laboratory of Electronics.

Within the Institute, special honor was given this year to Professor Morris Halle, who was selected as the 1978-79 recipient of the James R. Killian, Jr. Faculty Achievement Award. The Award is given each year to a member of the faculty in recognition of extraordinary professional accomplishment and service to the Institute. A leading scholar in the field of linguistics, Professor Halle was cited by the faculty selection committee as a man with gracious human qualities who is viewed by his students and colleagues as "at once literate, informed, theoretically perspicacious, and with a sure instinct of where to look."

An event of special significance for the Department of Mathematics and for the Institute occurred on August 15, 1978 at the International Congress of Mathematicians in Helsinki, Finland. Professor Daniel G. Quillen was a recipient of the Fields Medal for his work in algebraic K-theory and his proofs of the Adams and the Serre conjectures. The award also recognized his fundamental contributions to several branches of mathematics, including partial differential equations, topology and algebra.

The Fields Medal is the most prestigious award which an individual can receive for mathematical research. It is often thought of as the mathematical equivalent of the Nobel Prize. The medal is awarded every four years to one or more individuals under the age of 40 for exceptionally outstanding contributions to mathematical research. Professor Quillen has joined a very select group; the total number of recipients since the award began in 1936 is 24. He has brought honor to himself and to his institution, and we signal his accomplishments with pleasure and pride.

We take pleasure in noting that in November, Professor Morris Cohen was a recipient of the National Medal of Science, for his contributions to advancing knowledge of physical and mechanical metallurgy. The nation's highest award for scientific or engineering achievement, the award is given each year to a select few individuals who have made extraordinary contributions to their fields.

In the life sciences, special recognition was given this year to Professor Phillips Robbins, who was named American Cancer Society Professor of Biochemistry in recognition of his work in cell biochemistry; and to Professor David Botstein, who received the 1978 Eli Lilly & Company Award, which is given each year to a scientist under 40 years of age for outstanding research in microbiology or immunology.

Also in the School of Science, Professor John M. Edmond of the Department of Earth and Planetary Sciences received the James B. Macelwane Award from the American Geophysical
President and Chancellor

Union in recognition of his work in ocean chemistry. The award is given in recognition of significant contributions to the geophysical sciences by a scientist less than 36 years old.

In the School of Humanities and Social Science, Professor Ann M. Graybiel of the Department of Psychology was awarded the Charles Judson Herrick Award by the American Association of Anatomists for work of high merit in the field of comparative neurology.

In the School of Engineering, Professor Robert W. Mann received the ASME medal from the American Society of Mechanical Engineers, an annual award given for eminently distinguished engineering achievement. Professor Mann was selected for his pioneering contributions to the field of bioengineering and for bringing together engineering and medicine in the development of aids to the physically handicapped.

In the Sloan School of Management, Professor John D. C. Little received the prestigious Charles Coolidge Parlin Award from the Operations Research Society of America for outstanding contributions to the science of marketing. As further recognition of his leadership in the field, he was elected president of the Society this past spring.

Several members of the faculty accepted positions of leadership and service in the government during the past year: Professor John M. Deutch, of the Department of Chemistry was named director of Energy Research in the US Department of Energy; Professor Sanford A. Miller of the Department of Nutrition and Food Science was appointed director of the Bureau of Foods in the Food and Drug Administration; and Professor Alexander Rich of the Department of Biology was named to the US-USSR Joint Commission on Scientific and Technical Cooperation.

Dr. Rich and two other M.I.T. colleagues in the life sciences -- Professor David Baltimore and Professor Har Gobind Khorana -- were among the 14 new members named this past year by Pope Paul VI to the Pontifical Academy of Sciences.

A salute for extraordinary achievements must go this year as well to all those who helped the Institute survive the "Blizzard of '78." The storm, which began on Registration Day, February 6, immobilized the state -- and especially the Boston area -- for a full week, and classes did not begin meeting until the following Monday, February 13. Some employees of the Institute found themselves snowed in at M.I.T. -- a few were to spend the week there. Others, indeed most, were snowed out. Nevertheless, paths and campus roadways which had been blocked beyond the capacity of normal snow-removal equipment were reopened, floods were cleaned up, emergencies were seen to, nearly 3,000 resident students were fed, libraries and athletic facilities were opened, and the Institute, and those members of the community who did three weeks work in seven days, survived in fine style. Much is owed to the heroic efforts of those who carried on under extraordinarily difficult conditions. Included in this group were physical plant employees, telephone operators, members of the Campus Patrol, the dining staff, nurses and doctors, administrative staff, and many students and faculty. Because of the strenuous efforts of all those who labored without regard to time or the nature of the task (including the overnight launching of a suburbs-to-M.I.T. shuttle bus system), we were able to carry on under extremely difficult circumstances, and we wish to take this occasion to express once again our gratitude to all who helped.

A number of our colleagues have accepted major responsibilities in the academic administration of the Institute this past year. They include Walter H. Abelman, Chairman of the Board of Tutors and Advisors in the Harvard-M.I.T. Division of Health Sciences and Technology; Ernest G. Cravalho, Associate Director for medical engineering and physics in the Harvard-M.I.T. Division of Health Sciences and Technology; Richard Held, head of the Department of Psychology; Jack L. Kerrebrock, head of the Department of Aeronautics and Astronautics (effective July 1, 1978); James L. Kinsey, head of the Department of Chemistry; Alan J. Lazarus, Associate Dean for Student Affairs and Director of the Office of Freshman Advising;
Lawrence M. Lidsky, Acting Director of the Plasma Fusion Center; Irving M. London, Director of the Whitaker College of Health Sciences, Technology, and Management; Daniel Roos, Director of the Center for Transportation Studies; Robert C. Seamans, Jr., Dean of the School of Engineering; Lawrence E. Susskind, head of the Department of Urban Studies and Planning (effective July 1, 1978); Joseph M. Sussman, Associate Dean for Educational Programs in the School of Engineering; and Carl I. Wunsch, head of the Department of Earth and Planetary Sciences.

The past year also marked the retirement of 10 distinguished members of the faculty and of three valued colleagues in the administration of the Institute. Their contributions and years of service have had a significant influence on the people and programs of M.I.T. The retiring members of the faculty are: Professor William F. Bottiglia, Professor of Management and Humanities in the Sloan School of Management; Professor William W. Buechner, Department of Physics; Professor J. Harvey Evans, Department of Ocean Engineering; Professor Irving Kaplan, Department of Nuclear Engineering; Professor Alfred A. H. Keil, Department of Ocean Engineering and Ford Professor of Engineering; Institute Professor Salvador E. Luria, Department of Biology (who continues as the Director of the Center for Cancer Research); Professor Kevin Lynch, Department of Urban Studies and Planning; Professor Charles A. Myers, Sloan Fellows Professor of Management and Director of the Industrial Relations Section; Professor John B. Stanbury, Department of Nutrition and Food Science; and Professor George B. Thomas, Jr., Department of Mathematics. Retiring from the administrative staff this year are: Paul V. Cusick, Vice President for Fiscal Relations; Robert J. Davis, Director of Personnel Relations; and Frederick W. Watriss, Associate Treasurer.

We were saddened this year by the deaths of several colleagues whose presence we miss, yet whose contributions to the stature and character of M.I.T. are long-lived and gratefully remembered.

Melvin L. Cabral, Administrative Officer of the Department of Civil Engineering, died in August 1977. A member of the M.I.T. community for 24 years, Mr. Cabral was an effective member of the leadership team in one of the Institute's major departments.

Christopher Goetze, Associate Professor of Geology in the Department of Earth and Planetary Sciences, died in November 1977 after a short illness. Considered a brilliant experimentalist in geophysics, his intellectual sophistication was marked by common sense and compassion.

Arthur C. Hardy, Professor of Physics Emeritus, died in October 1977 at the age of 81. A nationally known physicist and pioneer in the photography and optics fields, Professor Hardy was a member of the M.I.T. faculty for over 30 years.

Joseph H. Keenan, Professor of Mechanical Engineering Emeritus, died in July 1977. An internationally recognized authority on thermodynamics, his 1941 text is considered to be the basis of contemporary teaching on the subject, and he was widely recognized as a scholar and a teacher of the first order.

James B. Lampert, Vice President for Resource Development, died in July 1978 following a brief illness. General Lampert came to the Institute in 1972, following his retirement from a 38-year career with the United States Army, and had been centrally involved with our fund-raising activities, including the planning for and direction of the Leadership Campaign, for nearly six years. All of us who had the opportunity to work with him came to appreciate those qualities of intellect, personality, and character which made him a noble, gentle, and most effective person. He led his staff to high accomplishment by the example of his own high standards, hard work, and human concerns.
M. Bryce Leggett, Associate Director of Admissions, died suddenly in August 1977. His responsibilities centered on the admissions of transfer students and special students, and he provided valued advice and counsel to many members of the M.I.T. community, including students, faculty, and administrators.

Robert L. Loria, Operations Manager at the Laboratory for Nuclear Science, died in February 1978. One of M.I.T.'s experts in the complicated procedures for procuring materials and equipment used in nuclear and particle physics, he was admired not only for his professional competence but for his courage in carrying on in the face of long-term illness.

Ralph Lowell, Life Member Emeritus of the M.I.T. Corporation, died in May 1978 at the age of 87. Long active in numerous Institute affairs, he served a total of 29 years on the M.I.T. Corporation, and since 1945 had been the sole trustee of the Lowell Institute, which supports the Lowell Institute School. He took an active, personal interest in the programs of M.I.T. and of the Lowell Institute School and in his passing, M.I.T. has lost not only a strong supporter but a good friend.

Dale Runge, Assistant Professor of Management, died in September 1977. During his five years at M.I.T. as student, research associate, and teacher, Professor Runge had been associated with the School's Systems Dynamics Group and his untimely death left unfulfilled a promising future.

C. Warren Smalzel, Institute Secretary for Corporations from 1964 until his retirement, last year, died suddenly in November 1977. Following a research and management career in the Navy and work in private industry, he came to M.I.T. in 1964 and served with energy and dedicated spirit in developing corporate relations for the Institute.

Allan J. Urquhart, M.I.T. Benefits Officer, died in July 1977 following a heart attack. At M.I.T. he was responsible for a large and complex benefits program, and was highly regarded for his wisdom and compassion in dealing with benefits problems by people throughout the M.I.T. community.

Silvio N. Vitale, M.I.T.'s fencing coach for 27 years until his retirement in 1975, died in February 1977. Affectionately known as "maestro," he saw to it that his M.I.T. teams ruled the New England Intercollegiate fencing scene for almost three decades. In addition, he was instrumental in starting the M.I.T. Day Camp, which has provided summer recreation to children in the M.I.T. and Cambridge communities for the past 18 years.

Irving W. Wilson, Life Member Emeritus of the Corporation, died in October 1977 following a brief illness. A member of the Class of 1911, he served nearly 28 years on the Corporation and gave generously of his time and talent to M.I.T. He took special interest in alumni affairs, was active as a member and head of several academic department visiting committees, and provided invaluable assistance in raising capital funds for the Institute. M.I.T. has benefited greatly from his participation in its governance and in his passing, has lost a wise and good friend.

JEROME B. WIESNER, PRESIDENT
PAUL E. GRAY, CHANCELLOR
STATISTICS FOR THE YEAR

The following paragraphs report briefly on the various aspects of the Institute's activities and operations during 1977-78.

Registration

In 1977-78 student enrollment was 8,712, an increase of 115 over the 8,597 in 1976-77. This total was comprised of 4,547 undergraduates and 4,165 graduate students. Graduate students who entered M.I.T. last year held degrees from 403 colleges and universities, 231 American and 172 foreign. The foreign student population was 1,598, representing 18 percent of the total population. The foreign students were citizens of 89 countries.

Degrees awarded by the Institute in 1977-78 included 1,083 bachelor's degrees, 934 master's degrees, 108 engineer's degrees, 425 doctoral degrees -- a total of 2,550.

The number of women at M.I.T., both graduate and undergraduate, has increased continually. In 1977-78, there were 1,382 women students at the Institute, compared with 1,361 in 1976-77. In September 1977, 174 first-year women entered M.I.T., representing 16 percent of the entering class. In 1977-78, a total of 348 degrees were awarded to women.

Student Financial Aid

During the 1977-78 year the student financial aid program was again characterized by increase in total awards, in loans made, and in the amount of scholarship assistance. There was a significant increase in the number of individuals assisted.

A total of 2,378 undergraduates who demonstrated the need for assistance (52 percent of the enrollment) received $6,204,594 in scholarship aid and $2,831,751 in loans. The total, $9,036,345 represented a 12 percent increase in direct aid over last year.

Scholarship assistance was provided by the scholarship endowment in the amount of $2,517,971, by outside gifts for scholarships in the amount of $1,006,916, and by direct grants to needy students totaling $1,356,242 (an increase of 20 percent). Scholarship assistance from M.I.T.'s own operating funds was provided to the extent of $1,201,340 (a 26 percent increase). The special program of scholarship aid to minority group students represented an additional $122,125 from specially designated funds. An additional 284 students received direct grants from outside agencies, irrespective of need. The undergraduate scholarship endowment was aided by the addition of new funds which represented an increase of $707,797 and which raised the principal of the endowment to $25,673,461.

Loans totaling $2,831,751 were made to needy undergraduates. Of this amount, $922,857 came from the Technology Loan Fund, and $1,908,894 from the National Defense Loan Fund. An additional $1,201,674 (a 57 percent increase) was obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources.

Graduate students obtained $1,391,397 from the Technology Loan Fund. Of this total, $779,853 was loaned under the Guaranteed Loan Program and qualified for Federal interest subsidies and guarantees. The total loaned by M.I.T. to both graduate and undergraduate students was $4,223,148, a decrease of 4 percent from last year's total.
Statistics for the Year

Loans
Staff awards for tuition
President and Chancellor

Career Planning and Placement

This was the busiest year in the Career Planning and Placement Office in a decade. A strong demand in industry for engineers, combined with rising enrollments in engineering, brought recruiters and students to the office in large numbers. A total of 333 private firms and government agencies made recruiting visits, many of them coming several times. Students met with them in over 6,000 interviews. For the fourth year in a row the Office published a resume book containing the resumes of US students in engineering and science. This year 580 students submitted resumes, 80 more than the year before and twice as many as in 1974-75, the first year of publication. The resume book, which is made available to employers at cost, was requested this year by 130 employers.

A small but significant number of the recruiting companies were from other countries. It is a development to be welcomed and encouraged, because the Institute's large contingent of international students generally has little opportunity to keep abreast of employment opportunities in their home countries. That they would like to stay in closer touch is clear. With the help of a grant from a Venezuelan national oil company, Lagoven S.A., the Office wrote in November to all non-US seniors and graduate students informing them of the services of the Home Country Employment Registry in Washington, established by the National Association for Foreign Student Affairs. A reply card was enclosed permitting a student to enter his or her credentials in the Registry. By the end of the year 480 students had returned the card. It remains to be seen how effective the Registry was in putting students in touch with employers.

The strong demand in industry for technically trained people was reflected in the area of Alumni Career Services, which received 2,166 job listings for experienced personnel compared with 1,687 in 1976-77, an increase of 28 percent. Openings were particularly numerous in electrical and mechanical engineering, programming, technical writing, and certain fields of management (sales, marketing, finance and business development). Many companies coming to recruit students seize the opportunity also to list openings for alumni.

The number of alumni registering with the Office dropped to 370 from 450 in 1976-77. The number of alumni registrants has traditionally declined when jobs have been more numerous. The registrants were older, with the percentage in their 20s dropping to 25 percent from 37 percent the year before and the percentage in their 30s rising from 30 to 45 percent. 30 percent were over 40.

Finances

As reported by the Vice President for Financial Operations and the Treasurer, the total financial operations of the Institute, including sponsored research, increased from the level of 1976-77. Education and general expenses -- excluding the direct expenses of departmental and interdepartmental research, and the Lincoln Laboratory -- amounted to $130,928,000 during 1977-78, compared to $117,057,000 in 1976-77. Reflected in the finances of the Institute was the use in operations of unrestricted funds of $5,875,000, compared with $5,801,000 the preceding year.

The direct expenses of campus departmental and interdepartmental sponsored research increased from $77,804,000 to $89,736,000, and the direct expenses of the Lincoln Laboratory's sponsored research increased to $96,595,000 from $80,503,000 because of an overall increase in government research support.

The construction program of the Institute continued to make progress in 1977-78 with the book value of educational plant facilities increasing from $203,340,000 to $205,992,000.
Statistics for the Year

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 $348,481,000 and a market value of $409,528,000. This compares to book and market totals of $332,706,000 and $401,096,000 last year.

Gifts

Gifts, grants, and bequests to M.I.T. from private donors increased from $26,899,000 in fiscal year 1976-77 to $31,287,000 in fiscal year 1977-78. The latter figure includes unrestricted direct gifts to the Alumni Fund of $1,949,000 which constituted part of the total of $4,972,000 reported by the Alumni Fund in 1977-78.

Physical Plant and Campus Environment

Completed during the year was the construction of Energy Laboratory Research Facilities and the upgrading of building services in the Sloan Automotive Laboratory (Building 31). This $3 million program included the installation of a three-megawatt combustion chamber, a fluidized bed facility, and a major upgrading of an existing Magnetohydrodynamic (MHD) Simulation Facility. Also included in the installation was a data acquisition computer facility to be shared by the various research programs.

Other projects completed included a 13,000 gross square foot interim animal care facility on Vassar Street between the Cyclotron (Building 44) and the Parsons Laboratory for Hydrodynamics (Building 48); renovations to Huntington Hall (10-250); renovations to the first floor of Building 10 for the Alumni Center-Exhibition Hall and the Electric Power Systems Engineering Laboratory. Also completed was an additional 4,000 gross square feet for cancer research in the Seeley G. Mudd Building. Finally, the construction of a new outdoor track, field and game facility of the Henry G. Steinbrenner (Class of 1927) Stadium was completed and dedicated in April 1978.

To accommodate the large entering class, Random Hall was reopened as a dormitory during the year. Although some maintenance was accomplished before occupancy, basic renovation work was deferred for the summer of 1978. A major part of this work involves energy-saving improvements to be funded through a low-interest loan from the Department of Housing and Urban Development. Through the efforts of both residents and staff members of various departments, Random Hall is functioning as an integral part of the housing system.

Various facilities programs, proposals, and studies were conducted during the year and numerous space change renovations and renewal projects were completed. Included among the latter were facilities for the Career Planning and Placement Office, Alumni offices, Department of Chemistry, Department of Mathematics, Information Center, News Office, Graphic Arts, Center for Materials Research in Archaeology and Ethnology, Department of Earth and Planetary Sciences as well as others.

The end of fiscal year 1978 marks the completion of the first full year of operation with the facilities management system, a $2 million computer-based network installed as an energy conservation measure utilized to centrally monitor and control 34 of the Institute's most energy intensive buildings. Original studies forecasted, and experience has verified, a pay-off period of less than two years for automatic control of building environmental systems.
Personnel Changes

CORPORATION

CHANGES OF APPOINTMENT

Louis W. Cabot
Life Member

Edward J. Hanley
Life Member Emeritus

Richard L. Terrell
Life Member

Katrina M. Wootton
Member

TERMS EXPIRED

Angus N. MacDonald
Member

Charles B. McCoy
Member

Laurence Storch
Member

James E. Turner
Member

DEATHS

Ralph Lowell
Life Member Emeritus

Irving W. Wilson
Life Member Emeritus

FACULTY

DEATHS

Christopher Goetze
Associate Professor of
Earth and Planetary Sciences

RETIREMENTS

William F. Bottiglia
Professor in Sloan School
of Management

William W. Buechner
Professor in Physics

J. Harvey Evans
Professor in Ocean Engineering

Irving Kaplan
Professor in Nuclear Engineering

Alfred A. H. Keil
Professor in School
of Engineering

Salvador E. Luria
Institute Professor

Kevin A. Lynch
Professor in Urban Studies
and Planning

Charles A. Myers
Professor in Sloan School
of Management

John B. Stanbury
Professor in Nutrition and
Food Science

George B. Thomas, Jr.
Professor in Mathematics
Personnel Changes

RESIGNATIONS

**Professors:**

Jack E. Baldwin  
Chemistry

Arden L. Bement  
Nuclear Engineering

Robert E. Hall  
Economics

William A. Little  
Civil Engineering

Donlyn Lyndon  
Architecture

Jose M. Roesset  
Civil Engineering

Henry M. Stommel  
Meteorology

**Assistant Professors:**

Kyu S. Woo  
Architecture

**Associate Professors:**

Barry A. Blesser  
Electrical Engineering and Computer Science

Lloyd A. Clomburg  
Chemical Engineering

William A. Davis, Jr.  
Urban Studies and Planning

Ira P. Goldstein  
Electrical Engineering and Computer Science

Eugene M. Kleinberg  
Mathematics

Ernesto Pollitt  
Nutrition and Food Science

David G. Schaeffer  
Mathematics

Richard S. Sidell  
Mechanical Engineering

Donald S. Barton  
Physics

Robert C. Channon  
Humanities

Peter P. Chen  
Sloan School of Management

Richard A. Cohn  
Sloan School of Management

Donald Corner  
Architecture

Carleton E. DeTar  
Physics

Owen L. Deutsch  
Nuclear Engineering

Stamatia Frondistou-Yannas  
Civil Engineering

Reuben T. Harris, Jr.  
Sloan School of Management

Douglas E. Kenyon  
Mechanical Engineering

James P. Kostman  
Linguistics and Philosophy

Alcira G. Kreimer  
Urban Studies and Planning

James M. Lyneis  
Sloan School of Management

Carol D. Meyer  
Chemistry

Lorenzo Morris  
Political Science

Bruce R. Patton  
Physics

Bryan R. Pearce  
Civil Engineering

Kevin W. S. Roberts  
Economics

Mary-Lou Sayles  
Athletics

Nak-Ho Sung  
Mechanical Engineering

Jenny Young  
Architecture

PROMOTIONS

To Professor:

David Botstein  
Biology

Nazli Choucri Field  
Political Science

Rudiger Dornbusch  
Economics

Shaoul Ezekiel  
Aeronautics and Astronautics

Paul L. Joskow  
Economics

Kenneth C. Russell  
Materials Science and Engineering

Gerald E. Schneider  
Psychology

Christopher T. Walsh  
Chemistry

Thomas F. Weiss  
Electrical Engineering and Computer Science

Ioannis V. Yannas  
Mechanical Engineering
President and Chancellor

To Associate Professor:

Arnold I. Barnett
Sloan School of Management

James M. Becker
Civil Engineering

George W. Brandenburg
Physics

Leonard G. Buckle
Urban Studies and Planning

Suzann R. T. Buckle
Urban Studies and Planning

Claude R. Canizares
Physics

Peter S. Donaldson
Humanities

Richard G. Donnelly
Chemical Engineering

Robert W. Field
Chemistry

Ted R. I. Greenwood
Political Science

Madhu S. Gupta
Electrical Engineering
and Computer Science

Robert M. Hollister
Urban Studies and Planning

David E. Housman
Biology

James Howe
Humanities

Richard O. Hynes
Biology

Robert L. Jaffe
Physics

John D. Joannopoulos
Physics

Paul C. Joss
Physics

John G. Kassakian
Electrical Engineering
and Computer Science

Ralph Katz
Sloan School of Management

Susan G. Kleinmann
Physics

James H. McEllan
Electrical Engineering
and Computer Science

Richard B. Melrose
Mathematics

Edward Y. Miller
Mathematics

Peter Molnar
Earth and Planetary Sciences

Peter A. Politzer
Nuclear Engineering

Robert O. Ritchie
Mechanical Engineering

Eugenia Kalnay de Rivas
Meteorology

Richard R. Schrock
Chemistry

Charles B. Thorn
Physics

Daniele Veneziano
Civil Engineering

Eric A. von Hippel
Sloan School of Management

Langdon Winner
School of Humanities and
Social Science

Ronald W. C. Yeung
Ocean Engineering

To Assistant Professor:

Walter A. Alessi
Athletics

John A. Benedick
Athletics

Joao Manuel de Oliveira
Ocean Engineering

William T. M. Dunsmuir
Mathematics

Elizabeth S. Hafen
Physics

Adi Shamir
Mathematics

Manuel Weiss
Athletics

Barry F. Zevin
Architecture

CHANGES OF APPOINTMENT

Timothy C. Aarset
Assistant Professor of
Humanities

Richard B. Adler
Professor of Electrical
Engineering and
Associate Head for
Electrical Science and
Engineering in Electrical
Engineering and Computer
Science

Nicholas Ashford
Associate Professor in
School of Engineering

James M. Becker
Class of 1922 Associate
Professor of
Civil Engineering

Jagdish Bhagwati
Ford International Professor
of Economics

Donald L. M. Blackmer
Director of Program in
Science, Technology, and
Society, Professor of
Political Science, and
Associate Dean of School of
Humanities and Social Science
Personnel Changes

Herbert S. Bridge
Professor of Physics and
Director of Center for
Space Research

Michael P. Cleary
Carl Richard Soderberg
Assistant Professor of
Mechanical Engineering

Muriel Cooper
Associate Professor of
Architecture

Fernando J. Corbató
Cecil H. Green Professor of
Computer Science and
Engineering in Electrical
Engineering and Computer
Science

Isabelle de Courtivron
Assistant Professor of
Humanities

William M. Deen
Hermann von Helmholtz
Assistant Professor of Health
Sciences and Technology and
Assistant Professor of
Chemical Engineering

Stan N. Finklestein
Assistant Professor in Sloan
School of Management

Stanley Fischer
Professor and Acting Associate
Head of Economics

James M. Flink
Research Associate in
Nutrition and Food Science

Christos Georgakis
Esther and Harold E. Edgerton
Assistant Professor of
Chemical Engineering

John M. Gerzso
Assistant Professor of
Architecture

Samuel A. Goldblith
Vice President for Resource
Development and Underwood-
Prescott Professor of Food
Science in Nutrition and
Food Science

Robert Halfman
Acting Dean for Student Affairs
and Professor of Aeronautics
and Astronautics

Harold F. Hemond
Assistant Professor of
Civil Engineering

Douglas A. Hibbs
Research Affiliate in
Political Science

Pierre A. Humblet
Assistant Professor of
Electrical Engineering and
Computer Science

Victor Kac
Associate Professor of
Mathematics

Shun Kanda
Associate Professor of
Architecture

Jack L. Kerrebrock
Richard Cockburn Maclaurin
Professor and Head of
Aeronautics and Astronautics

James L. Kinsey
Professor and Head of
Chemistry

Robert S. Langer
Assistant Professor of Nutrition
and Food Science

Raphael D. Levine
Visiting Professor of Chemistry

John D. C. Little
George Maverick Bunker Professor
in Sloan School of Management

Irving M. London
Grover M. Hermann Professor
of Biology, Director of Joint
Harvard-M.I.T. Division
of Health Sciences and
Technology, and Director of
Whitaker College of Health
Sciences, Technology, and
Management

George Lusztig
Professor of Mathematics

Boris Magasanik
Jacques Monod Professor
of Biology

Paula Menyuk
Visiting Professor of Health
Sciences and Technology in
Whitaker College of Health
Sciences, Technology, and
Management and Research
Affiliate in Research
Laboratory of Electronics

Walter E. Morrow, Jr.
Professor of Electrical
Engineering and Computer
Science and Director of
Lincoln Laboratory

Joel Moses
Professor of Computer Science
and Engineering and Associate
Head for Computer Science
and Engineering in Electrical
Engineering and Computer
Science

Janet H. Murray
Research Associate in
Humanities

Barbara S. Nelson
Assistant Professor and
Associate Director of
Division for Study and
Research in Education

David F. Noble
Assistant Professor in School
of Humanities and Social
Science
President and Chancellor

Francis Noblesse
Henry L. Doherty Assistant
Professor of Ocean Engineering

Charles M. Oman
Hermann von Helmholtz Associate
Professor of Health Sciences
and Technology and Associate
Professor of Aeronautics and
Astronautics

Frederick A. Putnam
Joseph R. Mares Assistant
Professor of Chemical
Engineering

Alician V. Quinlan
Henry L. Doherty Assistant
Professor of Mechanical
Engineering

Daniel Roos
Director of the Center for
Transportation Studies and
Professor of Civil Engineering

Edgar H. Schein
Sloan Fellows Professor of
Management in Sloan School
of Management

Robert C. Seamans, Jr.
Dean of School of Engineering
and Henry R. Luce Professor
of Environment and Public
Policy

William W. Seifert
Senior Lecturer in Civil Engineering

Jagadish Shukla
Visiting Associate Professor of
Meteorology

Dieter J. Sigmar
Adjunct Professor of Nuclear
Engineering

Kenneth A. Smith
Joseph R. Mares Professor
of Chemical Engineering

Rachel M. Strickland
Assistant Professor of
Architecture

Robert Suskind
Visiting Lecturer in Nutrition
and Food Science

Lawrence E. Susskind
Associate Professor and Head of
Urban Studies and Planning

William T. Thompkins, Jr.
Assistant Professor of
Aeronautics and Astronautics

Barbara A. Underwood
Associate Professor of Nutrition
and Food Science

Costas G. Vayenas
DuPont Assistant Professor of
Chemical Engineering

Gerald L. Wilson
Professor of Electrical and
Mechanical Engineering,
Philip Sporn Professor of
Energy Processing, Director of
Electric Power Systems
Engineering Laboratory, and
Head of Electrical Engineering
and Computer Science

Carl I. Wunsch
Cecil and Ida Green Professor of
Physical Oceanography and
Head of Earth and Planetary
Sciences

NEW FACULTY APPOINTMENTS

Professors:

Robert W. Balluffi
Materials Science and Engineering

Ronald C. Davidson
Professor of Physics and Director
of Plasma Fusion Center

Norman Geschwind
Harvard-M.I.T. Division of
Health Sciences and
Technology and Psychology

Loren R. Graham
School of Humanities and
Social Science

Daniel L. McFadden
Economics

Pauline R. Maier
Humanities

Satoru Masamune
Chemistry

Merritt R. Smith
School of Humanities and
Social Science

Associate Professors:

Michael J. Baum
Nutrition and Food Science

Dimitri P. Bertsekas
Electrical Engineering and
Computer Science

James L. Elliot
Associate Professor of Earth
and Planetary Sciences and
Director of the George R.
Wallace, Jr. Astrophysical
Observatory

Gary A. Hack
Urban Studies and Planning

Eduardo Kausel
Civil Engineering

Walter H. Olson
Harvard-M.I.T. Division of
Health Sciences and
Technology and Electrical
Engineering and Computer
Science

Daniel N. Osherson
Division for Study and Research
in Education and Psychology

Gregory A. Petsko
Chemistry
Personnel Changes

Michael Pyatok
Architecture

Emma G. Rothschild
Associate Professor and Director of the Writing Program in Humanities

Edward B. Turk
Humanities

Stephen J. Vamosi
Architecture

William S. Widnall
Aeronautics and Astronautics

Assistant Professors:

A. Julia Alissandratos
Humanities

Dimitri A. Antoniadis
Electrical Engineering and Computer Science

Arvind
Electrical Engineering and Computer Science

Alan D. Brinkley
Humanities

Kathryn J. Crecelius
Humanities

Judith W. DeCew
Linguistics and Philosophy

Raymond Deck, Jr.
Humanities

David Dollenmayer
Humanities

David H. Friedman
Architecture

Sy David Friedman
Mathematics

Howard R. Horvitz
Biology

Hilary M. Irvine
Civil Engineering

Roger D. Kamm
Mechanical Engineering

Jae S. Lim
Electrical Engineering and Computer Science

Edwin W. McCann
Linguistics and Philosophy

Michael D. Meyer
Civil Engineering

Gary L. Miller
Mathematics

Michael G. O'Callaghan
Mechanical Engineering

Marie-Elisabeth Paté
Civil Engineering

Stephen B. Pope
Mechanical Engineering

David P. Reed
Electrical Engineering and Computer Science

Mary F. Roberts
Chemistry

Jay Rosellini
Humanities

William R. Roush
Chemistry

Donald R. Sadoway
Materials Science and Engineering

Robert T. Sauer
Biology

Warren P. Seering
Mechanical Engineering

Peter M. Senge
Sloan School of Management

Yosef Sheffi
Civil Engineering

Frank S. Spear
Earth and Planetary Sciences

Thomas J. Teisberg
Economics

Eugene B. Trubowitz
Mathematics

Alexander J. Varshavsky
Biology

David A. Vogan
Mathematics

John S. Whitaker
Physics

Paul C. Xirouchakis
Ocean Engineering

Henry I. Smith
Electrical Engineering and Computer Science

Joseph Ablow
Humanities

Hans A. Bethe
Physics

Dean R. Chapman
Jerome Clarke Hunsaker Visiting Professor in Aeronautics and Astronautics

Hugh L. Davies
Crosby Visiting Professor in Earth and Planetary Sciences

Francisco R. del Valle
Nutrition and Food Science

Charles A. Desoer
Electrical Engineering and Computer Science
President and Chancellor

Robert F. Engle
Economics

M. Gareth Evans
Linguistics and Philosophy

Robert W. Floyd
Electrical Engineering and Computer Science

Saul Friedlander
School of Humanities and Social Science

Joseph L. Gastwirth
Mathematics

Eugene Goodheart
Humanities

Howard E. Gruber
Division for Study and Research in Education

Charles Harbutt
Architecture

David A. Kendrick
Sloan School of Management

Marion E. Koshland
Biology

Andras Kovach
Humanities

David Lazarus
Physics

Marianne Martin
Humanities

Adolf D. May
Civil Engineering

James D. Murray
Mathematics

Mahmood J. Nahvi
Electrical Engineering and Computer Science

Werner Oechslin
Architecture

Mario Ojeda-Gomez
Political Science

Yoh-Han Pao
Electrical Engineering and Computer Science

Peter S. Pershan
Physics

John G. Proakis
Electrical Engineering and Computer Science

Robert B. Raphael
Physics

Fritz Ringer
Humanities

Georges Ripka
Physics

Som D. Sharma
Ocean Engineering

Hermina Sinclair-de Zwart
Division for Study and Research in Education

Raphael Sivan
Aeronautics and Astronautics

Gordon L. Squires
Physics

Ingrid Stadler
Humanities

John H. Sweeney III
Visiting Professor and Head of Naval Science and Professor of Ocean Engineering

Ning H. Tang
Civil Engineering

Hugh P. Taylor, Jr.
Crosby Visiting Professor in Earth and Planetary Sciences

Sheldon H. White
Division for Study and Research in Education

Visiting Associate Professors:

J. Robin Arthur
Civil Engineering

Lance F. Bosart
Meteorology

Richard N. Boyd
Linguistics and Philosophy

Jane E. Bridge
Mathematics

Harvey A. Cohen
Division for Study and Research in Education

Lynn Conway
Electrical Engineering and Computer Science

John C. Cox
Sloan School of Management

Ray C. Fair
Economics

Thane Gustafson
Political Science

John V. Guttag
Electrical Engineering and Computer Science

Lloyd J. Griffiths
Electrical Engineering and Computer Science

Joel L. Horowitz
Civil Engineering

Herbert E. Klei
Nutrition and Food Science

Alain L. Kornhauser
Civil Engineering

Donald Q. Lamb, Jr.
Physics

E. Harry Law
Mechanical Engineering
Personnel Changes

Mark Liberman  
Linguistics and Philosophy

Richard W. Longman  
Mechanical Engineering

Kenan E. Sahin  
Electrical Engineering and Computer Science

Audrey Terras  
Mathematics

Wilhelmus A. Wetjs  
Harvard-M.I.T. Division of Health Sciences and Technology

Visiting Assistant Professors:

Steve Barnett  
Humanities

Zvi Bodie  
Sloan School of Management

Carolyn Dry  
Architecture

James W. Foss  
Architecture

Shun Kanda  
Architecture

Nellie McKay  
Humanities

Allen J. Michel  
Sloan School of Management

Eduardo M. Modiano  
Sloan School of Management

Seyed Ahmad Noorbakhsh  
Aeronautics and Astronautics

William F. Schelter  
Mathematics

Elena Semeka-Pankratov  
Humanities

David R. Wheeler  
Urban Studies and Planning

AWARDS

Robert M. Solow  
Killian Award Lecturer for the Academic Year 1977-78

ADMINISTRATION

DEATHS

James B. Lampert  
Vice President for Resource Development

RETIRED

Paul V. Cusick  
Vice President for Fiscal Relations

Robert J. Davis  
Director Office of Personnel Relations

Mark J. Dondero  
Safety Engineer Safety Office

James E. Gross  
Manager, Campus Housing Maintenance Services Housing and Food Services

Mary D. Howe  
Assistant to the Director Summer Session Office

Arthur H. Litchfield  
Buyer Purchasing Office

Priscilla E. Mead  
Program Administrator Office of Personnel Development

William B. Morrison  
Manager Faculty Club

Frederic W. Watriss  
Associate Treasurer

RESIGNATIONS

A. Blair Bergstrom  
Journals Manager MIT Press

James J. Bishop  
Associate Dean for Student Affairs/Counselor Dean for Student Affairs

Carol M. Bostick  
Senior Staff Accountant Associate Treasurer and Recording Secretary

Jane Browning  
Program Coordinator, Ph.D. Program Sloan School of Management

Kenneth C. Browning  
Associate Dean for Student Affairs

Joseph G. Carr  
Manager of Proposals and Publications Resource Planning

Alfred R. Doig, Jr.  
Senior Industrial Liaison Officer Industrial Liaison Program

James P. Donohue  
Director, Systems Planning and Development Information Processing Services

Carola B. Eisenberg  
Dean for Student Affairs

Maiajaleena Elkins  
Staff Writer/Editor School of Architecture and Planning

Eric H. Engberg  
Programming Analyst Information Processing Services

Arthur B. Evans  
Acquisitions Editor MIT Press
Mario G. Furtado  
Design Manager  
MIT Press

Laura W. Giroux  
Administrative Officer  
Laboratory of Architecture and Planning

Jay Goldman  
Systems Programmer  
Information Processing Services

David J. Griffiths  
Programming Analyst  
Information Processing Services

Charles A. Hatvany  
Senior Systems Analyst  
Alumni Association

Colin H. Jones  
Acquisitions Editor  
MIT Press

Kevin J. Kinsella  
District Officer  
Volunteer Leadership Campaign

Susan C. Knight  
Associate Director, Council for the Arts at M.I.T.  
Office of the President and Chancellor

Frederick D. Leach  
Area Coordinator  
Information Processing Services

Walter Lehmann  
Assistant Director  
M.I.T. Associates Program

Michael F. Luck  
Director, Development Office  
Resource Planning

Howard A. Markowitz  
Liaison Officer, Detroit Institute of Technology-M.I.T. Association  
Vice President for Research

Victor M. Maslov  
Senior Systems Analyst  
Resource Planning

Catherine R. McDonald  
Area Coordinator  
Information Processing Services

Francis H. McGrory  
Assistant Director  
Office of Sponsored Programs

Anne K. Mengler  
Assistant to the Director, Development Office  
Resource Planning

Bernard A. Morris  
Administrative Assistant  
Civil Engineering

Carsten C. Mortensen  
Applications Programmer  
Information Processing Services

Christopher L. Mullendore  
Systems Programmer  
Information Processing Services

Ellen O. O'Hara  
Program Administrator  
Office of Personnel Development

William G. Otenti  
Assistant Manager  
Credit Union

Lewis A. Redding  
Personnel Officer  
Office of Personnel Services

Stephen Ringle  
Gallery Manager  
Committee on the Visual Arts

Paul J. Sala, Jr.  
Manager, Programming and Development  
Information Processing Services

Christine A. Samia  
Systems Analyst  
Information Processing Services

Anne Sayre  
Publicity Manager  
MIT Press

Dennis L. Sheckler  
Systems Programmer  
Information Processing Services

Marjory Supovitz  
Projects Director  
Committee on the Visual Arts

Peter Talbert-Hall  
Sales Representative  
MIT Press

Paul S. Tasner  
Editor  
MIT Press

A. Christine Thomas  
Administrative Assistant  
School of Humanities and Social Science

APPOINTMENTS AND CHANGES

Janet K. Anderson  
Assistant Director for Administration  
Industrial Liaison Program

Gene F. Armstrong  
Computer Services Coordinator  
Information Processing Services

Richard S. Armstrong  
Assistant Director of Admissions  
Admissions Office

Roderick R. Arthur  
Business Manager and Assistant to the Director of Athletics

Bernard S. Autrey, Jr.  
Project Architect  
Physical Plant

Vera Ballard  
Program Administrator  
Office of Personnel Development

Barbara Barlow  
Administrative Assistant  
School of Architecture and Planning
Personnel Changes

Clare Stanley Beard
Applications Programmer
Information Processing Services

Robert F. Berman
Applications Programmer
Information Processing Services

Doris Cole Berizzi
Architect, Building Programming and Design
Physical Plant

Laurence H. Bishoff
Chief Administrative Officer, M.I.T. Health Plan and Associate Director for Administration
Medical Department

John T. Blake
Systems Analyst
Information Processing Services

D. Steven Blum
Staff Writer/Editor
Resource Planning

Mildene D. Bradley
Co-Manager, In-House Composition System
MIT Press

Ronald Calderon
Senior Staff Accountant
Comptroller's Accounting Office

Clare K. Chapman
Senior Researcher/Writer
Resource Development

Deborah J. Cohen
Manager, Proposals and Publications
Resource Planning

Laurence Cohen
Acquisitions Editor
MIT Press

Anthony Colozzi
Facilities Officer
Electrical Engineering and Computer Science

Laurence J. Connelly
Accounting Officer
Comptroller's Accounting Office

Roger Lloyd Conover
Acquisitions Editor
MIT Press

Loren C. Cox
Executive Director, Center for Energy Policy Research
Sloan School of Management

Paula B. Cronin
Associate Director for Placement
Sloan School of Management

Irvin F. Curtis
Administrative Assistant
Mechanical Engineering

Anthony R. Davis
Assistant Director
Office of Sponsored Programs

Stephen P. Denker
Director of M.I.T. Alumni Fund
Alumni Association

Wendell A. Derry
Institute Property Officer
Office of Facilities Management Systems

Mary E. DeSesa
Administrative Assistant
MIT Press

Jane P. Devlin
Senior Programming Analyst
Information Processing Services

Anthony Dovidio
Applications Programmer
Information Processing Services

John F. Doyle
Assistant to the Director
Office of Sponsored Programs

Michael Frey
Senior Applications Analyst
Office of Facilities Management Systems

Frances W. Gardiner
Assistant to the Director of Placement
Sloan School of Management

Haig Gechijian
Staff Engineer, Manager of Engineering Services
Physical Plant

Marc S. Gerstein
Assistant Curator
Committee on the Visual Arts

Jill A. Gilpatrick
Director of Sports Information Athletics

Stephen Gorman
Assistant Accounting Officer
Comptroller's Accounting Office

Joyce J. Graham
Senior Programming Analyst
Information Processing Services

Virginia Gunter
Director, Margaret Hutchinson Compton Gallery Committee on the Visual Arts

Kathy Halbreich
Projects Director
Committee on the Visual Arts

James F. Hanlon
Staff Accountant
Comptroller's Accounting Office

Sharon L. Harris
Financial Administrator
Chemistry

Earl M. Harvey
Staff Architect/Coordinator of Architectural Design
Physical Plant

Martha J. Heigham
Administrative Assistant
Operations Research Center
Personnel Changes

Susan S. Minai-Azary
Systems Programmer
Information Processing Services

Conor Moran
Manager of West Plaza
Superintendent's Office

Patricia Moulton
Administrative Assistant
Office of Sponsored Programs

Cheryl A. Murphy
Assistant Director, Undergraduate Research Opportunities Program
Office of the President and Chancellor

Victoria J. Murphy
Administrative Assistant
Civil Engineering

John E. Newcomb
Associate Director
Center for Advanced Engineering Study

Margaret M. Norris
Assistant to the Dean for Student Affairs
Dean for Student Affairs

Richard J. Noyes
Manager of Self-Study Subject Development
Center for Advanced Engineering Study

Peggy O'Brien
Employment Officer
Office of Personnel Services

Rene H. Olivieri
Acquisitions Editor
MIT Press

Paul A. Palmisciano
Systems Analyst
Information Processing Services

Michael J. Parr
Assistant Manager of Labor Relations
Office of Personnel Relations

George N. Petievich
Resident Administrative Officer, Technology Adaptation Program
Office of the Provost

Kenneth R. Phillips
Senior Staff Accountant
Comptroller's Accounting Office

Leonard A. Phillips
Staff Writer/Editor
Alumni Association

Daniel R. Pike
Gallery Manager
Committee on the Visual Arts

Nancy C. Pitts
Systems Programmer
Information Processing Services

John T. Preston
Assistant Director
M.I.T. Associates Program

Robert J. Radocchia
Manager
M.I.T. Quarter Century Club

Ann Reinke
Journals Manager
MIT Press

Wendy J. Richmond
Associate Designer
MIT Press

Kathleen Anne Rick
Personnel Officer
Office of Personnel Services

Linda L. Rounds
Financial Manager
Medical Department

Barry M. Rowe
Director of Purchasing and Stores Purchasing Office

Joseph M. Salvatore
Staff Architect/Engineer, Project Development
Physical Plant

Roger A. Samuel
Industrial Liaison Officer
Industrial Liaison Program

George K. Sankey
Industrial Liaison Officer
Industrial Liaison Program

Donna R. Savicki
Administrative Officer
Aeronautics and Astronautics

Donna A. Schenkel
Designer
MIT Press

Mabelle B. Scofield
Administrative Assistant
Civil Engineering

Thomas A. Shea
Area Coordinator
Information Processing Services

Garrett L. Sheldon
Manager, Business Systems Development
Information Processing Services

Robert A. Sherwood
Associate Dean for Student Affairs
Dean for Student Affairs

W. Olin Sibert
Systems Programmer
Information Processing Services

Elsa G. Sonnabend
Associate Director, Council for the Arts at M.I.T.
Office of the President and Chancellor

Natalie D. Speckmann
Administrative Assistant
Mechanical Engineering

Jimmy Edwin Stover
Applications Programmer
Information Processing Services

Donna J. Taylor
Associate Benefits Officer
Office of Personnel Relations
President and Chancellor

Andrew M. Thomson  
Technical Supervisor  
Information Processing Services

Michael S. Thornton  
Staff Writer/Editor  
Information Processing Services

William Toscano  
Staff Accountant  
Harvard-M. I. T. Division of Health Sciences and Technology

Alice W. Tripp  
Program Coordinator  
Resource Planning

Pamela W. Turner  
Director of Recruitment and Placement, Manager of Accelerated Master's Program, and Lecturer Sloan School of Management

Thomas F. Vacha  
Project Director, Facilities Management Systems  
Physical Plant

Rosemary Viano  
Administrative Assistant  
Athletics

Bruce D. Wedlock  
Director of Patent Marketing, Director of Lowell Institute School, and Lecturer in Electrical Engineering and Computer Science

Barbara Sutton Weinblatt  
Assistant for Special Events  
Campus Information Services

Sandra Marie Wells  
Senior Applications Programmer  
Information Processing Services

Sandramarie G. Williams  
Administrative Assistant  
Mechanical Engineering

Virginia L. Willis  
Administrative Assistant  
Nutrition and Food Science
A major focus during the past year has been a series of initiatives to tackle what remains a vexing problem on all college campuses: the persistence of tensions between different ethnic groups, tensions that reflect the problems of the larger society in which we live. Committees of students, faculty, and staff have worked on developing educational programs to improve understanding via lecture series and small group meetings. This is not a task that can be completed but must represent the commitment to a continuing effort in the years to come.

The housing program has been remarkably successful in maintaining student morale in the face of great overcrowding. This was due to the leadership provided by Associate Dean Kenneth Browning. Ken's unusual talents merited -- and obtained -- recognition when he was offered and accepted the position of Vice-Provost of Grinnell College in Iowa. All of us felt the loss personally but shared his pride in the new post; we wish him well. A Search Committee formed in the spring selected an excellent successor: Robert Sherwood was appointed as Associate Dean for Student Affairs with responsibility for our housing programs. The Residents Program was strengthened with the appointment of Professor Julian and Doreen Beinart as the new Faculty Family in Residence at Burton-Conner. On a negative note, we will lose the Senturias from McCormick; the process of searching for their successors has begun.

The Office of Freshman Advising, restructured in accordance with the recommendations of the Rogers Committee, has gotten off to a splendid start under the leadership of Dr. Alan Lazarus, Senior Research Scientist in the Department of Physics, ably supported by the continuing efforts of Assistant Dean for Student Affairs, Bonny Kellermann.

The Advising and Counseling Section enjoyed an excellent year. A major new initiative, under the leadership of Dean Robert Halfman, was the development of a proposal for a Peer Advising System, endorsed by the Committee on Student Environment and the Psychiatric and Social Service. We have also received a commitment for small financial support from the administration, and staff backing from the Office of the Dean for Student Affairs and the Medical Department. The plan is set for inauguration in fall 1978. All of us were saddened by the imminent departure of Associate Dean James J. Bishop, who has been appointed Dean of Students at Amherst College. It is a tribute to the excellence of the Office of the Dean for Student Affairs that two of our colleagues, Ken and Jim, have secured such major posts.

Within the Office of the Dean for Student Affairs, we have continued our efforts to plan a program that will allow us to focus attention on problems at the Institute which are not the particular responsibility of any given group, and yet are of a major concern to the community as a whole. Dean Holliday Heine chaired a committee consisting of faculty, staff, and students which worked this spring to plan the first meeting of the series for fall 1978. The agenda for September will be the topic of "Taking Time Away from M.I.T."

From a personal standpoint, the most rewarding part of my work as Dean for Student Affairs continues to be the opportunity to get to know M.I.T. students, through undergraduate seminars, freshman and pre-medical advising, dinners in the housing system, gatherings in my
home, advising students individually and in small groups, and participating with them in planning and decision making about community life at the Institute. The year begins with a bang during R/O Week and ends in the nostalgic leave-taking at graduation when I again have the opportunity to meet many of the parents who have given us the privilege of having their children as students.

What keeps us all alive, staff and faculty alike, is the exuberance, the excitement, and the creativity of the splendid young men and women we continue to be able to recruit. With such good beginnings, the endings are sure to be superb.

CAROLA EISENBERG

Office of Freshman Advising (O.F.A.)

This is the first year following the report of the Freshman Advisory Council Steering Committee, and many of its recommendations have been put into effect. There were two major changes. First, the new director of the office is Associate Dean for Student Affairs, Dr. Alan Lazarus, who serves half-time; he also has a half-time appointment in the Department of Physics as Senior Research Scientist. The intent of the Steering Committee was to make a closer link to the faculty by having a full or part-time faculty member as director.

Dean Bonny Kellermann has continued to serve full-time in the office. She has acted as associate director and provided the continuity and knowledge that has made the half-time role possible. Her continued dedication and perspective on the freshman year have been the mainstay of the program.

Second, as recommended by the Steering Committee, the name of the office was changed to the Office of Freshman Advising to reflect a broader concern with the freshman year, and an ad hoc Committee on Freshman Advising (C.O.F.A.) was appointed by the President to advise and assist the director. The members of the committee are: Professor Carl Garland, Chemistry; Dr. Lazarus, ex officio; Professors James Melcher, Electrical Engineering and Computer Science (Chairman); James Munkres, Mathematics; Stewart Myers, Management (C.E.P. representative); John Marcou, Class of 1978 (term ending fall 1978). Dean Kellermann has also attended the meetings. The broad spectrum of the members' views and their deep commitment to the Institute have been especially helpful.

In recruiting new freshman advisors, we followed the Steering Committee's recommendations and concentrated our efforts on faculty in an attempt to make a small shift towards increased faculty involvement. For July 1978 the resulting distribution of advisors will be as follows:

<table>
<thead>
<tr>
<th></th>
<th>Faculty</th>
<th>Instructors/Lecturers</th>
<th>Staff</th>
<th>Graduate Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978-79</td>
<td>107</td>
<td>26</td>
<td>70</td>
<td>26</td>
</tr>
<tr>
<td>1977-78</td>
<td>115</td>
<td>21</td>
<td>72</td>
<td>40</td>
</tr>
<tr>
<td>New Advisors</td>
<td>23</td>
<td>12</td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>
Except for a decrease in the number of graduate student advisors, (since we did not recruit any) there was little change. Nevertheless, the willingness of so many advisors to make a voluntary time commitment in the face of increasing and budgetary pressures is impressive. It should also be stressed that most advisors have undergraduate "associate" advisors who provide current information on the realities of undergraduate life at M. I. T.

**Academic Performance**

This year's freshman class worked hard and seriously on academic matters, according to anecdotal information. Nevertheless, the formal statistics show an apparent increase in the number of students receiving either a formal warning of unsatisfactory performance from the Committee on Academic Performance ("C.A.P. warning") or a more informal letter from our office (O.F.A. letter) suggesting that the student think over his or her performance and discuss it with one of several resources. The fluctuations from year to year are curious.

<table>
<thead>
<tr>
<th>C.A.P. Warning</th>
<th>O.F.A. Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring 1978</td>
<td>75</td>
</tr>
<tr>
<td>Spring 1977</td>
<td>47</td>
</tr>
<tr>
<td>Spring 1976</td>
<td>68</td>
</tr>
</tbody>
</table>

Ten freshmen were required to withdraw for at least one term; (three were required to withdraw at the end of the fall term). Eighteen other students withdrew for various reasons during the first year.

The principal counseling of freshmen is done by their advisors, but we continue to counsel individual students who come to our office independently or who are urged to come by their advisors.

We continued to stress the importance of using the freshman evaluation forms as means of providing a fuller view of a student's performance and as a crucial component of the pass/fail freshman grading system. Shown below are the results of a study of the returns of evaluations for a sample of 50 students (of 1,073) during the past academic year.

<table>
<thead>
<tr>
<th>Percentage of Evaluations Returned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 1977</td>
</tr>
<tr>
<td>Mid</td>
</tr>
<tr>
<td>Chemistry</td>
</tr>
<tr>
<td>Humanities</td>
</tr>
<tr>
<td>Mathematics</td>
</tr>
<tr>
<td>Physics</td>
</tr>
<tr>
<td>Spring 1978</td>
</tr>
<tr>
<td>Mid</td>
</tr>
<tr>
<td>Chemistry</td>
</tr>
<tr>
<td>Humanities</td>
</tr>
<tr>
<td>Mathematics</td>
</tr>
<tr>
<td>Physics</td>
</tr>
</tbody>
</table>

* no data
It is evident that we need to improve the use of the evaluations in the spring term especially at the end when time pressures are so intense. In the fall term, students and instructors tend not to use the forms when class communication is good enough to make the forms seem superfluous. We need to understand the reasons for the drop in the spring.

Members of the O.F.A. continue to serve on faculty committees ex officio: the Committee on Academic Performance, the Committee on Curricula, and the Committee on Undergraduate Admissions and Financial Aid. In addition, we hold membership on the faculty/staff Advisory Committee to the Office of Minority Education, the Upward Bound Steering Committee, and the Community Service Fund. We also attend meetings chaired by Dean Robert Alberty for faculty teaching science requirement subjects taken by many freshmen.

John Shelton, Class of 1979, was student coordinator for 1977 Residence/Orientation Week. Barry Newman, Class of 1979, is in the process of coordinating these efforts for fall 1978.

Approximately a dozen students participated in a Freshman Handbook Workshop which began during I.A.P. and continued into the spring semester. These students gave their advice on revisions and solicited and selected quotations and essays from students for the new book. Margo Woodruff contributed her expertise as one of the photography editors for the book.

Staff Changes

Marie-France Pierre left her half-time administrative assistant position in March. Susan Barham will continue in her half-time administrative assistant position until September. Rosemary Mone was hired in May for the principal secretarial position. Deborah Andrew replaced Elizabeth Pierce in September. Her position provides secretarial support for the Undergraduate Seminar Program as well as the Office of Freshman Advising.

Rosebeth Rosen, Class of 1978, and William Harper, Class of 1979, continued to serve as student assistants during the academic year. Roger Goun, Class of 1981, was hired to replace Ms. Rosen who graduated in June.

Undergraduate Seminar Program

The Undergraduate Seminar Program was fortunate to have Professor Michael Driscoll accept the responsibility of Faculty Chairman this year. With this assistance, the program provided the opportunity for increased numbers of undergraduates to participate in learning situations generally characterized as current and interactive. Although the offering of 60 seminars in the fall term was slightly below the number offered last year, enrollment showed an all-time high of 901 students (702 freshmen and 199 upperclass students) registered in the fifth week of the fall term. The 39 seminars offered in the spring term also showed a slight decrease from previous years. Fifth-week registration showed 545 students (323 freshmen and 222 upperclass students) enrolled in seminars in the spring term.
A major issue which came up during the year concerns seminar instructors who are not members of the faculty. These seminars are to be reviewed by appropriate departments whenever possible; we are still reviewing how to deal with seminars which do not fall under the purview of any department.

BONNY S. KELLERMANN

Undesignated Sophomore Program

The erratic downtrend of the past few years continued -- 140 students registered for the fall term and 105 for the spring. Comparable numbers for the previous year were 170 (fall term) and 101 (spring term). There were also fewer volunteers for advising -- for this period there were 60 advisors drawn from the majority of Courses similar in range and experience to the students' freshman advisors.

The Advising and Counseling section continued the support formerly offered, especially with end of term difficulties.

ROBERT L. HALFMAN

Office of Preprofessional Advising and Education

The Office of Preprofessional Advising and Education continued to provide a focus for students who are interested in careers in medicine and law. Throughout the year meetings were arranged as an effective way to provide information to students.

In September, meetings with freshmen acquainted them with the advisory services of the Premedical and Prelaw councils as well as services available from the Preprofessional Advising and Education Office. Later that month, Dr. Jacob Swartz, Associate Dean of the Boston University School of Medicine, spoke with medical school applicants about the nature and format of the medical school interview. In February, sophomores were told of the planning necessary for a medical education. That same month, members of the Council met with students who will be attending medical school next year. Discussion focused on criteria for selecting among medical schools. In March, a session was held to acquaint M.I.T. students with the recent changes on the Medical College Admission Test (MCAT). In April, there were meetings for students who will apply for admission to medical or law school for the class entering in September 1979.

Representatives from two medical schools, eight law schools, one dental school, and one school of health administration visited M.I.T. during the year. They met with students as well as members of the Advisory Councils. These sessions are of benefit to the Advisory Councils and the students as well as the professional schools in that they provide a source of helpful information.
Dean Susan Haigh Houpt attended the meeting of the Northeast Association of Advisors to the Health Professions in New York City in April. She also participated in the annual meeting of the Northeast Association of Prelaw Advisors at Haverford College in Philadelphia in June. The contacts made at these meetings, both with other advisors and with professional schools, provide an opportunity for mutual support.

Dean Houpt organized an informal gathering of premedical students at the home of Dean Carola Eisenberg. Physicians, medical students, and premedical students were invited to share their thoughts about medical education and the medical profession.

Dean Houpt continues to serve as advisor to the Association of Black Premedical Students, and sponsored one of the members who attended the annual meeting of the Student National Medical Association at Meharry Medical College in April. The students benefit from the experience of meeting with black medical students and physicians at these conferences.

During Independent Activities Period, the Preprofessional Advising and Education Office sponsored or cosponsored a number of offerings. These included, "So You Want to Be a Lawyer," cosponsored with Professor Lawrence Bacow; "A Brief Introduction to the Law," cosponsored with Professor Jeffrey Meldman; and "Issues and Concerns for those Planning a Medical Career."

During this past year 87 members of the class of 1980 were assigned to members of the Premedical Advisory Council. It is anticipated that several more members of the class will be assigned to advisors in September. Last year at this time, 86 individuals who will apply for admission to medical school in 1979 had been assigned to advisors; at the present time, that number has grown to 165.

Letters were written in support of 61 applicants to law school. Law schools often require a letter from M.I.T. attesting to a student's citizenship while he or she was registered as a student. Thirty-one letters for currently registered students and 30 letters for former students were written.

PREMEDICAL AND PRELAW STATISTICS

A total of 149 individuals applied to medical and dental schools for admission in 1978. Admission to at least one school was obtained by 76 (75 percent) of the 101 S.B. candidates, and 21 (41 percent) of the additional 48 applicants. Altogether the 149 applicants submitted 2,015 applications to 108 medical schools, a mean of 19 per student.

Ninety-seven applicants received acceptances from 65 medical schools. The mean number of acceptances was 2.4 among the students who received acceptances. The ratio of acceptances to applications was 9 percent.

Four citizens of foreign countries applied to medical school in the US. One was admitted.

Thirty-two of the accepted applicants (33 percent) were accepted to only one school. Nineteen of these were accepted only by their state school (30 percent of the total number of applicants accepted).

Ninety-five applicants are attending 42 medical schools; two have deferred their acceptance for one year.
Minority Student Support

Eight second- and third-year students applied to medical school; 1 was admitted.

Twenty-two of the applicants had failed to gain admission to medical school in a previous year; 8 were admitted (36 percent).

Twenty-one alumni of M.I.T. applied to medical school through the Preprofessional Advising and Education Office. Eight (38 percent) were admitted. Of the 7 alumni who applied to medical school for the first time, 2 (28 percent) were admitted.

Thirty-eight undergraduate and graduate students and 32 alumni who graduated between 1943 and 1977 applied to law school for admission in 1978. They submitted 468 applications to 61 law schools. The students submitted an average of 8 applications. The alumni submitted an average of 5 applications.

Six (18 percent) of the students accepted to law school have decided not to attend. Two students have received deferrals for one year. Four (18 percent) of the alumni who were accepted to law school have decided not to attend.

We received 105 LSAT scores for 95 individuals. This includes the scores for 34 people who never applied to law school.

Ten applicants repeated the LSAT. They showed an improvement of from 1 to 125 points. The average improvement in score was 66 points. The mean scores are 694 for students who applied to law school and 708 for alumni who applied.

SUSAN HAIGH HOUP'T

Minority Student Support

Support activities for minority students continue to be a primary function of the Office of the Dean for Student Affairs.

Small group and individual discussions with students, alumni, parents, faculty, and staff are an important source of information concerning the minority students' educational experience at the Institute.

Incidents interpreted as having negative racial overtones at the beginning of the 1977-78 academic year indicated the need to continue to focus on operational objectives defined in 1976: 1) to help prevent "crisis" situations; 2) to define and develop social attitudes and behavior that influence the development of a positive self-image, thereby resulting in achievement-motivation. Several lectures by Brenda Verner, political and media analyst, were used as a heuristic technique to motivate a positive self-identity and to understand the origin of certain negative attitudes and myths pervasive in our society. The lectures were entitled: "Historical Stereotyping of African-American Women and Children in Popular Media," "Historical Images of African-American Men in Popular Media," and "Historical Stereotypes: African-American Family and Culture."

Special interest groups, professional and service, such as the M.I.T. Black Electrical, Mechanical, and Chemical Engineers, Association of Black Pre-medical Students and the
National Society of Black Engineers, continue to thrive with the advice and counseling of faculty members.

Improved interpersonal relationships resulted from group meetings of minority undergraduate men and women. Several meetings, by student request, were held with students from Harvard and Brown universities and Wellesley College. Because of the growth and interest of the weekly minority female undergraduate discussion groups, a similar group for minority undergraduate males was initiated in spring 1978. Staff advisors were James J. Bishop, Associate Dean for Student Affairs; Nelson Armstrong, Director, Student Employment; John L. Mack, Associate Director of Admissions; and Isaac Colbert, Consultant/Trainer, Office of Personnel Development.

The establishment of an undergraduate chapter of the national sorority of Alpha Kappa Alpha, Inc. has enriched the lives of the African-American undergraduate women by offering several options for participating in helping others. The sorority serves as a means of contacting other students in the New England area. The members' service projects include "Tutoring Plus," special tutoring programs for SATs and ACTs for local high school students, and library assistance for the Boston Public School system. Several social activities were also sponsored for the M.I.T. student community.

The M.I.T. Gospel Chorus sponsored its annual concert which was a very successful event.

Several career seminars to acquaint students with career options in science and engineering were jointly sponsored by the General Electric and Procter & Gamble Corporations.

Forty-nine African-American students including two college transfer students were registered in the Class of 1978. Forty-six percent or 23 students graduated in 1978. Two students graduated in 1977 and one student graduated in 1976. Fifty-three percent of the Class of 1978 received undergraduate degrees. One student from the Class of 1971 received an undergraduate degree in June 1978. A total of 27 African-Americans received undergraduate degrees in June 1978.

Ten Mexican Americans registered in the Class of 1978. Four students received undergraduate degrees, a total of 40 percent.

Seven Puerto Rican students registered in the Class of 1978 including one college transfer student. Five students or 71 percent of the total number of students received undergraduate degrees. A grand total of 34 of the 66 minority students received undergraduate degrees in June 1978.

Of the 66 students registered in the Class of 1978, 27 students had participated in the special service Project Interphase, 1974. Twelve of these participants are included in the grand total of 34 minority students receiving undergraduate degrees in 1978 (see Chart I). Chart II indicates departmental specialization for minority students in the Class of 1978.

For further disposition of the Class of 1978 as to withdrawals, transfers, and those students continuing, refer to Chart I. Six minority students received service, athletic, and scholastic awards at the June 1978 commencement exercises. They are as follows: Judith E. Martin, Class of 1980, Robert H. Boit Writing Prize, for writing in all categories by undergraduates at M.I.T., first prize for short stories, second prize for poetry; Vincent W. James, Class of 1978, Karl Taylor Compton Prize, for outstanding contributions in promoting high standards of achievement and good citizenship within the M.I.T. community; Mark J. T. Smith, Class of 1978, The Class of 1948 Award, presented to the outstanding senior athlete of the year; Harold Challenor, Class of 1978 and Diane E. Waters, Class of 1978, Albert G. Hill Prize, awarded to the minority student who has made continued contributions to the
Minority Student Support

improvement of the quality of life for minorities at M.I.T. while satisfactorily progressing academically; Sheila L. Luster, Class of 1978, The Betsy Schumacher Award, for excellence in athletic competition by an undergraduate woman, and the American Defense Preparedness Gold Scholarship Key Award.

CHART I
Minority Students Admitted & Registered in fall 1974
(Class of 1978)

<table>
<thead>
<tr>
<th>African-Americans</th>
<th>Mexican Americans</th>
<th>Puerto Ricans</th>
<th>Native American</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduated</td>
<td>27* ++</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Withdraw</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Transferred</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Continuing</td>
<td>11</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>10</td>
<td>7</td>
<td>0</td>
</tr>
</tbody>
</table>


++ One minority student from the Class of 1971 received an undergraduate degree at graduation exercises in June 1978.

A total of 34 minority students received undergraduate degrees in June 1978.

A total of 12 out of 27 Project Interphase 1974 participants received undergraduate degrees in June 1978. Six of the Project Interphase 1974 participants have withdrawn, two have transferred, and seven are still pursuing degrees.

CHART II
Minority Graduates - Class of 1978

<table>
<thead>
<tr>
<th>Departmental Programs</th>
<th>African-American</th>
<th>Mexican American</th>
<th>Puerto Rican</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>School of Architecture and Planning</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>School of Engineering</td>
<td>11</td>
<td>10</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>School of Humanities and Social Science</td>
<td>1*</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sloan School of Management</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>School of Science</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>15</td>
<td>12</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

* One student, Class of 1971, received an undergraduate degree in June 1978.
The following conferences and seminars provided professional growth and development: a seminar on "The Association" held in Dallas, Texas; a conference on the "Role of Women in Technology," sponsored by the Massachusetts Association of Women Deans, Administrators, and Counselors at Regis College, Weston, Massachusetts; the first annual conference on "Black Women in Science and Engineering" held at Prairie View A&M University, Prairie View, Texas, at which I was the keynote speaker; a symposium on "Drinking Among College Students" sponsored by the Medical Foundation, Inc., Boston, Massachusetts.

I wish to thank Dean Carola Eisenberg, Dr. Jerome Wiesner, Dr. Paul Gray, Myra Rodrigues, the Dean for Student Affairs Staff, the Office of Minority Education, the Office of Minority Affairs, the Career Planning and Placement Office, John Mack, Nelson Armstrong, and Isaac Colbert for their support.

MARY O. HOPE

Women's Program

The main focus of the Women's Program again this year has been on efforts designed to increase the number of women students at M.I.T. Several women faculty and staff members and I have formed an Ad Hoc Committee on the Admission of Women to evaluate the current efforts in women's admissions and to develop new recruiting activities aimed at increasing the size of the female applicant pool. This spring a telethon was sponsored for women faculty members to call admitted women students, answering their questions and encouraging them to come to M.I.T. We are now planning a series of workshops for the fall under the auspices of Project WITS (Work in Technology and Science). This will be a collaborative endeavor among some colleges in the area to look for ways to approach the problem of early identification and support of female interest in science and technology.

Integral to the women's admissions program are the activities undertaken by women undergraduates through the Association for Women Students. This year these have involved:

1) writing to those women who filed preliminary applications for admission but who then did not follow up;

2) sitting in the Admissions Office to be available to speak to applicants and their parents when they come for interviews;

3) writing letters to all admitted women students, urging them to come to M.I.T.;

4) hosting visiting prospective "freshwomen."

In addition, the members of A.W.S. are very concerned with supporting the women students currently at M.I.T. Throughout the year they have had numerous Sunday brunches at which they heard speakers and just relaxed together. As a special effort for this coming fall, A.W.S. is reviving the Big Sister/Little Sister program so that every entering woman student will have an upperclass student who is specifically interested in her welfare.

The Margaret Cheney Room is a suite reserved for the exclusive use of women students. Patterns of use for this facility have varied over the years. This year I have tried to
reestablish a Cheney Room Committee so that the women students can participate more in the decisions concerning this facility.

Finally, I am a member of the Joint Committee of the M.I.T.-Wellesley Exchange Program, the Evaluation Task Group for the Handicapped, the Faculty Coordinating Committee on Student Advising, and the Dean's Office Housing Group.

HOLLIDAY C. HEINE

Advising and Counseling

In nearly all aspects, the areas and levels of activities of the Advising and Counseling Section followed the patterns of the prior year. Primary attention was focused upon helping individual students with a variety of academic and personal matters, handling administrative issues pertaining to them, and cooperating with faculty and staff members as they also sought to assist the students.

Our "counseling" conferences with individual students increased from 1,616 in 1976-77 to 1,729 for 1977-78. Our "brief encounters" with students about counseling matters went from 491 to 542. The percentages of these conferences that were held with women students, foreign students, graduate students, and non-registered students remained virtually the same as they were in 1976-77. The percentage of conferences held with minority students dropped slightly from 22 percent in 1976-77 to 17 percent for this year. Actual numbers of conferences with minority students were 355 and 298, respectively. The conferences held with non-students about the affairs of individual students increased by 30 percent from 381 to 494. Although some of the increase is due to a slight broadening of the definition, much of it stems from the several emergency incidents of the year and from our deliberate efforts to increase interactions with faculty and staff about their advisees and other students they had referred to us.

For the first time in two years the Section was able to resume the follow-up and outreach program which had not been carried out since 1975-76. The reduction in staff had prevented continuation of the program which was first developed and implemented that year. Following Dean Holliday Heine's return from maternity leave, the staff felt that it would be able to carry out a selective follow-up and outreach program for students who experienced academic difficulties during the previous terms of enrollment. Letters were sent to 143 students including 31 who had just returned to M.I.T. in the spring term following negotiated withdrawals. The remainder were selected on the basis of our gleaning from the C.A.P. grades review meetings that the students were experiencing difficulties of the types which we in the Dean's Office were particularly suited to handle.

The second level of activity involved serving on various Dean's Office and Institute committees. In addition to those mentioned in the 1976-77 report, Dean Heine joined the Evaluation Task Force for the Handicapped, and Dean James Bishop joined the Committee on Student Environment and the Science Subject Requirement Committee. Deans Heine and Bishop were members of the ad hoc faculty coordinating group on student advising.

Following periodic discussions during the last five years, Dean Robert Halfman and a group of students, mostly from the Experimental Study Group, wrote a thoughtful and detailed
Dean for Student Affairs

proposal for a peer advisory group. The proposed 7 p.m. to 7 a.m. student-to-student information and advisory service received strong endorsement from the Committee on Student Environment, the Psychiatric and Social services, and the Dean for Student Affairs. After receiving some financial backing from the President and Chancellor's Office and commitments for staff support from the Dean's Office and Medical Department, the group is striving to begin its operation in September 1978.

As in 1976-77, the Advising and Counseling Section started the fall term with a shortage of staff. Dean Heine took a maternity leave in August and resumed full-time work in mid-November. The office is very grateful for the continued dedicated support and experience of Joanne Murray and Jane Brandford. Their continued work was extremely helpful during a year filled with difficult moments and considerable turnover among our secretaries. Our sadness over Denise Roemer's January resignation was lessened by the birth shortly afterwards of her and her husband's first child, Sheryl. We were delighted that Lillian Sakey became a full-time employee in February. Ms. Sakey, who had helped us through several peak periods on a part-time basis, brings a wealth of personal and professional strengths to the secretarial group.

JAMES J. BISHOP

Student Community Affairs, Student Activities, and Governance

In this report last year two themes were developed: the increasing number of social occasions being sponsored both by undergraduate and graduate students; and the increasing interest expressed by a variety of sources concerning the quality of student life. This year these themes have continued to grow and broaden. They are not unrelated.

A large portion of the increase in social events this year has come from cooperative sponsorship by multiple segments of the community, i.e., two or three Institute Houses, two or three fraternities with Institute Houses, two or three activities together with undergraduate or graduate committees, and so on. These combinations of sponsorship are endless and indeed are new and refreshingly different. They have added immeasurably to the mobility of the student community.

The Beaver, a new weekly student publication, was created this past year primarily to give added exposure to these social events and activities on the M.I.T. campus and at Simmons and Wellesley. Four of these occasions this year aided charities; namely, Muscular Dystrophy, Easter Seals, Epilepsy, and Tutoring in Cambridge. Also striking is the fact that each of the governance units produced an arts program this year. The Undergraduate Association sponsored the Stanley Allen Sherman Mime Show in December and the Graduate Student Council sponsored the Boston Repertory Ballet in workshop and performance during I.A.P. The Graduate Student Council in April also cosponsored, with the Undergraduate Association and the Council for the Arts, a three-day showing of the luminous murals of Stephen Hannock.

Questions regarding the student environment and the quality of student life continue to be discussed by several of the committees of the Undergraduate Association and of the Graduate Student Council, as well as by ad hoc committees of the Office of the Dean for Student Affairs, and by the Committee on the Visual Arts, the Committee on Student Environment, and the
Corporation Joint Advisory Committee. An active dialogue on many of these issues appeared in the campus student media; while many of the student activities have programmed events to address expressed needs.

This plural and cooperative approach to student events and environment, noted above, is to be found also in several additional areas. In this regard I wish to acknowledge the assistance of the M.I.T. Alumni Association and staff with regard to: 1) the appointment of Richard Knight, Secretary of the Alumni Association, to membership on the Activities Development Board; 2) the developing program of the M.I.T. Alumni Family Committee, under the leadership of Fagi Levenson, which is arranging home or event hospitality to students by area Alumni hosts; and 3) the support of Class organization and activities provided by James Champy, Executive Vice President of the Alumni Association; Nancy Wheatley, Director of Conferences and Special Programs; and Norman Leventhal, President of the Alumni Association. Also acknowledged with gratitude is the financial assistance of the Council for the Arts to many of the programmed events of our student activities which focus on the arts.

The Graduate Student Council continues to improve its programs of orientation for new graduate students in September and February. The standing committees of the Council continue also to reflect the several areas of graduate concerns and to plan for programs to address them.

The Undergraduate Association and its several standing committees moved forward capably on their agenda. Although there was lively interest expressed in student elections this year, all governance and activity units continue to express the need for more involvement of students in leadership roles. Over the past two years the Interfraternity Conference has especially addressed this issue.

The number of Student Activities recognized by the Association of Student Activities and the Graduate Student Council continues to remain constant at approximately 100. The Lecture Series Committee had an expanded program and audience this year; the Chorallaries, the new singing group, has given us all new pleasure and enjoyment; and the Saturday Bus to the Stop and Shop has added to community sociability while serving a basic community need. Alpha Phi Omega conducted Open House '78 under the leadership of Hy Tran, Class of 1979. The response from the community was judged to be about 20,000 and the program and its management continued to reflect the high standards of preceding years.

Space utilization continues to be a major concern of the Student Center Committee Scheduling Officers, the Association of Student Activities Executive Committee, and the Graduate Student Council Activities section. Program space in Kresge Auditorium, the Stratton Student Center, Walker Memorial, and Burton-Conner Dining Hall continues to be scheduled at prime time capacity. Thanks to the good will and understanding of the community of users and the beyond-duty efforts of the Physical Plant operating staff, most projected programs can be accommodated, although frequently with compromises.

The M.I.T. Chapel was in use for 11 memorial services, 81 weddings, 380 scheduled religious services, and 40 musical and theatrical programs. The Reverend Constance Parvey, Lutheran Counselor, left at the end of December for an assignment with the World Council of Churches in Geneva, Switzerland. Her powerful and effective ministry will be long remembered. The Reverend Scott Paradise, new Episcopal Counselor, was installed at services in the Chapel on May 3. During the year, the Reverend Herbert Vetter, representing the Unitarian-Universalist Association, established office hours at The Religious Counselors Center. The religious community looks forward with anticipation to the meetings of the World Council of Churches to be held at M.I.T. during July 1979.

ROBERT J. HOLDEN
Residential Program

FRATERNITIES AND INDEPENDENT LIVING GROUPS

The 1976-77 academic year was viewed as a watershed year for fraternities and independent living groups. The interest and activity which took a surge then continued unabated in 1977-78. Some of the accomplishments and projects of the Interfraternity Conference (I.F.C.) follow:

The I.F.C., under the leadership of David Soule and John Helferich, both of the Class of 1979, conducted a very thorough examination on the topic of expanding the fraternity system. They evaluated the needs and constraints, examined the issue of national affiliation, and interviewed interest groups on campus. At their meeting of April 11, 1978, the I.F.C. voted that Zeta Psi should be selected for colonization after Rush Week 1978.

The I.F.C. has wholeheartedly supported the sprinkler protection program recommended by the Alumni Interfraternity Conference and Dean's Office. They have, by resolution, set 1980 as a target for all houses to be fully protected and are vigorously encouraging fast action.

Improved internal communications and the beginning of a secretariat have taken some of the load from other officers and made the I.F.C. more effective through more timely communication. There is much more communication among houses and between houses and I.F.C. officers. I.F.C. officers regularly visit houses; in fact, each officer has three to four houses with which he or she maintains liaison.

Thomas Gilbert, Jr., Class of 1978, spearheaded an exhaustive look into the issues of employee benefits and legal requirements of employers for the benefit of those houses with cooks. With the support of Dean Kenneth Wadleigh and Merrick Leler, health plans have been suggested, ambulatory care in the M.I.T. Medical Department has been made available, and a much better understanding of requirements and options has been achieved and communicated.

At the instigation of James Bidigare, Class of 1978, the James R. Killian, Jr. Award for Community Service was established to recognize outstanding community service efforts of houses and to stimulate more efforts of this nature. Individual fraternities already perform an enormous amount of community service work; applying for the award will bring more of this to the eye and mind of the M.I.T. community. The benefits accrue not only to the houses which perform the work but also to fraternities in general and to M.I.T.'s image. This year's recipient was Lambda Chi Alpha.

The I.F.C. organized a major clean-up of the Esplanade in the fall, which was written up in the Boston Herald American.

At the instigation of Jim Bidigare and due to the outstanding organizational efforts of Mark Bye, Class of 1978, the Northeast Regional Interfraternity Conference was resurrected. Held on April 7-9, the meeting proved to be a useful forum for the exchange of ideas between I.F.C.'s at schools from east of Ohio and north of Maryland. It also improved the image of M.I.T. in...
Residential Program

general, as students at other schools learned of the scope of the fraternity program and about student life in general. Seminars were held on pledging, rush, and public relations. At the business session, the NEIFC constitution was ratified and M.I.T. was chosen as the site for the 1979 meeting.

More communication with dormitories, particularly with reference to R/O Week activities, has long been a necessity. This year marked the first major stride in a long time. A set of agreements has been drawn up and both sides recognize the need for continued negotiation and communication. The I.F.C. leadership was instrumental in seeing the discussion continue after R/O Week in order to provide a sound basis for R/O 1978.

An excellent rush workshop and idea exchange was initiated by Rush Chairman Milton Roye, Class of 1978. Houses were able to learn of successful rush practices and approaches from others. Better communication with black students and the Black Student Union was established. More minority students than ever before (21 minorities, including 12 black) pledged (good progress but a long way to go). Milt worked with this office to develop a letter about fraternities at M.I.T. to be mailed to freshman parents with joint signatures.

Through the instigation of Jim Bidigare and with good efforts from several other students (with D.S.A. financial support) a set of two intensive day-and-a-half workshops on "Leadership" were held for fraternity officers during I.A.P. These seminars were run by two Sloan School doctoral students under the supervision of Professor Reuben Harris. They were well attended, and we have heard only enthusiastic feedback. They were so successful that another on "Retreats" was held this spring.

Bennett Golub, Class of 1979, worked hard as Financial Management Chairman to reestablish a bad debts resolution process within the system. He also spent considerable effort talking to legislators in an attempt to have the meals tax removed from fraternity meals. He was unsuccessful, but he "fought the good fight" and learned a lot. (Even large-scale lobbying efforts have been unsuccessful.)

The I.F.C. conceived and executed a well-received "Block Party" on Briggs Field during Kaleidoscope. This marks the first successful I.F.C.-sponsored, campus-wide party in a very long time. Other fraternities, including Sigma Alpha Epsilon, Theta Chi, Phi Gamma Delta, and Lambda Chi Alpha, have also contributed to campus-wide social functions.

The Fraternity Day Symposium, initiated by Dave Dobos in February 1977, was repeated in expanded format. This has now become a tradition to which the fraternities look forward.

Under the leadership of Scott Golden, Class of 1978, a Freshman Symposium was planned and scheduled early in the fall term. Unfortunately, response was small (apparently due to a low level of publicity and sunny Saturday weather) but an impressive array of resource personnel was present and a high level of discussion took place.

Barbara Hill, Class of 1980, did an excellent job of centralizing information about fraternity summer housing, for the benefit of houses, prospective boarders, and the Dean's Office.

Although there was little widespread publicity about it, the I.F.C. Judicial Committee handled more cases than in any recent year and did so with quiet effectiveness and fairness. The fact that this area was not heard from is indeed a credit to the people and the process.

The close working and living relationships and the management opportunities available in the fraternities continue to develop strong character and leadership abilities that others have come to expect in our students. The I.F.C. has always played a strong role in the M.I.T. community at-large, and this year was no exception. Both Steven Piet, Class of 1978,
Chairman of the I.F.C., and James Bidigare, Class of 1978, I.F.C. Community Relations Chairman, received Karl Taylor Compton awards for outstanding contributions to and good citizenship within the M.I.T. community. Jim also received the Frederick Gardiner Fassett award. The newly elected officers within the fraternities continue to show concern for strengthening the system and interactions with the Dean's Office and the Institute community. We can look forward to another "banner" year in the fraternity system.

INSTITUTE HOUSES

Last year's report stated that with a class of 1,040, the Institute experienced the greatest crowding ever. Fortunately (or unfortunately) we did not know about 1977-78! With 1,073 freshmen arriving in September, M.I.T. was forced to expand its capacity, and Random Hall was brought back into the Institute housing system. Even with this addition of 96 beds, there were 113 extra people.

It is a credit to the upperclassmen who moved into Random Hall, to create a nucleus for support and run a Rush Orientation, that 32 freshmen indicated Random as their first choice.

This year 80 percent of the freshmen were placed in their first-choice house with seven percent in their second. The final distribution was as follows:

<table>
<thead>
<tr>
<th></th>
<th>MEN</th>
<th>WOMEN</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institute Houses</td>
<td>562</td>
<td>138</td>
<td>700</td>
</tr>
<tr>
<td>Independent Living Groups</td>
<td>330</td>
<td>32</td>
<td>360</td>
</tr>
<tr>
<td>Off-Campus (Commuters, etc.)</td>
<td>12</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>TOTAL</td>
<td>904</td>
<td>171</td>
<td>1,073</td>
</tr>
</tbody>
</table>

The overall residential distribution of undergraduate students for the fall term was as follows:
RESIDENTIAL DISTRIBUTION OF M.I.T. STUDENTS

Fall Term 1977-78

<table>
<thead>
<tr>
<th>Institute Houses</th>
<th>MEN</th>
<th>WOMEN</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Sex Housing</td>
<td>800</td>
<td>229</td>
<td>1,029</td>
</tr>
<tr>
<td>Coed Housing, but not Coed Floor</td>
<td>152</td>
<td>-</td>
<td>152</td>
</tr>
<tr>
<td>Coed Housing</td>
<td>934</td>
<td>292</td>
<td>1,226</td>
</tr>
<tr>
<td>TOTAL INSTITUTE HOUSES</td>
<td>1,886</td>
<td>521</td>
<td>2,407</td>
</tr>
</tbody>
</table>

| TOTAL (49.6%)                        | 2,407  | (52.9%)|

Fraternities and Independent Residences

| Boston -- Single-Sex (20)            | 811    | -      | 811     |
| Coed (1)                             | 20     | 12     | 32      |
| Cambridge -- Single-Sex (7)          | 279    | 37     | 316     |
| Coed (2)                             | 50     | 31     | 81      |
| Brookline -- Single-Sex (1)          | 72     | -      | 72      |
| Coed (1)                             | 20     | 12     | 32      |
| TOTAL FRATERNITIES, ETC.             | 1,252  | (33.0%)| 92 (12.3%)| 1,344 (29.6%)|

| Married Student Housing              | 30     | -      | 30      |

| TOTAL "ON-CAMPUS"                    | 3,168  | (83.4%)| 613 (31.8%)| 3,781 (83.2%)|
| TOTAL "OFF-CAMPUS"                   | 630    | (16.6%)| 136 (18.1%)| 766 (16.8%)|

TOTAL UNDERGRADUATES

|TOTAL (100%)                          | 3,798  | 749    | 4,547   |

On October 7, 1977 ceremonies were held dedicating and naming four of the New West Campus Houses. In choosing the individuals so honored, the Corporation expressed lasting appreciation to these alumni and friends for their extraordinary service and generosity to M.I.T. The four houses were dedicated in honor of Jonathan (Class of 1923) and Blanche Ballard; William A. Coolidge, life member of the Corporation; Thomas C. Desmond, Class of 1909; and Leonard D. Lawrence, Class of 1929. Following the dedication ceremonies attended by members of the Corporation, administration, and House Residents, the students hosted those honored at a reception and a series of dinners. Many of the guests found that not only had they "acquired" a house with their name attached, but also a large family of interesting undergraduates who have begun a steady stream of communication as programs develop and activities take place.

Two of the houses in the New West Campus group were not named at this time -- Russian (House 1) and French/German (House 6). These have been active groups who have meals together on a regular basis and have a schedule of cultural events; the graduate residents are native speakers of the respective languages. With the appointment of Margery Resnick as Director of Modern Languages, several discussions took place in early spring to identify ways in which the language sections could be more involved. Seven full-time appointments at the faculty level have been made for the academic year 1978-79, and thus we see better communication with modern languages and a continuity that had been lacking in the past.

One problem still to be addressed is the request from a number of students for a Spanish House. Attempts to find a location within the existing housing system that will meet the needs of the program and not impact on or disrupt current living groups have been unsuccessful -- given our current crowding.
FACULTY AND GRADUATE RESIDENT PROGRAM

This continues to be a very valuable, highly effective program. The availability of faculty families and graduate students to our undergraduates in the Institute Houses is an important factor in the success of our housing system. Someone is always at hand to help in times of stress and crisis or to share in the joys and excitement of living, learning, and growing in the environment that is M.I.T.

This past year, in spite of increased advertising and word-of-mouth promotion by members of the program and the staff of the Dean's Office, the number of applicants for the number of openings was down. The small size of the applicant pool makes selection of the right graduate resident(s) for a given living unit a more difficult and time-consuming process.

Several theories have been advanced as to why fewer graduate students are applying: a need to concentrate all efforts on academics and thus graduate in a shorter period of time; a negative attitude by some members of the faculty toward the program, thus persuading their graduate students not to apply; the reluctance of many young people to formalize their living arrangements by marriage thus making them ineligible to apply. In spite of the low numbers, an excellent group of graduate students was chosen to fill the vacancies and the Dean's Office looks forward to working with them.

Dean James and Eleanor Bruce left the Residency Program and Burton-Conner last summer after six devoted, hectic/happy years as Faculty Residents. Dean Bruce, who served as Dean of the School of Engineering during the 1976-77 academic year, and Mrs. Bruce left behind them a host of friends. The sadness in losing them was counterbalanced by the acceptance of an appointment as Faculty Residents in Burton-Conner by Professor Julian and Doreen Beinart, effective September 1, 1977. Professor Beinart, of the Department of Architecture, has long been concerned about the quality of the environment as it affects the lives of our students. He has been working with members of the community to improve Amherst Alley. Mrs. Beinart, wanting to know the members of the house as quickly as possible, became a member of the Desk Staff and works one hour a week in the afternoon. Their immediate involvement proves the wisdom of our choice!

The "last minute" decision to bring Random Hall into the system created a problem in identifying a senior faculty family to move in on short notice into a very small apartment. We were fortunate indeed to be able to appoint Professor Thomas Lockwood of the Department of Nutrition and Food Science as Junior Faculty Resident. His efforts have done much to create a unified House with 84 freshmen and 12 upperclassmen who had not lived together before.

The end of an academic year brings not only the loss of students who graduate and move on to exciting new careers but of Faculty Residents who move in to a community and their own home. Sadly, this year was no exception. Professor Stephen and Alice Senturia leave McCormick Hall after six years of caring for and sharing the lives of our young women undergraduates. Professor Senturia, of the Department of Electrical Engineering and Computer Science, and Mrs. Senturia will be missed in the program. We wish them well. At this writing a group of McCormick students and Dean Carola Eisenberg are working to identify a replacement. We are hopeful that a family will be appointed and able to move in by September 1.

On April 14 Kenneth Browning, Class of 1966, Associate Dean for Student Affairs, left M.I.T. after 16 years to become Vice-Provost of Grinnell College in Iowa. His ability, wit, and wisdom will be greatly missed. With the invaluable and ever ready help of Lisa Kunstadter, as administrative assistant, and Beth Gardner, secretary, the academic year came to a close.
Talbot House

with a minimal number of problems and crises in the housing area. We look forward to working with Robert Sherwood who joins us July 1.

ALICE M. SEELINGER

Talbot House

Talbot House has continued to enjoy popularity with a variety of groups from the M.I.T. community. During 1977-78, 59 different groups comprised of 1,252 individuals stayed at Talbot House. These groups can be categorized as academic groups (30), living groups (15), recreation groups (9), and clubs (5).

Talbot House was occupied almost every weekend throughout the year. It was fully booked during Independent Activities Period when nine different groups stayed at the House. We have tried to encourage more use of Talbot House during weekdays, but work schedules being as they are, we have not had much success. In an effort to accomplish this, we mailed a leaflet to members of the faculty and administrative staff in September. As a result, many groups learned about Talbot House and requested its use.

An increase in the price structure for House usage has allowed us to keep in reserve the money which was given by Laurence Rockefeller. The charges are now consistent with actual costs. After 10 years, Talbot House is in need of a new coat of paint both inside and out and other cosmetic renovations. We plan to schedule these projects throughout the coming year.

SUSAN HAIGH HOUPT

Foreign Study Office

The Junior Year Abroad program continues, on a relatively small scale, to be an excellent opportunity for undergraduates. It is also beneficial to M.I.T. as an incentive to prospective freshmen and as an opportunity to increase the cultural awareness of the student body as a whole. The number of participants remained the same as the previous year’s with 15 students going abroad: eight for the full academic year, one for the fall term, five for the spring term, and one for the summer. The countries represented were Canada, England, France, Germany, Israel, Malaysia, Scotland, and Switzerland.

The number of student inquiries about foreign or domestic study also seemed to remain stable at approximately 500 student visits to the Foreign Study Office. Foreign study personnel no longer issue International Student Identity Cards but approximately 300 applications and explanations were given out.
Dean for Student Affairs

The Domestic Year Away program is an experimental program of the Committee on Educational Policy. In May 1973, the Committee decided to continue the program as an experiment "...pending conclusion of a more general examination of credit, residence, and exchange issues." Five students participated in the program this year; two for the full year and three for the fall term. The schools attended were Vassar College, the University of Miami, Stanford University, Columbia University, and the University of Wisconsin. Although the number of participating students continues to be small, the program greatly benefits many upperclass students whose M.I.T. goals are further defined by having made a thoughtful comparison of M.I.T. study with that at another school.

ROBERT L. HALFMAN

Department of Athletics

The most progressive step made this past year with significant impact on the continued development of the athletic program at M.I.T. was the appointment of a separate Corporation Visiting Committee for the Department of Athletics. The new Committee held its initial meeting in February with Irénée du Pont, Jr., Class of 1943, presiding. Members of the staff and student leadership participated in a series of discussions relating the role of athletics to the mainstream of educational priorities at the Institute, and acquainting the Committee with problems and needs in the achievement of the unique goals associated with a program planned around the sports and recreational interests of all students at M.I.T. We look forward to continued assistance from the Visiting Committee in the evaluation of the Department's efforts to meet these goals, particularly as we cope with new challenges on the horizon. Although we will have a separate Visiting Committee, it should be noted that the Department of Athletics will continue to function within the framework of the Office of the Dean for Student Affairs.

In terms of "bricks-and-mortar" progress, the construction and dedication of the Steinbrenner Stadium on April 30, made possible by a gift from the children of Henry G. Steinbrenner, Class of 1927, marked a milestone in the much needed modernization and expansion of our athletic facilities. The new stadium was constructed approximately 100 feet to the west of its former location, in a very tight site plan, thereby providing space for the new Events Center-Ice Rink-Field House.

The Steinbrenner Stadium provides a new 400-meter running track with a synthetic rubber all-weather surface and similar facilities for the field events. The game oval inside the running track will accommodate home contests in soccer, lacrosse, field hockey, and other outdoor events within the M.I.T. community. Modest spectator accommodations are included, together with a magnificent commemorative entrance. This will provide a gateway for future development of the M.I.T. campus and residential system and, more immediately, for existing and future parking facilities to the new Events Center/Athletic Facility and to the entire West Campus complex (including the Stratton Student Center, Kresge Auditorium, Kresge Chapel, and the student residences overlooking the Charles River Basin and the Boston skyline).

In addition to the foregoing highlights, I mention briefly the following items as significant in reporting the events of the year 1977-78:
Department of Athletics

the continued generosity of Mr. and Mrs. H. W. McCurdy, Class of 1922, most recently provided for the refurbishing of the McCurdy Lounge in the crew house, three new rowing shells, two new "ergometers," and additional new indoor training apparatus for well over 150 students committed to heavyweight, lightweight, and women's rowing;

a new coaching launch, Ralph T. Jope II, and a new rowing shell were provided by a gift for the family of Ralph T. Jope, Class of 1928;

a victim of the January blizzard and high winds, the J. B. Carr Indoor Tennis Center will be reactivated in early September with the erection of an improved air structure;

the impact of the renovation and expansion of the "Jack" Wood Sailing Pavilion completed in October 1976 becomes more evident with each sailing season and a nucleus of "Friends of M.I.T. Sailing," headed by George Warren Smith, Class of 1926, held their second annual open house on Technology Day this past June 9th;

the continued stabilization of a sound program of women's intercollegiate athletics under the leadership of Professor Jane Betts, whose report is carried in detail subsequently herein;

a marked improvement in sports medicine and in our program of prevention and treatment of athletic injuries, including pre-participation medical examination of all students entering intercollegiate athletics, which has replaced the former procedure of screening the family physician's report with examination of only those students showing special need;

a leveling off and, indeed, what is believed to be a temporary drop in participation statistics in several sports in men's intercollegiates due to limited space available during the current crunch on facilities, particularly during the long winter months; we expect a return to modest growth patterns with the construction of the new indoor athletic facility.

PHYSICAL EDUCATION

There were 6,232 registrations in 54 different courses offered in the physical education curriculum during 1977-78, including 7 courses offered only during Independent Activities Period: Basketball Officiating, Hockey Officiating, Intermediate Karate, Box Lacrosse, Advanced Squash, Water Polo Fundamentals, and Yoga.

This represents a slight drop in total registrations (2.5 percent) below the previous year, including non-credit registrations which have, in the past, attracted increasing numbers of graduate students, faculty, and significant numbers of undergraduates who have registered for instruction well beyond the minimum of 8 points required for graduation. In analysis of Table I, section b reveals a 52 percent drop in non-credit registrations for 1977-78 over the previous year. The Department believes this sharp drop-off in the non-credit registrations is a reflection of the crowded and unattractive conditions which exist in our locker and dressing facilities, compounded by the fact that there was a 27 percent increase in student registrations required for credit in 1977-78, Table I, section d.

The high quality of instruction which has been available to all members of the M.I.T. community in relatively small classes has been one of the unique contributions of the Department to the community.

The downward slide in non-credit registrations presents further challenge to the Department and the Institute to upgrade the locker-dressing facilities available to the community if we are to be able to continue to offer healthful and recreational opportunities.
Statistics for the Physical Education Program for 1977-78 follow in Tables I and II.

### TABLE I

**Five-Year Summary -- Student and Staff Registrations**

<table>
<thead>
<tr>
<th></th>
<th>77-78</th>
<th>76-77</th>
<th>75-76</th>
<th>74-75</th>
<th>73-74</th>
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</thead>
<tbody>
<tr>
<td>(a) Total Registrations</td>
<td>6,232</td>
<td>6,462</td>
<td>6,354</td>
<td>6,882</td>
<td>6,036</td>
</tr>
<tr>
<td>Change Over Previous Year</td>
<td>-150</td>
<td>+108</td>
<td>-528</td>
<td>+846</td>
<td>+628</td>
</tr>
<tr>
<td>% Change Over Previous Year</td>
<td>-2.5%</td>
<td>+1.7%</td>
<td>-7.6%</td>
<td>+14%</td>
<td>+11%</td>
</tr>
<tr>
<td>5-Year Change</td>
<td>+15%</td>
<td></td>
<td></td>
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<tr>
<td>(b) Non-Credit Registrations</td>
<td>1,195</td>
<td>2,492</td>
<td>2,053</td>
<td>2,653</td>
<td>2,067</td>
</tr>
<tr>
<td>Changes Over Previous Year</td>
<td>-1,297</td>
<td>+439</td>
<td>-614</td>
<td>+586</td>
<td>+624</td>
</tr>
<tr>
<td>% Change Over Previous Year</td>
<td>-52%</td>
<td>+21%</td>
<td>-23%</td>
<td>+28%</td>
<td>+43%</td>
</tr>
<tr>
<td>5-Year Change</td>
<td>-17%</td>
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### (c) Analysis of Non-Credit Registrations

<p>| | | | | | |</p>
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<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Students</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1st Year</td>
<td>1</td>
<td>65</td>
<td>58</td>
<td>63</td>
<td>27</td>
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<tr>
<td>2nd Year</td>
<td>24</td>
<td>308</td>
<td>313</td>
<td>293</td>
<td>171</td>
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<tr>
<td>3rd Year</td>
<td>52</td>
<td>413</td>
<td>282</td>
<td>341</td>
<td>438</td>
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<tr>
<td>4th Year</td>
<td>50</td>
<td>336</td>
<td>388</td>
<td>415</td>
<td>329</td>
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<tr>
<td>Graduates</td>
<td>770</td>
<td>905</td>
<td>734</td>
<td>1,015</td>
<td>713</td>
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<tr>
<td>Staff</td>
<td>298</td>
<td>465</td>
<td>279</td>
<td>526</td>
<td>389</td>
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<tr>
<td></td>
<td>1,195</td>
<td>2,492</td>
<td>2,054</td>
<td>2,653</td>
<td>2,067</td>
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### (d) Total Registrations Less Non-Credit Registrations

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<tr>
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<th>77-78</th>
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<th>75-76</th>
<th>74-75</th>
<th>73-74</th>
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<tbody>
<tr>
<td>Total Registrations</td>
<td>6,230</td>
<td>6,462</td>
<td>6,354</td>
<td>6,882</td>
<td>6,036</td>
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<tr>
<td>Non-Credit</td>
<td>1,195</td>
<td>2,492</td>
<td>2,053</td>
<td>2,653</td>
<td>2,067</td>
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<tr>
<td>Credit Registrations</td>
<td>5,035</td>
<td>3,970</td>
<td>4,301</td>
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<tr>
<td>% Change Over Previous Year</td>
<td>+27%</td>
<td>-8%</td>
<td>+2%</td>
<td>+7%</td>
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<tr>
<td>5-Year Change</td>
<td>+27%</td>
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### TABLE II

Registration Statistics for 1977-78

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<tr>
<th>Activity</th>
<th>1977-78</th>
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<tr>
<td>Swimming</td>
<td>633</td>
<td>166</td>
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<tr>
<td>- Beginning</td>
<td>319</td>
<td></td>
</tr>
<tr>
<td>- Intermediate</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>- Advanced Techniques</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>- Diving</td>
<td>30</td>
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<tr>
<td>- Red Cross Adv. Life</td>
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<td>- Red Cross W.S.I.</td>
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<td>- Scuba</td>
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<tr>
<td>Dance</td>
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<tr>
<td>- Ballet, Beginning</td>
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<tr>
<td>- Intermediate</td>
<td>101</td>
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<tr>
<td>- Folk</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>- Modern</td>
<td>37</td>
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<tr>
<td>- Modern Jazz Blues</td>
<td>75</td>
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<tr>
<td>- Partner</td>
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<tr>
<td>- Tap</td>
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<tr>
<td>Tennis</td>
<td>490</td>
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<tr>
<td>- Beginning</td>
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<tr>
<td>- Advanced Beginning</td>
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<tr>
<td>- Intermediate</td>
<td>149</td>
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<tr>
<td>Physical Development</td>
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<tr>
<td>Sailing</td>
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<td>Fencing</td>
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<td>Ice Skating</td>
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<td>- Beginning</td>
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<td>- Figure</td>
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<tr>
<td>Pistol</td>
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<tr>
<td>Archery</td>
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<tr>
<td>Rifle</td>
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<tr>
<td>Golf</td>
<td>154</td>
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<tr>
<td>Beginning</td>
<td>107</td>
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<tr>
<td>Intermediate</td>
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<tr>
<td>Sculling</td>
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<td>Golf</td>
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<td>Gymnastics</td>
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<td>Softball</td>
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<td>Volleyball</td>
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<td>Lacrosse</td>
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<tr>
<td>Karate</td>
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<tr>
<td>Football, Touch</td>
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<tr>
<td>Rock Climbing</td>
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<tr>
<td>Judo</td>
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<tr>
<td>Basketball Fundamentals</td>
<td>54</td>
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<tr>
<td>Hockey</td>
<td>45</td>
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<tr>
<td>First Aid</td>
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<td>Field Hockey</td>
<td>30</td>
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<tr>
<td>Bicycling</td>
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<tr>
<td>Self Defense</td>
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<tr>
<td>Table Tennis</td>
<td>12</td>
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<tr>
<td>Independent Activities</td>
<td>753</td>
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</tr>
<tr>
<td>Period</td>
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<tr>
<td>TOTAL</td>
<td>6,232</td>
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</tr>
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</table>
INTERCOLLEGIATE ATHLETICS

Approximately 20 percent of the undergraduate men and women opt for an in-depth commitment to intercollegiate athletics. Team and individual performances vary from year to year, and the won-lost records in the 22 sports for men and 10 sports for women will never be a true measure of the success of this segment of our athletic program. Approximately 960 students competed regularly in 32 sports in 609 contests in Cambridge or at New England and East Coast sites of our opponents.

For a student's perception of the intercollegiate program, I will quote from an article in the May 16, 1978 edition of The Tech, entitled "MIT Sports: Another Banner Year" written by Sports Editor Tom Curtis, Class of 1981.

From the soccer team's upset of Brandeis in October to the Greater Boston Track and Field Championships held here in April, it was another banner year for M.I.T. sports. As the year draws to a close, it is time to look back at the top M.I.T. sports accomplishments.

Here is my list of this year's top ten sports triumphs:

1) The accomplishments of Mark Smith '78 and John Rodriques '80 at the NCAA Fencing Championships top my list. Despite the handicap of fencing with two men instead of three, the duo still captured 19th place for M.I.T. in the Championships. In the process, Smith became the first native-born American in M.I.T. history to win All-American fencing honors.

2) Another outstanding All-American performance was given by freshman Leslie Harris at the AIAW Small College Gymnastics Championships. Having won the Massachusetts State All-Around Championship, Harris went to the National Championships and captured fifth place on the uneven parallel bars.

3) The Year's greatest team effort was soccer's 2-1 double overtime upset of defending national champion Brandeis. Jeff Tyrrell '80 held Brandeis' high scorer to one shot and scored M.I.T.'s winning goal. The team's goalie, Jamie Bernard '79 played a typically brilliant game as he made 19 saves.

4) Preston Vorliecek '79 joins Smith and Harris on the list of 1978 M.I.T. All-Americans. At the NCAA Division III Swimming Championships, Vorliecek finished sixth in the 200-yard breaststroke. He also set M.I.T. records in both the 100- and 200-yard breaststroke events.

5) For the third consecutive year, the women's volleyball team captured the Massachusetts State Championship. Having won Division II State titles the previous two years, the team moved up to Division I and successfully challenged the big schools.

6) Four outdoor collegiate records at the Massachusetts State Outdoor Pistol Championships capped another great season for the pistol team. The team set records in every event. In addition, David Schaller '78 capped his senior year with an individual record in the center fire event.
7) The surprise of the year was the water polo team's third place finish at the New England Championships. Not having had a winning season in several years, the team rolled over its opposition this year. Only Brown and Yale finished higher than the M.I.T. water polo team.

8) The perennially strong sailing team took the New England fall championship by capturing the Schell Trophy. This was one of two New England Championships won by M.I.T. this year. (Fencing had the other one.)

9) An event such as the Greater Boston Track and Field Championships must be on this list. This was the first time M.I.T. had hosted the meet; the event also marked the official opening of the new track.

10) The soccer team ridded itself of the stigma of being perennial losers by beating Coast Guard 2-0 in the last game of the season. The team thus finished with a 7-6 record, its first winning record since 1963.

### Intercollegiate Letter Awards for 1977-78

<table>
<thead>
<tr>
<th>Undergraduate Men</th>
<th>Undergraduate Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varsity Letters</td>
<td>235</td>
</tr>
<tr>
<td>J-V Letters</td>
<td>177</td>
</tr>
<tr>
<td>Frosh Numerals</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>459</td>
</tr>
<tr>
<td>Varsity Letters</td>
<td>84</td>
</tr>
<tr>
<td>J-V Letters</td>
<td>53</td>
</tr>
<tr>
<td>Frosh Numerals</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>148</td>
</tr>
</tbody>
</table>

### WOMEN'S ATHLETICS

This year was a stable one for M.I.T. women's athletics which is coordinated by Professor Jane Betts, Assistant Director of Athletics. The ramifications of change due to Title IX are accepted as fact and history. The varsity programs for women are established with competent and qualified coaches, competitive schedules that are stable year by year, and practice times and athletic facilities that have met the immediate needs of student athletes. Overall, 1977-78 was a positive year for women's athletics.

### Varsity Programs

The varsity program for women included 10 varsity sports. Participation numbers in addition to significant events and accomplishments were as follows:
Dean for Student Affairs

<table>
<thead>
<tr>
<th>Season</th>
<th>Sport</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>Fall Sailing</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Fall Tennis</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Field Hockey</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Volleyball*</td>
<td>17</td>
</tr>
<tr>
<td>Winter</td>
<td>Basketball*</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Fencing*</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Gymnastics</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Swimming</td>
<td>10</td>
</tr>
<tr>
<td>Spring</td>
<td>Crew*</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Softball</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Spring Sailing</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Spring Tennis</td>
<td>15</td>
</tr>
</tbody>
</table>

* includes sub-varsity teams in regular competition

Outstanding Varsity Achievements

The volleyball team won the Massachusetts Association of Intercollegiate Athletics for Women's Division I Tournament, and was selected to participate in the Eastern Association of Intercollegiate Athletics for Women Small College Championships at the State University of New York at Binghamton.

Freshman gymnast Leslie Harris won the All Around event, uneven bars, balance beam, and vaulting in the first Massachusetts Intercollegiate Championships. She qualified for and competed in the EAIAW Championships at the University of Pittsburgh. She also qualified for and competed in the AIAW Small College Championships at the US Air Force Academy where she took 10th place in vaulting and fifth place in uneven bars to become M.I.T.'s first female All American.

Sub-Varsity teams competed in basketball, crew, fencing, and volleyball. It was particularly encouraging to have enough interest in basketball that the J-V schedule that had been dropped in 1976-77 could be reinstated. The total participation in the women's varsity and sub-varsity program was 208.

Club Programs

Three women's teams competed at the club level this year: water polo, rugby, and cross country. The cross country team was exclusively undergraduate students. The team was coached by Athletic Board member Bill Brace and was closely allied with the Athletic Department for scheduling purposes.

Activities

Invitational Basketball Tournament. On February 3 and 4, M.I.T. sponsored a six-team invitational basketball tournament involving Brown University, Bates College, the University of Chicago, the University of Pennsylvania, and Swarthmore College. An all tournament breakfast was held at the Hyatt Regency Hotel, an all star team and tournament MVP were selected. Brown University won the tournament, which was considered to be successful.
Women's Athletic Council. The W.A.C. conducted three major activities this year. The first was an alumnas reception held at the Student Center on Saturday during the basketball tournament. The W.A.C. sold polo shirts which had the logo "M.I.T. Women's Sports" on them. In May, the W.A.C. gave a pot luck brunch for all women athletes and coaches. The 1978-79 Co-chairpersons for the W.A.C. are Suzie Stulz and Michelle Prettyman.

Professional Activities. M.I.T. was represented locally at the regular meetings of the Metropolitan Women's Intercollegiate Council, at the Massachusetts Association of Intercollegiate Athletics for Women (MAIAW) fall and spring Delegate Assembly and at the AIAW Delegate Assembly.

Manny Weiss is a member of the MAIAW Tennis Tournament Committee. Deborah Clum was a member of the MAIAW seeding and selection committee for the softball tournament. Harriett Pearce was a panelist at a Sports Medicine Program at Children's Hospital and will represent M.I.T. at the National Athletic Trainer's Association Convention. Professor Betts was elected President of the MAIAW. Most coaches participated in various professional activities, specifically related to their sports.

GBCAA. Representatives of women's programs from GBCAA member institutions have proposed women's competition through the Greater Boston Collegiate Athletic Association. The groundwork for this avenue of competition was prepared this year and the actual competition is anticipated for 1978-79.

Honors. Leslie Harris was selected to receive the Varsity Club Award (Freshman Athlete of the Year). Helen Miyasaki was the recipient of the M.I.T.A.A. Pewter Bowl and the Cochrane Award. Joan Sienkiewicz was a co-winner of the Burton R. Anderson Award (Manager of the Year). And Sheila Luster was awarded the Betsy Schumacker Award (Outstanding Female Athlete).

Research. Ms. Pearce and Professor Betts have made a preliminary proposal to the Harvard-M.I.T. Division of Health Sciences and Technology to study strength training in women during the 1978-79 academic year. The future looks promising for research in the Athletic Department.

A number of factors have contributed in positive ways to the overall program of women's athletics.

Definite improvements occurred this year in the area of sports medicine for women athletes. The acquisition of the NATA certified trainer had a significant impact on the athletes' physical training and care when injuries occurred. The voluntary services of a Registered Physical Therapist (Adele Severson) on a regular daily basis complemented our medical personnel and was extremely valuable. Medical examinations provided by the Medical Department also contributed to our overall effort to provide the most wholesome experience for our student athletes.

Major equipment purchases such as an eight-oared shell, a 40 x 40 foot floor exercise mat, softball pitching machine, training room furnishings, ice machine, uniforms and warm ups for various teams were helpful in respectfully preparing the M.I.T. teams to meet the competition.

As these facts were assembled, it became evident that the real core of the program is the staff. Every person involved with the women's program in a professional way did a first class job. It is our opinion that our women athletes are happy with their programs at M.I.T. This can only reflect the outstanding jobs that were done by our coaches and support personnel. We believe that M.I.T. is and can continue to be recognized as an institution that has an exceptional program of women's athletics in New England.
INTERMURAL ATHLETICS

Interest continues to grow in intramural athletics as reflected by a nine percent increase in the number of teams active in 24 sports, including two new sports: fencing and indoor track, and an 11 percent increase in the number of students participating.

A primary concern is the dilution of the "intramural experience" brought on by the number of teams entered in the more popular sports: basketball 145, volleyball 127, ice hockey 63. We anxiously await the construction of the new indoor athletic facility which will more than double the number of basketball and volleyball courts, and permit scheduling of ice hockey games independent of inclement weather.

Intramural Participation Statistics 1977-78

<table>
<thead>
<tr>
<th>Sport</th>
<th>Number of Teams</th>
<th>Approximate Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badminton</td>
<td>41</td>
<td>205</td>
</tr>
<tr>
<td>Basketball</td>
<td>145</td>
<td>1,160</td>
</tr>
<tr>
<td>Bowling</td>
<td>98</td>
<td>294</td>
</tr>
<tr>
<td>Chess</td>
<td>20</td>
<td>120</td>
</tr>
<tr>
<td>Cross Country</td>
<td>29</td>
<td>161</td>
</tr>
<tr>
<td>Cycling</td>
<td>-</td>
<td>41</td>
</tr>
<tr>
<td>Fencing</td>
<td>16</td>
<td>65</td>
</tr>
<tr>
<td>Football</td>
<td>80</td>
<td>1,200</td>
</tr>
<tr>
<td>Hockey</td>
<td>63</td>
<td>630</td>
</tr>
<tr>
<td>Pool</td>
<td>24</td>
<td>120</td>
</tr>
<tr>
<td>Rifle</td>
<td>47</td>
<td>228</td>
</tr>
<tr>
<td>Sailing</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>Soccer</td>
<td>69</td>
<td>1,242</td>
</tr>
<tr>
<td>Softball</td>
<td>157</td>
<td>2,120</td>
</tr>
<tr>
<td>Squash</td>
<td>53</td>
<td>265</td>
</tr>
<tr>
<td>Swimming</td>
<td>17</td>
<td>102</td>
</tr>
<tr>
<td>Table Tennis</td>
<td>59</td>
<td>413</td>
</tr>
<tr>
<td>Tennis</td>
<td>127</td>
<td>635</td>
</tr>
<tr>
<td>Track (Indoor)</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>Track (Outdoor)</td>
<td>19</td>
<td>139</td>
</tr>
<tr>
<td>Volleyball</td>
<td>127</td>
<td>1,016</td>
</tr>
<tr>
<td>Water Polo</td>
<td>38</td>
<td>380</td>
</tr>
<tr>
<td>Weight Lifting</td>
<td>7</td>
<td>42</td>
</tr>
<tr>
<td>Wrestling</td>
<td>12</td>
<td>108</td>
</tr>
</tbody>
</table>

1,266                 10,808
Department of Athletics

These figures represent an 11 percent increase over 1976-77.

Club Athletics

A "club" sport, as distinguished from an institutionally sponsored "varsity" team, is generally a self-motivated, self-organized team within a special interest group in one of the sports less popularly sponsored among the colleges and universities of the country: rugby, cricket, bicycling, etc. There are no eligibility rules. Hence, club athletics are particularly attractive to M.I.T. graduate students and members of the young teaching staff who are unable to make regular commitments to highly organized teams.

Although club status connotes self-support, the Department of Athletics encourages and supports club athletics with the limits of available space and resources.

<table>
<thead>
<tr>
<th>Clubs Active in 1977-78</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archery</td>
</tr>
<tr>
<td>Badminton</td>
</tr>
<tr>
<td>Bicycling</td>
</tr>
<tr>
<td>Graduate Crew</td>
</tr>
<tr>
<td>Cricket</td>
</tr>
<tr>
<td>Dance Workshop</td>
</tr>
<tr>
<td>Folk Dance</td>
</tr>
<tr>
<td>Round Dance</td>
</tr>
<tr>
<td>Fencing</td>
</tr>
<tr>
<td>Figure Skating</td>
</tr>
<tr>
<td>Judo</td>
</tr>
<tr>
<td>Karate, 2 clubs</td>
</tr>
<tr>
<td>Rifle/Pistol</td>
</tr>
<tr>
<td>Rugby, Men's</td>
</tr>
<tr>
<td>Rugby, Women's</td>
</tr>
<tr>
<td>Scuba</td>
</tr>
<tr>
<td>Graduate Soccer</td>
</tr>
<tr>
<td>Squash, Women's</td>
</tr>
<tr>
<td>Squash, M.S.R.A.</td>
</tr>
<tr>
<td>Table Tennis</td>
</tr>
<tr>
<td>Volleyball, Men's</td>
</tr>
<tr>
<td>Water Polo, Spring</td>
</tr>
<tr>
<td>Weight Lifting</td>
</tr>
<tr>
<td>White Water</td>
</tr>
</tbody>
</table>

Recreation for Students and the M.I.T. Community

The recreational interests of all students and members of the M.I.T. community are a major concern to the Department, particularly the interests of those students who, for various reasons, do not participate in organized intramural or intercollegiate sports. Wherever possible, the Department is attempting to decentralize the location of facilities for informal recreation for better accessibility to so-called casual participants.

Within the scope of the existing crunch on athletic facilities, the needs of the "casuals" are least met during the popular hours for recreation. A major goal in the Institute's development plan for the modernization and expansion of our sports facilities is the inclusion of sufficient space to meet the recreational needs of the casual student participant as well as those of the students who seek out organized programs. Other users of the athletic facilities must necessarily defer to student priorities during periods of peak use by students.
A review of the sale of athletic cards during the past year reveals that approximately 81 percent of the student community was active in some phase of the program, as was a sizable number of faculty, staff, employees, and alumni.

### Athletic Card Sales for 1977-78

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>6,645</td>
</tr>
<tr>
<td>Faculty</td>
<td>381</td>
</tr>
<tr>
<td>Academic Staff</td>
<td>1,590</td>
</tr>
<tr>
<td>Exempt Employees</td>
<td>29</td>
</tr>
<tr>
<td>Bi-Weekly Employees</td>
<td>248</td>
</tr>
<tr>
<td>Weekly</td>
<td>22</td>
</tr>
<tr>
<td>Alumni</td>
<td>373</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9,288</strong></td>
</tr>
</tbody>
</table>

**Sailing Cards:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>764</td>
</tr>
<tr>
<td>Faculty/Staff</td>
<td>166</td>
</tr>
<tr>
<td>Alumni</td>
<td>64</td>
</tr>
<tr>
<td>Specials</td>
<td>253</td>
</tr>
<tr>
<td>Physical Education</td>
<td>403</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,650</strong></td>
</tr>
</tbody>
</table>

### Cambridge and Greater Boston Community Relations

The Department regularly extends the use of our facilities to community interests at times not conflicting with our primary commitment to M.I.T. students. We are especially anxious to assist in sponsoring programs of interaction among our students and young people from surrounding communities.

Periods of recess during the academic year present the best opportunities for the Department to host community events. Also, we are able to accommodate a number of single event occasions during off-season and other periods of relatively low level student use, in close liaison with the office of the Special Assistant to the President for Urban Affairs. Typical events include the Massachusetts State Science Fair and the Cambridge Mayor's Annual St. Patrick's Day Party.

The MIT-NCAA Volunteers for Youth Program is an example of a very successful effort to bring M.I.T. students closer to the surrounding Cambridge Community in a program of great benefit to both groups. Begun last November following a visit by students from Stanford University (whose visit had been sponsored by a grant from the National Collegiate Athletic Association), the M.I.T. program made rapid headway under the leadership of Bruce Wrobel, Class of 1979, a member of the varsity wrestling team. Mr. Wrobel was assisted by other interested members of the Varsity Club in organizing and offering their services in a Big Brother/Big Sister program to assist troubled youngsters in the Cambridge elementary schools. By the end of the school year, 18 Big Brothers and 11 Big Sisters were matched up with the same number of Cambridge students in a liaison arranged by M.I.T. students active in athletics. They worked directly with counselors at the Fletcher School, the Roberts School, and the Kennedy School.

The MIT-NCAA Volunteers for Youth Program now includes an Advisory Committee consisting of Professor John Benedick, M.I.T. Swimming and Water Polo Coach, as Faculty Advisor,
Dr. Lora Tessman, M.I.T. Medical Department, as Psychiatric Advisor, and three Cambridge School Counselors: Ms. Susan Palmeri, Ms. Dorothy Haley, and Mr. David Villandry. The latter also serves as Community Advisor.

**Major Athletic Awards for 1977-78**

The Class of 1948 Award to the Senior Athlete of the Year was presented to Mark J. T. Smith, Class of 1978. The Admiral Edward L. Cochrane Award to the Senior who has best combined the qualities of leadership, humility, and scholarship in intercollegiate athletics was presented to Helen E. Miyasaki, Class of 1978. The Malcolm G. Kispert Award to the senior scholar-athlete of the year was won by Neal L. Rockowitz, Class of 1978. Sheila L. Luster, Class of 1978, won the Betsy Schumacker Award for excellence in athletic competition by a woman student. The M.I.T.A.A. Pewter Bowl for outstanding contributions to women's athletics by a woman student was awarded to Helen E. Miyasaki.

The Straight T Award for national or regional recognition in intercollegiate athletics at M.I.T. was presented to: Jonas A. Aleksonis, Class of 1980; David E. Miller, Class of 1979; Kyle R. Brown, Class of 1980; Philip G. Morris, Class of 1979; Katherine S. Chrien, Class of 1980; Karen M. Samuelsen, Class of 1979; Leslie A. Harris, Class of 1981; David A. Schaller, Class of 1978; Alan J. Marcum, Class of 1978; Adra E. Smith, Class of 1980; and Dennis M. McMullen, Class of 1978; Preston L. Vorlicer, Class of 1979.

The Burton R. Anderson, Jr., Award to the Manager of the Year was won by Joan M. Sienkiewicz and Brian F. Wibecan, both of the Class of 1979. Leslie A. Harris, Class of 1981, received the Varsity Club Award to the Frosh Athlete of the Year. Craig T. Walloch, Class of 1978, received the Harold J. Pettigrove Award for outstanding contributions to intramural athletics.

**Staff Changes**

Jean A. Heiney was appointed Assistant Professor in Physical Education, Head Coach of Basketball, and Assistant Coach of Field Hockey and Softball. Harriett J. Pearce was appointed Instructor in Physical Education and Women's Trainer.
This volume documents trends and events at the Institute in a variety of ways. The departments and the five Schools report in the traditional manner; so does the Graduate School. Some of the interdepartmental laboratories report in greater or lesser detail the achievements in research of which they are justifiably proud. Other Institute units such as the Libraries, the MIT Press, the Summer Session, or the Committee on the Visual Arts have found their own reportorial mode. This diversity reflects the many facets of M.I.T. life and no single archival format can do justice to the increasing variety of responses to the intrinsic demands of the disciplines, to the variegated adaptations to extrinsic societal needs, to the human communication needs of the individuals who make up the M.I.T. community. This chronicle of M.I.T., written by several dozen authors, can thus hardly avoid appearing somewhat jumpy to the readers unless they will confine themselves to the lead-off essay by the President and Chancellor which summarizes the year's highlights. The Provost's section suffers particularly from this same unevenness given the variety of units and programs that report here; this introduction can provide a very modest remedy only by drawing attention to a few of the most significant changes that have taken place in academic units having a particular relation to the Provost's Office.

The Provost has the privilege of not only belonging to the various Institute-wide councils (Academic, Faculty, and Administrative) but also to those groups and committees that are singularly close to the functioning of the academic programs: the Committee on Educational Policy (C.E.P.), the Academic Appointments and the Educational Programs subgroups of the Academic Council, the Committee on Research, and the Committee on Resources and Space Planning (C.R.S.P.). Together these groups provide the Provost with regular contact with the School Deans, Department Heads, Laboratory and Program Directors, contact with those faculty members (including the chairman of the faculty), students, and administrators who are particularly concerned with academic policy.

Since C.R.S.P. does not present a formal annual report, it may be worthwhile focusing on some of the problems it faces. C.R.S.P. is composed of the Vice Presidents for Administration and Personnel, Operations, Financial Operations, and Research as well as the Assistant Director for Space Management (Secretary of C.R.S.P.), Director of Physical Plant, Executive Officer in the Provost's Office, Campus Architect, Director of Planning, and is chaired by the Provost. M.I.T.'s changing space needs reflect fairly directly changes in its academic programs. Requests for space changes (new facilities, renovation, and additional space) from all Institute units come before this group and are dealt with in as equitable a manner as scarce fiscal resources and the available space allow. During these last few years the increasing space crunch has become a source of great frustration for those looking for relief and for the committee which aims at providing it. The expansion of research laboratories and centers during the last two decades has often had to follow opportunistic paths hardly designed, for instance, to keep all physicists (involved in roughly one-fifth of the total campus research) in intellectually effective proximity to each other. The five million square feet which make up the Institute's academic space represent an enormous asset, with a replacement cost of close to $1 billion, but because of the way and order in which the buildings were built and space in them allocated and occupied, the Institute's physical map is much more of a mosaic than a cohesive structural arrangement of intellectually related units. In general, universities need to replace equipment and renovate heavily used labs, classrooms, and
M.I.T.'s post-World War II expansion has been extensive and some of the buildings built in that period are now in a state where the cost of rehabilitating even a small fraction of M.I.T.'s total academic space would run into quite a few millions of dollars.

In an institution as much committed to research -- i.e. to continued modification of the Institute's intellectual map -- the history of buildings reflects the history of its programs and indeed of ideas. Building 20, the temporary structure erected during World War II for the Radiation Laboratory, became after 1946 the headquarters of the Research Laboratory of Electronics. As R.L.E. grew much of it moved into Building 26. Yet Building 20 deserves special mention as an extraordinary incubator of many new ventures. The latest unit to find a home in Building 20 is the Center for Materials Research in Archaeology and Ethnology, a nine-institution Boston area consortium, which now occupies recently rehabilitated space in which R.L.E.'s Communications Biophysics group started more than a quarter century ago.

The past year has seen a set of issues coming to the fore that may demand much greater attention in the future. Our colleagues in the social sciences feel that the manner in which the Department of Health, Education and Welfare attempts to use the Committee on the Use of Humans as Experimental Subjects as a device for the regulation of personal interviews -- of opinion leaders, TV executives, etc. -- represents a major danger to the freedom of that type of research. Whether mature individuals become "experimental subjects" when interviewed by academics is an issue that in the view of some involves the First Amendment, and it is felt that universities cannot allow themselves to accept these guidelines passively.

The attentive reader of this annual report will note that the Joint Center for Urban Studies no longer appears in it. This is not a casual omission or symbolic of the Center's demise, but reflects the fact that after nearly two decades during which the Joint Center was administered by M.I.T., administrative arrangements were transferred to Harvard as of July 1, 1977. In the past year the Center has continued to enjoy vigorous scholarly activity as well as strong interaction with industry and various levels of government, all this under the continued directorship of Professor Arthur P. Solomon, a member of M.I.T.'s Department of Urban Studies and Planning.

Newly added to the Provost's section of this Report is the Electronic Systems Laboratory which changed its status during the past year: it became an Institute-wide interdepartmental laboratory after having been a component of the Department of Electrical Engineering and Computer Science for many years.

As for the rest, we shall have to let the various entries of this section speak for themselves, even those that have a particularly close connection with the Provost's Office, such as the Office of Minority Education, the Independent Activities Period, or the Wellesley Exchange, which celebrated its 10th anniversary in settings that combined felicitously art and scholarship.

WALTER A. ROSENBLITH
Center for International Studies

The Center for International Studies during the past year has continued to carry out research and analysis on a wide range of public policy issues that involve significant technological elements. The Center has thus, under its Director Eugene B. Skolnikoff, carried out its role as a focal point for engaging the Institute's social scientists, engineers, and natural scientists in the study of policy problems of common concern.

Arms control and defense studies have remained a major area of focus. In a program directed by Professor Jack Ruina (Department of Electrical Engineering and Computer Science) the Center has provided support for graduate students studying in these fields, for faculty and student research, and for an extensive series of seminars for the M.I.T. and Cambridge communities. The principal focus of our teaching and research activity has been on the impact of new technology on defense and arms control. Specific issues of concern have included the growing vulnerability of land-based strategic forces, the effect of further limitation of nuclear testing, the relevance of enrichment and separation technologies on the ability of non-nuclear powers to obtain fissionable materials, the so-called neutron bomb, the cruise missile, and the growing trade in advanced conventional arms.

Associated with the program during the past year have been Professors George Rathjens, William Kaufmann, and Professor Skolnikoff (all of the Department of Political Science); Professor Bernard Feld (Department of Physics); Dr. Kosta Tsipis (Research Associate, Center for International Studies); and Amelia Leiss (Assistant Director, Center for International Studies). Professor Ted Greenwood (Department of Political Science) has also worked with the program; he is currently on leave, working with the President's Office of Science and Technology Policy. Professor Feld and Dr. Tsipis took the initiative in an activity within the Center's arms control program aimed at engaging physical scientists from M.I.T. and other Cambridge institutions in an examination of the arms control impact of such military technological developments as the MX mobile missile and military applications of laser technology. They also are studying the potential peacekeeping applications of space and surveillance technologies.

During the past year, the Center was successful in securing long-term support from the Ford Foundation for continued work in defense policy and arms control matters. The Ford Foundation has provided the largest share of our funding in this field during the past and previous years and will thus continue to do so in the future. Over the past year, the Rockefeller Foundation also provided partial support for the work of Dr. Tsipis on cruise missiles.

Closely related to the Center's work on problems of defense and arms control has been study of aspects of nuclear energy generation. Work is nearly completed on a four-year study by Professors Henry Jacoby (Sloan School of Management), Paul Joskow (Department of Economics), and Joel Yellin (School of Humanities and Social Science) of the international implications of the growth of nuclear energy generation in the balance of this century. Their work has focused on issues such as uranium supplies and markets, energy costs, environmental impacts of nuclear power plant siting, etc. The study has drawn on US data and experience, as well as that of western European countries and Japan. This work was also funded by the Ford Foundation.

During the past year the Center organized bilateral meetings between American and German, Japanese, and French experts -- from academic institutions, research laboratories, government, and industry -- to explore questions arising out of the growing nuclear power industry. The
group discussed matters such as international nuclear fuel availability, reprocessing, and
different reactor technologies in relation to concerns about proliferation. Support for the
conferences, which we hope to continue in the future, has been provided by the American
Council on Germany, the Rockefeller Foundation, and the Ford Foundation; each was held in
collaboration with institutions in the respective country.

Several members of the Center also participated in a study of common energy-related problems
between Canada and the United States. Professor Greenwood, in particular, helped to look
at uranium supplies in the two countries and the implications of governmental restrictions on
its trade. The study was part of a major inquiry sponsored by the World Peace Foundation.

Issues relating to migration continue to be subjects of substantial research interest at the
Center. Professor Myron Weiner (Department of Political Science) heads the migration and
development study group. Research within this group includes Professor Weiner's work on
internal migration in India; research by Professor Wayne Cornelius (Department of Political
Science) on the effects of migration on the communities migrants come from and on the factors
that induce Mexican rural persons to migrate, frequently illegally, to the United States;
comparative study by Dr. John Harris (Research Associate, Center for International Studies)
of economic aspects of rural-urban migration in Kenya and Indonesia; research by Professor
Nazli Choucri (Department of Political Science) on the migration of skilled labor among Arab
countries in the Middle East; and the work of Dr. Rosemarie Rogers (Research Associate,
Center for International Studies) on the effects of the migration experience on attitudes of
Yugoslav migrants in Austria.

This migration work has been supported principally by the National Institute of Child Health
and Development, with some additional support for Dr. Weiner's work from the Ford-
Rockefeller Population Studies Program.

Communications have been a major component of the Center's research program since the
Center's founding. The Center's work is now part of a larger M.I.T. research program on
communication policy, which involves, along with the Center for International Studies, the
Center for Advanced Engineering Study, the Center for Policy Alternatives, the Electronic
Systems Laboratory, and the Laboratory for Computer Science. At the Center for International
Studies, work on communications policy is directed by Professor Ithiel de Sola Pool
(Department of Political Science). The project is supported by the Markle Foundation,
American Telephone and Telegraph, International Business Machines, Hughes Aircraft
Corporation, and the National Science Foundation. Professor Pool also directed preparation
of a guide to new Federal regulations affecting cable television and has begun a study of
violence on Japanese television, supported by the Hosa Bunker Foundation.

With support from the Rockefeller Foundation, the Andrew W. Mellon Foundation, and the
United Nations Environmental Program (UNEP), the Center has continued its work on
international environmental policy. Studies are under way that relate to the issue of ozone
depletion, and to a number of environmental problems identified on the UNEP priority list.
A new element in the program over the past year has been the exploration of proposed
engineering projects that could, if carried out, significantly affect the environment of substan-
tial sections of the globe -- so-called macroengineering projects. Closely related to this
topic has been a seminar organized around discussion of the persistence of the image of
catastrophe or holocaust in Western thought. This latter effort was organized by Dr. Saul
Friedlander (Research Associate, Center for International Studies, and Professor of History,
University of Tel Aviv). The environmental program is directed by Professor Rathjens and
also involves Professor Skolnikoff and Howard Margolis (Research Fellow, Center for
International Studies).
Over the past year the Center continued its collaboration with the Department of Nutrition and Food Science on a program of research, teaching, and advisory service on nutrition planning. Among the specific undertakings were: a study of US food aid policies as they affected other countries' nutrition plans, a number of activities in Pakistan to help that government carry out its national plan to improve the nutritional status of its population, a study of the ration shop system as one device to subsidize food for very low income families, an examination of the extent to which the incidence of breastfeeding has been declining in developing countries, an examination of the effect of malnutrition on behavior, development of simplified systems for measuring sub-critical nutritional deficiencies, and study of the effectiveness of large-scale food supplement efforts in India. Professor Nevin Scrimshaw (Department of Nutrition and Food Science) heads the program; also involved have been Professors Skolnikoff, Lance Taylor (Department of Economics), Barbara Underwood, Ernesto Pollitt, and Dr. Max Milner (all of the Department of Nutrition and Food Science), Dr. John Field, Lowell Lynch, and Dr. Desmond McCarthy (all three Research Associates, Center for International Studies). The program has been supported by the Agency for International Development, the Rockefeller Foundation, the National Science Foundation, and Community Systems Foundation.

During the past year the nutrition program developed a collaborative framework with the Harvard University School of Public Health for a joint program on food and nutrition studies. This program will be closely associated with the work on world hunger of the United Nations University.

In a closely related activity, the Center has been asked to be the focal point at M.I.T. for the Title XII Program, the program of research, technical assistance, and training established by the US government to encourage land grant and sea grant colleges and universities to contribute toward the goals of elimination of world hunger and famine. Professor Skolnikoff serves as Title XII Coordinator at the Institute.

The above are the major large project areas that have made up the Center's program over the past year. There have been many other projects as well: Professor Lincoln Bloomfield (Department of Political Science) has studied various aspects of American foreign policy and in particular has focused on the recent Special Session on Disarmament of the United Nations General Assembly. Professor William Griffith (Department of Political Science) has continued his study of Communist and radical movements around the world, with particular reference in the past year to Africa. Professor Douglas Hibbs (Department of Political Science) continued to work on models of inflation as a political phenomenon, and on political-economic modes of economic cycles. Professor Harold Isaacs (Department of Political Science) continued to draw together his years of work on questions of racial and ethnic identity. Professor Steven Kobrin (Sloan School of Management) began a study of how international firms assess political risk. Professor Daniel Holland (Sloan School of Management) studied ways to measure the rate of return to capital in different industrial societies. These studies were funded by the National Endowment for the Humanities, the Carthage Foundation, The Earhart Foundation, The Ford Foundation, and the International Business Project.

The Center received support during the past year from the Sloan Foundation and the Fleischmann Foundation for its core administrative costs, along with generous support from the Institute. In addition to the specific research projects outlined above, the Center conducted an extensive seminar series for the M.I.T. and Cambridge communities on topics related to its general research on international problems. The Center also publishes an extensive monograph series.

During the past year, the Center was fortunate in having in residence visiting scholars from a number of different countries working on problems related to the Center's research fields.
Provost

These individuals in the year just ended came from Brazil, Thailand, Indonesia, Britain, Poland, Chile, Israel, and Pakistan.

EUGENE B. SKOLNIKOFF

Clinical Research Center

The past year has been a year of change at the M.I.T. Clinical Research Center. Dr. Charles S. Davidson, Senior Lecturer and Program Director of the Clinical Research Center, retired and Dr. John Burke, Director of the Shriners Burns Center and Helen Andrus Professor of Surgery at Harvard University, was named as Program Director. Dr. William H. Dietz became Assistant Director at the same time.

The intensive investigative work at the Center has continued. In addition to studies conducted on individuals occupying the 12 beds, an active outpatient program is under way as well. During the year, the outpatient studies have increased in number so that, at times, some of our nutrition studies will have as many as 100 ambulatory persons on special diets under investigation with special blood studies to accompany them. These studies are under the direct supervision of Professor Nevin S. Scrimshaw and his senior colleague, Professor Vernon R. Young, as well as their junior colleagues. These studies are of fundamental importance to our understanding of human nutritional requirements, particularly the amino acid requirements to calorie (energy) requirements. In addition, Professor Scrimshaw and his colleagues are among the major contributors to investigations of new protein sources conducted in collaboration with the Clinical Research Center.

The clinical nutrition program, under the direction of Professor Robert M. Suskind, has had a successful year. There are currently 10 physicians enrolled in this program. Their research, which is conducted in the Clinical Research Center as well as in Boston's Children's Hospital, Deaconess Hospital, University Hospital, and Massachusetts General Hospital, includes investigations of the nutritional and metabolic aspects of obesity, renal disease, congenital heart disease, anorexia nervosa, cystic fibrosis, and thermal burns.

The Department of Psychology has continued to make important contributions to and use of the Center. Dr. Suzanne Corkin, Lecturer in Psychology, has continued the studies initiated by the late Professor Hans-Lukas Teuber on the aftereffects of cingulotomay and of cortical mapping. Professor Richard Held plans to use the Center to investigate the visual acuity of infants and children, and Professors Alan Hein and Emilio Bizzi are currently doing research which will further expand their department's use of the Center.

Dr. Robley Evans and Dr. Melvin Chalfen of the Argonne National Laboratory, Center for Human Radiobiology, in Phoenix, Arizona, and here at M.I.T., have continued their studies in the Center of bone-seeking radioisotopes in humans. These studies are long-term and appear to be of great importance in our understanding of the effect of isotopes and their handling in the body.

Professor Richard Wurtman and his colleagues have continued to investigate the effects of the administration of dietary precursors of neurotransmitters on human disease states. His group has shown that the administration of choline, the precursor of acetylcholine, causes a significant reduction in the athetoid movements of tardive dyskinesia.
During the past year there have been over 20 active research protocols in progress in the Clinical Research Center. In addition, 2,847 patient-days of care were rendered during the past year.

JOHN F. BURKE

Laboratory for Computer Science (L.C.S.)

The Laboratory for Computer Science is an M.I.T. 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 in 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 that now span four principal areas.

The first such area 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 and for drug administration carried out by the Clinical Decision-Making Research Group; the use of mathematical knowledge by the Mathlab Research Group for an automated mathematical assistant; the use of knowledge in programs that comprehend typed natural-language (English) queries; and the use of Morse-code knowledge by programs that can detect Morse-code signals in extremely noisy environments.

A second main focus of Laboratory research strives to effect sizable improvements in the ease of utilization and cost effectiveness of computing systems. For example, the Programming Methodology Research Group strives to achieve this broad goal through a top-down approach for the development of programs subject to certain constraints that are imposed upon the programmer. Toward the same goal, the Domain Specific Systems Research Group is exploring the programming of real-time systems from higher-level, domain-specific languages for the control of physical processes. Other research examples in this area include the study of very large data bases, the architecture of very fast multi-processor machines by the Computation Structures Research Group, the architecture of individual "personal" machines, and the organization of geographically distributed systems of computers. The latter research program is carried out by the Computer Systems and Programming Methodology Research Groups from the point of view of exploiting the decreasing costs of processors and memories, improving overall performance and reliability, protecting information, and ensuring privacy.

The Laboratory's third principal area of research involves exploration and development of theoretical foundations in computer science. For example, the Theory of Computation Research Group strives to understand ultimate limits in space and time associated with various classes of algorithms. Other research in this area includes the Semantics of Programming Languages from both analytical and synthetic viewpoints and the links between mathematics and the privacy/authentication issues associated with distributed systems.
The fourth area of Laboratory research is entitled Computers and People and entails societal as well as technical aspects of the interrelationships between people and machines. Examples of research in this area include the sociological impact of computers on individuals; the ethical problems of distributed responsibility posed by multi-programmer systems; and various dynamic and sophisticated graphic interfaces between computers and their users.

During the past year, the Laboratory consisted of 221 members -- 36 faculty members, 11 visitors, 56 professional and support staff, 85 graduate and 33 undergraduate students -- organized into 14 research groups. The academic affiliation of most of the faculty and students is with the Department of Electrical Engineering and Computer Science. Other departments represented in the Laboratory membership are Mathematics, Architecture, the Division for Study and Research in Education, Humanities, and the Sloan School of Management. Laboratory research during 1977-78 was funded by seven governmental and industrial organizations.

The 1977-78 year was very active. Technical results were disseminated through the publications of the Laboratory members and will not be discussed here. Highlights of the year included the following.

A major breakthrough was achieved by Professors Ronald Rivest, Leonard Adleman, and Adi Shamir in linking privacy and authentication of machine data to unsolved mathematical problems. That is, schemes were devised such that violation of privacy is tantamount to the solution of unsolved or computationally "hopeless" problems. This work was highlighted by many publications in the popular press as well as by the conventional stream of professional publications.

A technical services group was formed within the Laboratory to undertake implementation of the L.C.S. network -- a data communications medium intended to link laboratory resources.

During this year cooperation began between this laboratory and the Lawrence Livermore Laboratory (LLL) of the University of California for the purpose of researching and developing very fast asynchronous, multi-processor machines. In this partnership, M.I.T. assumes the role of architect and LLL (a laboratory immersed in the solution of computationally intense problems) assumes the role of user and critic.

The Laboratory's Distinguished Lecturer Series, initiated two years ago, has been again very successful in attracting members of the M.I.T. community. The 1977-78 lecturers under this series have been John Cocke (Fellow, IBM Corp.), Edsger W. Dijkstra (Research Fellow, Burroughs, The Netherlands), B. O. Evans (Vice President, Engineering Programming and Technology, IBM Corp.), Allen Newell (University Professor, Carnegie-Mellon University), Kenneth H. Olsen (President, Digital Equipment Corp.), Ivan E. Sutherland (Professor of Computer Science, California Institute of Technology), and Maurice V. Wilkes (Head of Computer Laboratory, Cambridge University, England).

The area of geographically distributed systems is rapidly becoming a major Laboratory focus. Such systems are of interest since people and the generation of information are by nature geographically distributed, and since the costs of computing and connecting computers continue to decrease. Potential problems in this area are many and may, in effect, limit the otherwise natural growth of distributed systems. As a result the Laboratory is exploring a wide variety of research problems on the reliability, robustness, and efficiency of these systems.

During 1977-78 research in previously established areas yielded several new results and insights in: 1) automated mathematical assistance, where we strive to aid scientists and engineers through programs such as MACSYMA for the symbolic manipulation of mathematical expressions; 2) natural language understanding, by computer programs, where we strive to develop programs (and associated theories) that comprehend typed statements in relatively
Libraries

Several major concerns dominated the activities of the M.I.T. Libraries during the past year, notably the Collection Analysis Project, staff development, copyright, space planning, automation and the future of the card catalogue, and the preparation and submission of a number of proposals for support from outside agencies. While many members of the staff were involved in one or more of these areas, the Libraries continued to order, process, and deliver materials and to provide reference and bibliographic services to the Institute community. The ability to maintain a high level of ongoing services concurrently with intensive planning and research efforts was clearly demonstrated during the past 12 months and the entire staff of the Libraries is to be congratulated for their efforts, which resulted in a very successful year. The positive developments that occurred were due in no small part to those members of the staff who undertook additional assignments and expended extra energy to compensate for the temporary absences of their colleagues. The dedication and enthusiasm that were shown by the staff during a rather hectic period made the job of administering the M.I.T. Libraries much easier for all those involved.

As described briefly in last year's annual report, M.I.T. participated as one of three research libraries in a Collection Analysis Project sponsored by the Association of Research Libraries under a grant from the Andrew W. Mellon Foundation. For a period of approximately eight months, the Libraries analyzed all aspects of their collection practices with a view toward producing a set of recommendations with three goals: 1) to establish a formal collection development philosophy and set of objectives; 2) to determine the most effective use of resources, both material and personnel; and 3) to improve the effectiveness of the collection development program.
A set of 36 recommendations emanating from this project was published in the Final Report issued in March 1978. The report was disseminated widely throughout the Libraries and the Institute and after extensive discussions with the staff, the Faculty Committee on the Library System, and other groups within and outside M.I.T., the Libraries have begun implementation of a number of the specific proposals that were made. The project was directed by Jutta R. Reed, Collections Development Librarian, and a Study Team consisting of five staff members: Christine L. Baldwin, Margaret E. DePopolo, Marilyn G. McSweeney, Susan K. Nutter, and Jacqueline Stymfai. Some 25 other members of the Libraries' staff worked on one of five Task Forces, each of which submitted a lengthy report that was used by the Study Team to produce the final report and set of recommendations.

While all the recommendations are critical to a successful collection development program and while they are, to a great extent, interrelated, it is possible to identify the more significant ones as a means of summarizing the philosophy that underlies collection development in the M.I.T. Libraries:

1) Implement the philosophy of system-wide, integrated collections structured by subjects as defined by M.I.T.'s instructional and research programs.

2) Adopt a set of collection development goals and objectives calling for identification of levels of collections, communication between librarians and users and among subject specialists, maintenance of a comprehensive set of collection policies, monitoring the effectiveness of the collection program, utilization of resource-sharing programs, and a materials preservation program.

3) Assign responsibility for collection development coordination to one librarian in each divisional library and have these individuals serve as a Collection Advisory Group under the leadership of the Collections Development Librarian to develop policies and improve communication throughout the system.

4) Develop a coordinated set of collection development policies.

5) Allocate materials funds by subject to provide support for and analysis of expenditures that are directly related to Institute programs.

6) Restructure the budget process to improve planning, preparation, and presentation.

7) Investigate the potential of a resource-sharing program with the Brown University Libraries.

8) Provide for more effective participation in the Boston Library Consortium.

9) Establish a conservation and preservation program including increased staff, adherence to recognized standards for binding and repair, and improved environmental conditions.

10) Review and evaluate periodically the progress made and the problems encountered in implementing the Project recommendations.

The new Federal copyright law (PL94-553), which became effective on January 1, 1978 and was the first major revision since 1909, had a major impact upon a number of activities in the Libraries. It is too early to report the ultimate effect of this change on libraries in
general, but the initial impact was sufficiently dramatic to have produced concern not only among librarians but also among faculty, research staff, and students, not to mention the strained relations between publishers and the scholarly community. Briefly, the Libraries were required to establish record maintenance programs for interlibrary borrowing, to post notices at coin-operated copying machines and in the Microreproduction Laboratory, to revise policies with regard to reserve collections, to make substantial changes in connection with the copyright of theses, and to develop mechanisms for obtaining multiple copies of materials needed for students for course reading. Discussions are still in progress with regard to performance of musical and dramatic works, and it is evident that for at least the next few years a considerable amount of administrative effort will go into dealing with effects of the new law. One major effect is the current plan to revise the National Interlibrary Loan Code to reflect the impact of the new law; the Director of Libraries serves on an American Library Association committee established for this purpose.

The past year saw the culmination of a major study to establish a set of policies for professional staff development in the M.I.T. Libraries. An advisory committee working with the Director and Associate Director and in consultation with the staff and the various administrative offices of the Institute developed a set of documents covering search procedures, appointment, evaluation, and promotion of librarians. The Committee developed revised classification descriptions for the librarian positions and, during the year, several individuals were evaluated and subsequently promoted under the provisions of the new program. In the coming year a new Staff Review and Development Committee will continue to work on other aspects of staff development including orientation, continuing education, and educational programs. The cooperation of the Office of Personnel Services, particularly the Wage and Salary Administrator, Kerry Wilson, was invaluable throughout the development of the program.

It is most gratifying to report that great progress was made during the past year in connection with the Libraries' efforts to establish a long-range space program for the collections. The Institute has assigned the building now occupied by the Metropolitan Storage Warehouse as the future home of a Resource Sharing Center that will house selected portions of the collections. Materials to be stored there will be carefully screened and selected on the basis of current and potential use and will be available both by direct access and through a campus-wide delivery system. Older monographs, backfiles of serials, large archival and manuscript collections, and archival copies of theses will make up the bulk of the holdings with materials being transferred gradually as staff and space capability permit. The Resource Sharing Center will also house Historical Collections. With the expectation that the building will not be available before 1981, the Libraries have been assigned additional space in the EPSCO building (N52) for interim storage.

It is expected that beginning in the fall of 1978, a number of collections will be moved to provide for growth in areas where there is a critical space problem. Among the first priorities will be the transfer of theses and other printed materials from the Institute Archives and Special Collections so that the rare book collections may be moved back from the Boston Public Library. These extremely valuable collections are of great potential use to the Institute community and to scholars in general and have been, for several years, stored in conditions of low accessibility and poor environment. Following this move, a large collection of older monographs will be moved from the basement of the Dewey Library, and materials from the basement of the Hayden Library will be screened and transferred. Once established, the Resource Sharing Center should provide for the space needs of the M.I.T. Libraries for many years as well as offer the potential of a cooperative storage facility with other libraries.

The ability to move large collections from presently overcrowded facilities will also enable the Libraries to plan for additional space for existing programs and for new services. Among the principal needs are expansion of the Music Library, expanded microform reading facilities in several libraries, additional space for the Institute Archives and Special Collections,
flexible space for the housing of government documents, and the potential of integrating the Reserve Book Room into the central core of the Hayden Library. Unfortunately, the most critical space situation in the Libraries will not be affected to any great extent by the development of a Resource Sharing Center. The Rotch Library continues to exist under the most compressed conditions, and the most optimistic outlook suggests that this situation is not likely to improve for several years. Relief may then be possible when the Medical Department moves to the new Health Services building on the East Campus. In the interim, difficult decisions will have to be made regarding remote location of architectural and planning materials, and users and staff will continue to have to cope with the present substandard conditions.

One of the major concerns for the Libraries has been and continues to be the potential impact of the Library of Congress' decision to close (freeze) its catalogue in early 1980 and to convert to the new Anglo-American Cataloguing Rules II. While the situation is fluid and uncertain, to say the least, some matters are clear. M.I.T. along with other research libraries will find it difficult if not impossible to maintain a conventional card catalogue in the face of these changes. What seems most likely is that the Libraries shall have to convert to some other mechanism for providing current bibliographic access to the collections. The optimal configuration at the moment would seem to be a computer-output-microform (COM) catalogue generated from machine-readable tapes along with an automated circulation system providing the first level of bibliographic access. Concurrently it will be necessary to decide what to do with the existing card catalogues, one covering materials from 1860 to 1963, the other beginning with 1964, which will be closed in 1980. The present thinking is to microfilm the older (Dewey Decimal Classification) catalogue but to maintain the 1964-1980 files for a number of years as a closed file. One tremendous benefit of all this turmoil is that the Libraries will, for the first time, be able in 1980 to provide a complete bibliographic record of a vast majority of the collection in every divisional and branch library on the campus and at Lincoln Laboratory. Combined with a delivery system that covers all collections including the Resource Sharing Center, the Libraries will certainly be able to provide more comprehensive and expeditious access to the collections.

Several major development programs were initiated during the year and two requests for support were approved during that time. A proposal to the National Endowment for the Humanities for support of the Institute Archives was approved, granting the Libraries more than $83,000 for a three-year staff support program to collect, inventory, catalogue, and make available the collections of papers of individuals who have made significant contributions to the development of 19th- and 20th-century science and technology. A grant from the R. K. Mellon Foundation for support of the Human Studies Collection was received and a part-time staff member was appointed to expand the collections and to revise and reissue the two bibliographies covering men's and women's studies. Proposals were submitted for support of the Resource Sharing Center, support of the operations of Historical Collections, and assistance in the restoration of our collection of architectural drawings, also housed in Historical Collections.

The Libraries' budget for fiscal year 1978 included funds to cover the increased cost of materials and services generated by inflation as well as a modest sum for support of acquisitions in emerging areas of teaching and research. The fiscal 1979 budget will also provide for inflationary increases, new acquisitions, and staff to begin planning for the Resource Sharing Center. In addition, the Libraries will be able to add a half-time staff member to handle circulation in the Rotch Library, provide additional support for binding and preservation programs, and hire additional students for the Barker Library and for the Institute Archives and Special Collections. Although the budget for materials is still constrained because of inflation and the increase in publishing, the Libraries are heartened by not having had to make any budget cuts for three years. The support of the Institute administration, particularly that of the Chancellor and the Provost, for the Libraries' programs and activities is most gratifying and greatly appreciated.
On July 1, 1977, Historical Collections was officially made a department of the M. I. T. Libraries. The integration of this program has proved to be both successful and mutually beneficial. Historical Collections and the Institute Archives have worked closely in identifying areas of responsibility, transferring collections to the most appropriate location, and developing joint programs for acquisitions, processing, and service. Major activities included the transfer of the globe and instrument collections, merger of the biographical files, and joint evaluation and acquisition of several important collections of papers and memorabilia. Individually the two departments have engaged in a wide spectrum of activities with the Archives emphasizing collection and processing of Institute records, oral history, and manuscripts, and Historical Collections continuing programs in exhibitions, preservation, and collection organization.

Major highlights of the year in other areas of the Libraries are outlined below.

**Public Service**

The Public Services group (of divisional and branch librarians) developed a set of standards for reference identifying appropriate levels of service for members of the Institute community and for outside users. A campus document delivery system was initiated, LIDS (Library Institute Delivery Service), offering delivery of materials to and from any library in the system within 24 to 48 hours. New policies were established for reserve collections. The Library User Relations Committee developed a slide orientation program for new staff and continued working on the guides to the M. I. T. Libraries. As of June 1978, 24 separate guides to individual collections, services, and programs were published or were in final preparation.

NASIC (Northeast Academic Science Information Center) services increased dramatically with the number of searches up 13 percent over the previous year, the number of data bases available increasing by 52 percent (from 67 to 102), and the total volume in terms of system use up 28 percent. The Microreproduction Laboratory installed a Xerox 4000 copier in the Hayden Library offering charge account service to Institute personnel; it has proved to be extremely successful.

**Technical Services**

The Catalogue Department made tremendous progress in expediting the processing of new materials, increasing monographic cataloguing overall by 15 percent, and reducing the pre-cataloguing arrearage by more than 33 percent and the total arrearage by 13 percent. The addition of an on-line printer to the OCLC terminals has increased the effectiveness of personnel while relieving the queuing problem at these terminals.

The list of serials and journals in the M.I.T. Libraries will be published in its 15th edition this summer in microfiche form. This change will permit more frequent updating and many more access points throughout the library system. The Collections Development Department has established a system-wide program of pre-order searching using the OCLC terminals that will offer more complete bibliographic information, less unwanted duplication, and expedited ordering and cataloguing.

**Collection Development**

Some of the major acquisitions received during the year are listed below. These are examples intended to indicate the scope of the collection activities of the M.I.T. Libraries:
• 10-K reports on microfiche replacing annual reports to stockholders for all major American companies (Dewey Library)

• Five union newspapers on microfilm replacing 60 bound and deteriorating volumes (Industrial Relations Collection)

• NTIS Reference Files (Barker Library)

• Arts and Humanities Citation Index (Humanities Library)

• Papers of Benjamin Henry Latrobe, microtext edition (Rotch Library)

• Ninth collective index to Chemical Abstracts, 1972-76 (Science Library and Chemistry Reading Room)

Other Activities

The Libraries presented a wide variety of activities during the 1978 Independent Activities Period including the second annual M. I. T. College Bowl, the third annual Book Collecting Contest, a series of four slide talks on "The Book as Art and Artifact," two seminars on how to use the Aeronautics and Astronautics Library, the establishment of a Browsery in the Humanities Library (subsequently made a permanent service), an oral history workshop, a program on T'ai Chai (the classical system of Chinese exercise), a lecture and slide presentation of women's mystery fiction, a course in the fundamentals of drawing, the second annual Chamber Music Society Marathon, a series of four visits centered about the theme "Introduction to the Conservation of Materials," and a series of four lectures on library automation, the last sponsored and organized by the Library Staff Association.

Gifts

During the past year the M. I. T. Libraries received gifts from a large number of individuals and organizations; a list of the former is included in the archival appendices of this report. Among the collections of printed materials were a collection of books from the library of the late Professor Jeffrey Pressman given by his wife, five 19th-century works on architectural history from I. Austin Kelly III, market research materials from Stanley Klein, and a large collection of books from former Dean of Engineering Gordon S. Brown.

In addition to the substantial collections of official Institute records deposited by many departments and offices, the Institute Archives and Special Collections acquired major manuscript collections from Mrs. Ruth Ippen (papers of Arthur T. Ippen), the Department of Humanities (Giorgio de Santillana papers), Department of Psychology (Hans-Lukas Teuber papers and videotapes), James R. Killian, Jerome B. Wiesner, John T. Edsall (papers of George Scatchard), and Mrs. Mary Russell Adams (papers of Henry Darwin Rogers).

Among the gifts to Historical Collections was one from Mrs. Eleanore Bloedel consisting of three manuscript letters, six models, and several rare books all connected with James Watt and the development of the steam engine; two collections of early radio equipment, one from former Professor of Electrical Engineering Marcy Eager and one from James H. Cannon; and a group of instruments used by Robert van de Graaff donated by the High Voltage Engineering Corporation.
Gifts for the acquisition of library materials were received from a number of alumni including matching gifts through M.I.T. Challenge '78 and other sources.

The successful conclusion of another year in the M.I.T. Libraries was due in large part to the efforts of the staff, which are sincerely appreciated. The Libraries have benefited as well from the support received from the Faculty Committee on the Library System, the Corporation Visiting Committee for the Libraries, faculty, students, and staff, and from the many, many individuals and offices in the Institute on whom we rely regularly.

STAFF ACTIVITIES

Laura B. Carchia was a member of the Committee on University Industrial Relations Librarians (CUIRL) and chaired the 32nd annual meeting on June 1 and 2 at M.I.T.

Clara-Mae Chittum was a member of the Planning Committee for the American Library Association (ALA) program on library automation.


Katharine G. Cipolla supervised the production of the "What is Engineering" series for the M.I.T. School of Engineering Committee on Engineering Education. She produced with Carole Schildhauer a videotape entitled "Locating Technical Translations," which was shown at the June Special Libraries Association (SLA) meeting and at Simmons College. She supervised production of four videotapes for Civil Engineering subject 1.06, April-May 1978. She gave a presentation on "Production of an Instructional Program in a Non-Print Medium" at the SLA Chemistry Division meeting in June. With Ms. Schildhauer she gave a presentation on "Use of Media in Bibliographic Instruction" to Professor Juan Freudenthal's class in bibliographic techniques at Simmons College in November and April.

Clementine I. Coblyn participated in M.I.T. Administrative Development Program X. She chaired the M.I.T. Libraries' Circulation Committee. She served on the Selection Committee for the Institute Organization Workshop. She was a member of the Boston Library Consortium (BLC) Readers' Services Committee. She was coauthor (with Mary Ann Griffin and Joan Stockard) of "Adding to Knowledge about Document Exposure Counts in Three Academic Libraries: Circulation and In-Library Use," to appear in Quantitative Measurement and Dynamic Library Services, Oryx Press.

Jacqueline Z. Colby was a member of the BLC Cataloguing Committee.

Linda Cuccurullo conducted with Judith DiLeo a survey of the career development of Association of Research Libraries (ARL) directors; the survey was done under the direction of Professor James Matarazzo of Simmons College.

Betty-Ann Curtis continued as a member of M.I.T.'s Employee Assistance Planning Group. She served on the Steering Committee of the M.I.T. Women's Forum.

Margaret E. DePopolo served on the School Council of the M.I.T. School of Architecture and Planning. She was elected Vice President/President Elect of the Council of Planning Librarians.

Judith DiLeo conducted with Linda Cuccurullo a survey of the career development of ARL directors; the survey was done under the direction of Professor Matarazzo of Simmons College.
Florence K. Doksansky was a member of the M.I.T. Working Group on Office/Clerical Issues. Her articles "Gems from the Boles Room" and "Rehabilitation--A New Dimension in Architecture; an Alumnus Interview with Mel Gadd" appeared in PLAN, Review of the School of Architecture and Planning. She served on the Nominating Committee of the New England Chapter of the Art Libraries Society/North America (ARLIS/NA). She made a presentation on interviewing techniques at the Chapter's meeting at M.I.T. in March. She was awarded a 1978 fellowship from the Council on Library Resources to study librarian staff development programs in academic library systems.

William J. Duggan was a member of the Finance Committee of the New England Library Information Network (NELINET).

David S. Ferriero was a member of the NELINET Committee on Interlibrary Communications. He was vice chair of the New England Library Association College Libraries Section and of the Association of College and Research Libraries (ACRL) National Conference Local Arrangements Committee.

Fae K. Hamilton was a member of the NELINET Quality Control Committee.

Kate S. Herzog served as Membership Chairman and Nominating Committee Chairman of the New England Chapter of the American Society for Information Science (ASIS). She participated in the M.I.T. Supervisory Development Program.

Irma Y. Johnson served as resource person for the M.I.T. Women's Forum Career Fair. She was a reviewer for College and Research Libraries. Her letter to the editors of Science appeared in the April 1978 issue. She presented a paper for the panel "Academic Libraries and a National Information Policy" at the ALA annual meeting in June. She was Deputy Chairman of the ACRL 1978 National Conference Program Committee and President of the New England Chapter of ACRL. She was a voting delegate of the Governor's Conference on Libraries and Information Science.

Robert L. Kehner was a member of the NELINET Government Documents Task Force.

Eileen Kibrick participated in M.I.T. Administrative Development Program IX.

James M. Kyed was a member of the Accreditation Study Committee of the Engineering Libraries Division of the American Society for Engineering Education.

Aleksander Leyfell continued as Research Fellow at the Harvard University Russian Research Center.

Leonore K. Linsky was a member of the BLC Program Committee. She participated in M.I.T. Administrative Development Program X.

Jay K. Lucker was a member of the M.I.T. Cable Television Policy Board. He was Treasurer of the M.I.T. Chapter of Phi Beta Kappa. He served as an M.I.T. Freshman Advisor. He was a guest member of the M.I.T. Press Editorial Board. He served as a member of the Board of Directors of the BLC and of the Board of Directors of the New England Deposit Library. He was a member of the Council of Universities for the Kennedy Library. He was a member of the Brown University Library Committee, the Lehigh University Library Visiting Committee, and the Southeastern Massachusetts University Advisory Committee on University Library Communications Center. He was a member of the Executive Committee and Committee on Future Governance of NELINET. He was chairman of the NASIC II Advisory Committee. He was a member of the Planning Committee on Subject Access of the Committee for the Coordination of National Bibliographic Control. Mr. Lucker continued as chairman of the ARL
Interlibrary Loan Committee. He was a member of the ARL Board of Directors and a member of the ALA Interlibrary Loan Committee and the ACRL Committee on Standards and Accreditation. He was a member of the Middle States Association of Colleges and Secondary Schools Commission on Higher Education accreditation team for Bryn Mawr College. Mr. Lucker was a contributor to American Reference Books Annual, published by Libraries Unlimited, Inc. His paper "Collection Analysis in a Decentralized System" appeared in Collection Analysis in Research Libraries, published by ARL, 1978. He reviewed grant proposals for the National Endowment for the Humanities.

Kathleen Maio conducted a seminar on "Women's Mystery Fiction" during Independent Activities Period (I.A.P.) 1978. Her presentation "Strange and Fierce Delight: Early Days of Women's Mystery Fiction" was given at the annual meeting of the Modern Language Association in December.

Marlene Manoff was abstractor for Abstracts of English Studies.

Hedy Mattson participated in M.I.T. Administrative Development Program XI.

Marlene Manoff was abstractor for Abstracts of English Studies.

Marilyn G. McSweeney was a member of the ACRL National Conference Local Arrangements Committee.

Suanne W. Muehlner was a member of the Classification Review Committee of M.I.T.'s Salary Administration Program. She was a member of the ALA Resources and Technical Services Division (RTSD) Reproduction of Library Materials Section Telefacsimile Committee. She was vice president of the Simmons College Library School Alumni Association. She was an SLA national scholarship referee for the Boston Chapter.

Judith I. Nathans was a member of M.I.T.'s Working Group on Office/Clerical Issues.

Frances R. L. Needleman was a member of the ALA RTSD Computer Filing Committee and a member of the BLC Cataloging Committee.


Margaret A. Otto served on the ALA Library Administration Division, Library Organization and Management Section (LOMS) Executive Committee as member-at-large and on the committee to study the future role of LOMS. She was a member of the Board of Directors of the Universal Serials and Book Exchange. She was vice chairman of the NELinet Executive Committee. Her article "The View from the Library Administrator," part of a group of articles under the heading "The Employment of Professionals in Support Positions: A Symposium," edited by Joseph Dagnese, appeared in the January 1978 issue of the Journal of Academic Librarianship.

Mary E. Pensyl presented with Susan Woodford papers on computerized literature searching at the fall meeting of ASIS. With Ms. Woodford she gave a demonstration of computerized searching at Simmons College on October 25. She gave a presentation on on-line searching as
a networking activity at the SLA Student Chapter meeting at Simmons College on February 15. With Ms. Woodford she gave a talk and demonstration at the New England On-line Users Group Workshop held at Pine Manor Junior College on May 17 and at the CUIRL meeting held at M.I.T. in June. She gave a talk entitled "Case Studies in the Use of Engineering Data Bases" at the Dialog Update Meeting in Chicago in June. She gave a talk entitled "Before You Touch the Terminal: Presearch Aspects for Librarians and Reference Librarians" at the Reference and Adult Services Division, Machine Assisted Reference Section meeting at the ALA conference in Chicago in June.

Kathleen A. Powers was vice chair of the BLC Readers' Services Committee. She was a member of the ACRL National Conference Local Arrangements Committee. She was M.I.T. Community Service Fund solicitor for the Libraries.

Jutta R. Reed chaired the ARL Collection Analysis Project Study Team. She discussed the Project at the Simmons College School of Library Science spring doctoral seminar in April. She chaired the M.I.T. Libraries' Government Documents Committee. She was a member of the BLC Selection/Acquisitions Committee. She was appointed to the ALA Collection Development Committee.

D. Gregory Sanford was a member of the New England Oral History Association Program Committee for the fall 1978 meeting. He conducted an Oral History Workshop at M.I.T. during I.A.P. 1978.

Carole Schildhauer served as the Libraries' Coordinator for I.A.P. 1978. She participated in M.I.T. Administrative Development Program XI. She presented a paper entitled "Practical Aspects of Bibliographic Instruction" at the June SLA meeting. With Ms. Cipolla she produced a videotape entitled "Locating Technical Translations," which was shown at the June SLA meeting and at Simmons College. With Ms. Cipolla she gave a presentation on "Use of Media in Bibliographic Instruction" to Professor Freudenthal's class in bibliographic techniques at Simmons College in November and April.


Peter R. Scott was a member of the American National Standards Institute Committee PH5, Micrographics. He was a member of the National Micrographics Association (NMA) Microfiche Standards Committee and of the NMA Conference of Fellows. He was a member of the NMA Awards Committee and chaired a subcommittee to study placement and content of targets and indexes on microfiche. Under the auspices of NMA he conducted a seminar on quality control. He gave a talk at a conference on government documents given at Dartmouth College.

Patricia M. Sheehan served in several capacities in the Governor's Conference on Libraries and Information Science: member of the Core Committee; member of the Citizens' Committee and speaker at the swearing-in by the Governor; member of the Program Subcommittee and liaison to Core Committee; Chairman and speaker at the technology session; and editor, Proceedings. She served on a Massachusetts Board of Library Commissioners panel on a Massachusetts library automation survey. She was New England representative of the ASIS Special Interest Group Public/Private Interface Committee on White House Conference. She served as NELINET Liaison. She was a member of the BLC Serials Committee. She was a referee of the 1978 ACRL Conference papers on technology. She was a Boston Civic Centre speaker on employment in libraries and automation. She was a member of Professor J. Francis Reintjes’s EDUCOM group on use of gaming simulator as means of studying impact of computer.
publication and other on-line bibliographic services on host computers within EDUCOM. She was United Way Campaign solicitor for the Libraries.

Helen W. Slotkin was a member of the Archives of Science Committee, College and University Archives Committee, and Machine Readable Record Committee of the Society of American Archivists. She presented a paper, "The Buckley Law: Current Interpretations," at a meeting of the SAA in October. She gave a talk, "Why University Libraries Collect Rare Books," at the annual meeting of the University of Louisville Library Associates in November. She organized and chaired a panel discussion on "Ethnomusicology Archives" for the annual meeting of the Music Library Association in February. She also reviewed grant proposals for the National Endowment for the Humanities.

Linda I. Solow was member-at-large of the Board of Directors of the International Association of Music Libraries, US branch. She was a member-at-large of the Board of Directors, a member of the Publications Committee, and Program Chairman of the 1978 Winter Meeting of the Music Library Association. She was joint editor of The Boston Composers Project, compiled by the Boston Area Music Librarians, 1978.


Barbara Steen was an instructor in drawing in the Planning Continuing Education Program of the Harvard Graduate School of Design-M.I.T. School of Architecture. She offered a course in drawing during I.A.P. 1978 and was a lecturer in the M.I.T. Department of Architecture in the spring.

Jacqueline Stymfal was a member of the NELINET Government Documents Task Force.

David C. Van Hoy was a member of the BLC Serials Committee. He participated in M.I.T. Supervisory Development Program. He chaired the Libraries' Serials Committee.

Susan Woodford presented with Ms. Pensyl papers on computerized literature searching at the fall meeting of ASIS. With Ms. Pensyl she gave a demonstration of computerized searching at Simmons College on October 25. They also gave a talk and demonstration at the New England On-line Users Group Workshop held at Pine Manor Junior College on May 17, and at the CUIRL meeting held at M.I.T. in June.


**Staff Changes**

The following new appointments were made this year: Rita V. Caviglia, Assistant Rotch Librarian for Public Services; Deborah A. Cozort, Assistant Archivist; Lawrence R. Harmon, Staff Assistant, Collection Analysis Project; Robert L. Kehner, Assistant Dewey Librarian for Documents; Barbara Mann, Assistant Barker Librarian for Processing; Kathleen A. Powers, Associate Humanities Librarian; and D. Gregory Sanford, Assistant for Oral History.
The following promotions took place during 1977-78: Christine L. Baldwin, Assistant Science Librarian; Lois M. Chalmers, Serials Cataloguer; Linda R. Cuccurullo, Cataloguer; David S. Ferriero, Humanities Librarian; Richard M. Fletcher, Assistant Humanities Librarian; Kate S. Herzog, Aeronautics and Astronautics Librarian; Micheline E. Jedrey, Assistant Rotch Librarian for Processing; David D. Lewallen, Assistant Dewey Librarian for Reference; Hedy Mattson, Lindgren Librarian; Marilyn G. McSweeney, Assistant Humanities Librarian; Mary E. Pensyl, Head NASIC Services; Nancy C. Schrock, Visual Collections Librarian; Linda I. Solow, Music Librarian; and Jacqueline Stymfal, Assistant Dewey Librarian for Collections.

Lawrence R. Harmon, Staff Assistant, Collection Analysis Project and D. Gregory Sanford, Assistant for Oral History resigned from the staff of the libraries this year.

JAY K. LUCKER

Center for Cancer Research

In the academic year 1977-78 the Center for Cancer Research continued the development of its program, which now involves over 150 workers, including 13 faculty members and 30 graduate students. The laboratory for the biological studies of chemical carcinogenesis was completed and negotiations are in process to add a new faculty member to take charge of this laboratory. The new undergraduate teaching laboratory for courses in biology related to cancer has already been activated and used in the fall term.

Professors Phillips Robbins and Richard Hynes have been recognized with the awards of an American Cancer Society Professorship and a National Institutes of Health Career Development Award, respectively.

A particularly pleasant aspect of work in the Cancer Center is the continuing and increasing participation of undergraduate students in our research programs; including Undergraduate Research Opportunities Program projects, about 24 undergraduates worked in the Cancer Center in the course of this year.

This year, we had three visitors on leave from faculty positions in other institutions. This kind of program is a valuable addition to the work of the Center.

This has been a year rich in valuable scientific advances. The research is being reported in appropriate journals.

SALVADOR EDWARD LURIA
Electronic Systems Laboratory (E.S.L.)

The basic goal of the Electronic Systems Laboratory is to carry out basic and applied research in the general area of complex engineering and sociotechnical systems. Research areas include basic theoretical development and selected applications involving the analysis and design of complex dynamic and stochastic systems. This work requires the use of concepts from a variety of fields including system theory, decision analysis, communication and information theory, control theory, operations research, and information systems technology.

The Laboratory was founded in 1939 and was originally called the Servo-Mechanism Laboratory. Its name was changed to the Electronic Systems Laboratory in 1959. Until March 1, 1978 E.S.L. was a departmental laboratory in the Department of Electrical Engineering and Computer Science. Since March 1, 1978 E.S.L. has been designated as an interdepartmental laboratory and reports to the Provost. The Director of E.S.L. is Professor Michael Athans, the Associate Director is Professor Robert G. Gallager, and the Assistant Director is Professor Alan S. Willsky. In the past year 16 faculty members, 2 visiting faculty, 12 full-time research staff, 4 visiting scientists, 14 support staff, and approximately 60 graduate and undergraduate students have been affiliated with the Electronic Systems Laboratory. Research support has been provided by the American Newspapers Publishers Association, the National Aeronautics and Space Administration, the Defense Advanced Research Projects Agency, the Department of Transportation, the Gannett Foundation, the Office of Naval Research, the Army Research Office, the Department of Energy, the National Science Foundation, the Air Force Office of Scientific Research, the Library of Congress, and General Motors Corporation.

Systems and Control Theory

A great deal of basic research in systems and control theory is being carried out by faculty, research staff, and graduate and undergraduate students. The objective of this effort is to provide basic and fundamental understanding in the analysis and design of complex stochastic and dynamic systems, as motivated by several applications.

Professors Willsky and Sanjoy Mitter and Dr. Alan Laub continued their basic research in the area of algebraic system theory, and numerical aspects of different algorithms that are important in understanding the structural properties of linear systems.

Professors Timothy L. Johnson and Willsky and Dr. Paul Houpt continued their basic research in the appropriate methodology for utilizing microprocessors and finite state machines for estimation and control of dynamic systems. The research includes topics of effects of limited compensator memory, roundoff errors, and their implications in the structure and performance of closed loop control systems.

Professor Willsky and Dr. Stanley Gershwin have continued their basic investigations in the development of theory of failure detection and isolation algorithms. Research topics include the effects of dynamic system modeling errors upon the performance of sensor failure detection and isolation algorithms, different suboptimal techniques with modest memory and real-time computational requirements for failure detection and isolation, and the trade-off between the algorithm complexity and performance as quantified by probabilities of false alarm and probabilities of detection and isolation.
Professors Athans and Willsky and Dr. David Castanon continued their basic research in developing a methodology for the design of robust control systems, with special emphasis on actuator failures, and trade-offs involving possible reconfigurations of the control system following the identification and isolation of a failed component. A general methodology has been developed which takes into account the system dynamics, the performance index, and the failure and repair rates of actuators so as to design a control system that continues to stabilize the system, if possible, in the presence of failures, with or without reconfiguration of the control system gains.

Professors Johnson and Mitter continued their basic study of problems of estimation and optimal control for distributed parameter systems. Specific topics under investigation include estimation and control studies for systems that involve time delays, as well as the optimal control of systems described by partial differential equations when the control can affect the system performance acting only through the system boundaries.

Professors Athans, Gunter, Stein, and Nils Sandell continued their basic research on the robustness of multivariable control systems using the Linear-Quadratic-Gaussian design methodology. Important areas of investigation relate to the development of inherent and guaranteed robustness properties measured in terms of gain and phase margins. Additional research is being carried out in the area of robustness of sampled data systems as a function of sampling frequency. Another important area of research deals with the inherent robustness of systems that are characterized by both fast and slow dynamics, when the control system is designed by ignoring the existence of the fast dynamics.

Professor Stein continued his fundamental investigation into design techniques which can be used to guarantee that certain of the eigenvalues and eigenvectors of a closed loop linear system will be near prespecified locations and directions, using the multivariable Linear-Quadratic-Gaussian methodology.

Professors Mitter, Sandell, Willsky, and Athans continued basic research in several aspects of modern estimation theory. Specific problems investigated include the development of performance bounds for suboptimal nonlinear filtering algorithms, stability and divergence properties of constant gain Extended Kalman Filters, decomposition techniques for estimation problems, and estimation algorithms for linear systems characterized by white noise parameters.

Dr. Castanon continued his basic research on fundamental aspects of dynamic and stochastic teams and games. Special attention has been paid in the correct mathematical formulation of stochastic dynamic Nash strategies and leader-follower Stackelberg strategies.

Professors Sandell, Athans, and Mitter and Drs. Laub and Castanon continued their research on the development of several analyses and design methodologies associated with estimation and control problems for large-scale systems and decentralized control. Specific design methodologies have been developed for estimation and control team-theoretic problems with and without nonclassical information patterns, off-line and on-line decomposition algorithms for estimation and control, the development of reliable software for the design of centralized and decentralized large-scale dynamic systems, the development of centralized and decentralized estimation and hypothesis testing algorithms, exact solutions to algebraic Riccati equations, and the studies of signaling strategies in nonclassical information problems. Specific results have been obtained for the decentralized and hierarchical control of systems with weak dynamic interactions, for systems characterized by time scale separation involving fast and slow dynamics, and for systems that have a high degree of symmetry.
Communications Network and Systems

A second major area of basic research carried out by faculty, research staff, and graduate students deals with basic problems in the analysis and design of complex communication networks. This research is motivated by the increasing use of both civilian and military data communication networks which may include both line switched and message switched strategies.

Professors Gallager, James Massey, and Cyril Leung and Dr. Pierre Humblet have continued their basic studies in data communication networks. Specific research projects include the development of decentralized flow control algorithms which allow only nearest neighbor communications, the development of methodologies that can be used to assess the minimum amount of protocol information needed for flow control, the effects of link and node failures, security aspects of data communication networks, and the dynamics of data communication networks in general.

Professors Gallager and Massey, Dr. Humblet, and John E. Ward have initiated a new research project that deals with fundamental understanding of all aspects of mobile ratio packet communication networks. The basic problem involves a set of moving nodes that wish to be able to communicate to both geographically fixed and other moving nodes. Strategies have to be developed such that at each instant of time, each particular node in the network is able to communicate with every other node in the network.

Professors Athans and Wilbur Davenport and Dr. Castanon have initiated a new study dealing with distributed information, communication, and decision problems as motivated by problems in Naval command, control, and communications systems. Research topics involve multisensor correlation studies carried out by distributed sensors and data bases, the dynamics and control of distributed data bases in a complex communications network, and general problems of decision making under uncertainty. This project involves close interactions with the research being carried out at the Naval Postgraduate School in Monterey, California and with the work being carried out in several government laboratories. A three-week workshop on this topic will be held at M.I.T. in August 1978.

Biographical Information Retrieval Interactive Systems

Professor J. Francis Reintjes and Richard Marcus continued their research in the coupling of interactive information systems. There are several data bases containing biographic information that are distributed throughout the country, and each system has its own language and protocol in order to retrieve information. Thus a user who wished to access several of these data systems had to learn the protocol for each one. The purpose of this research is to provide an interactive coupling device and suitable language, so that a user could communicate and retrieve information from these distributed data bases by learning only a single language and protocol.

Professor Reintjes and Donald Knudson are involved in the development of a full test image system for the Library of Congress. Both the systems aspects and the actual hardware interconnections are under investigation. This project, once complete, will provide the ability for each Senator and Representative to access the material stored in the Library of Congress.
Transportation Problems

Professor Athans and Drs. Houpt and Gershwin continued their applied research on the control of freeway corridor systems, that is the control of entrance ramps to a freeway and the coordination of signals in parallel arterials. The total decentralized estimation and control problem has been formulated and several control strategies have been developed. Additional studies in this area include the development of system optimized strategies in which energy optimization is the ultimate goal, as well as the effects of diamond lanes and modal split on the transportation problem in general. Current research is focused on the development of better dynamic models for traffic flow in weaving lanes especially in the vicinity of an entry and exit freeway ramp, the development of improved ramp control strategies so as to minimize the propagation of shock waves in the freeway traffic, and the coordination of a transportation system, part of which is under computer control and part of which is uncontrolled in the sense that the drivers make all decisions.

Professor Willsky and Drs. Houpt and Gershwin have completed a study that deals with the development of superior incident identification and location studies in freeways. Several new algorithms for incident detection have been developed which appear to be superior to existing ones in their ability to detect incidents in light traffic, distinguish incidents from normal traffic propagation phenomena, and which may result in savings in the number of loop detectors needed for incident location.

Mark Connelly continued his research on several aspects of air traffic control. In particular the value of an airborne traffic situation display for spacing, metering, collision avoidance, and four-dimensional area navigation are under investigation.

Professors Stein and Athans and Dr. Houpt have initiated a new research program in cooperation with the General Motors Research Laboratories which deals with the application of modern control and estimation techniques to problems related to the multivariable control of internal combustion engines. The study involves the coordination of several engine controls so as to minimize, to the degree possible, the pollutant emissions, while maximizing fuel economy without sacrificing drivability.

Energy Systems

Professor Sandell continued his investigations on the control of complex power systems using the tools of multivariable optimal control theory. New research directions include the control of AC power systems using multiterminal DC networks, both under normal and emergency conditions.

Professor Athans and Dr. Gershwin have initiated a new study, jointly with Systems Control Inc., of Palo Alto, California, on the concept of effectiveness of power systems with respect to the reliability of service, as influenced by capital expenditures, in improving the reliability of the distribution network, and as a function of different classes of customers. This study attempts to quantify the worth of the energy delivery system from the customer viewpoint, the cost to the utility, and the role of the regulatory agency.

Professor Johnson has completed the first phase of a research study that deals with the feasibility of using a chlorophyl generator to convert sunlight into electricity.
Industrial Systems

Professor Reintjes and Mr. Knudson continued their work in the general area of application of computers to the newspaper industry. The research involves computer-aided design methods for placement of advertisements, pictures, and stories and associated headlines in the newspaper. In addition, work has been carried out on novel techniques for bandwidth compression for transmittal of black and white pictures for newspaper reproduction.

Professors Athans and Cook, Drs. Gershwin and Laub, and Mr. Ward continued their investigations of the system aspects of flexible automated batch manufacturing systems. The research carried out includes investigation of deterministic and stochastic scheduling methods for classical flowshops with and without intermediate buffers, the impact of intermediate buffers and the production efficiency of an automated transfer line, and the optimization strategies at both the static and dynamic levels for interconnected manufacturing networks. The results of this research were presented during a two-day workshop held at M.I.T. in May 1978.

Economic Systems

Professors Athans, Edwin Kuh, and Robert Pindyck, and Dr. Castanon continued their investigations on the application of modern estimation and control methods to macroeconomic and microeconomic systems. The research involves short-term stabilization policies for aggregated econometric models of the US economy, the effects of coordination of monetary and fiscal policies, the selection of the planning horizon, sequential feedback stabilization strategies, and the fundamental impact of modeling uncertainty upon economic decisions.

Biomedical Problems

Professor Johnson continued his research on defining and measuring the properties of electrodes and their effects on the accuracy of measurement of diverse bioelectric phenomena.

General Purpose Software

Professors Sandell and Athans, Dr. Laub, and James Carrig are in the final stages of completion of a general purpose analysis and design package which can be used for the design of optimal estimators and compensators for linear-Gaussian systems with respect to quadratic performance indices. Both continuous-time systems and discrete-time systems can be handled by this general set of computer subroutines. Special attention has been paid to the development of lower-order subroutines with desirable numerical properties. This general computer package will be completed in the summer of 1978 and will become available to government agencies, industry, and other universities.

MICHAEL ATHANS
Harvard-M.I.T. Division of Health Sciences and Technology

In June of 1977, the Corporation of M.I.T. and the President and Fellows of Harvard College established the Harvard-M.I.T. Division of Health Sciences and Technology. The Division serves to institutionalize the Program in Health Sciences and Technology which was created in 1970.

The Governing Board of the Division which is responsible for the formulation of educational, administrative, and fiscal policies consists of President Derek C. Bok of Harvard and President Jerome B. Wiesner of M.I.T., Francis H. Burr, Thomas D. Cabot, Maurice Lazarus, and Gregory Smith.

An Administrative Council has been formed to foster further productive collaboration between the two universities in the health sciences. The Administrative Council includes the Provost of M.I.T., the Dean of the Harvard Faculty of Medicine, the Director of the Division of Health Sciences and Technology, the Dean of the Harvard Faculty of Arts and Sciences, the Dean of Engineering and Applied Physics at Harvard, the Dean of the Harvard School of Public Health, the Dean of the School of Engineering of M.I.T., and the Dean of the School of Science of M.I.T. During the past year this Council has reviewed the educational and research activities of the Division of Health Sciences and Technology and has discussed programs in the Harvard School of Public Health in the analysis of health practices, biostatistics, and epidemiology, and plans for an interdisciplinary postdoctoral fellowship program.

The Joint Faculty Committee is responsible for the development and conduct of the academic programs of the Division. During the past year, the members of the Joint Faculty Committee were Dr. Walter H. Abellmann, Dr. Harold Amos, Professor George B. Benedek, Dr. William Berenberg, Professor Ernest G. Cravalho, Dr. Herman N. Eisen, Dr. David G. Freiman, Professor Robert Hulsizer, Professor Farish A. Jenkins, Jr., Professor Richard Kronauer, Dr. Alexander Leaf, Dr. Irving M. London, Professor Boris Magasanik, Professor Robert W. Mann, Professor Roger G. Mark, Dr. William V. McDermott, Jr., Dr. James L. Whittenberger, and Professor Laurence R. Young.

EDUCATIONAL PROGRAMS

The Biomedical Sciences Curriculum for the M.D. Degree

An important feature of this educational program is the frequent review by faculty and students of subjects for which the Division is responsible. During the academic year 1977-78 evaluations were conducted by specially appointed task forces on the following subjects: 1) HST 040 Mechanisms of Microbial Pathogenesis; 2) HST 141 Molecular Basis of Some Clinical Disorders; 3) HST 900 Topics in the Economics of Health Care; 4) HST 030 Human Pathology; 5) HST 010 Functional Anatomy of Man; and 6) HST 050 Topics in Quantitative Physiology.

Major recommendations include an increase of opportunities for clinical experience in HST 141; increased emphasis on virology in HST 040 and the presentation of parasitology as an elective
course instead of as part of HST 040; an improved elective opportunity in immunology (HST 030); and the provision of tutorial assistance to students encountering difficulty in coping with the more rigorous portions of HST 010 Functional Anatomy and HST 050 Topics in Quantitative Physiology.

The Curriculum Committee is engaged in an evaluation of the student advisory system, the status of the fields of concentration, and the implementation of the thesis requirement for the degree of Doctor of Medicine. Questions identified for consideration in the future include an overall review of the schedules of students and the optimal balance between quantitative physical sciences and molecular and cellular biology.

Drs. Abelmann and Eisen, Cochairmen of the Curriculum Committee, have provided outstanding leadership in the work of the Committee.

Approximately 30 of the students who are candidates for the M.D. degree also are working for a Ph.D. degree. There is a persistent critical need to provide stipends to support these students. The support of the Health Sciences Fund of M.I.T., gifts from private donors, and the limited number of stipends available in the National Institutes of Health (NIH) supported Medical Scientists Training Program (MSTP) at Harvard Medical School have been of great help in meeting these requirements; but they still fall short of meeting the needs of students, especially those working for the Ph.D. at M.I.T. or in the Faculty of Arts and Sciences at Harvard. To meet these essential needs a joint application has been made by the Harvard-M.I.T. Division and by the Harvard Medical School for an increased number of funded positions in the NIH-supported MSTP program.

During the past year 382 applicants sought admission to the class of students that will enter as candidates for the M.D. degree in the Harvard-M.I.T. Division in September 1978. Approximately 100 of the most promising candidates were interviewed twice by members of the Admission Committee whose Chairman is Dr. Eisen, Professor of Biology at M.I.T. The quality of the applicants and especially of those selected for admission is extraordinarily high. There were fewer outstanding women applicants than in previous years and the number of minority applicants also diminished somewhat. More vigorous efforts at recruitment of minority candidates and women are needed in the future.


Doctoral Program in Medical Engineering and Medical Physics

This program is directed by Professor Ernest G. Cravalho, Matsushita Professor of Mechanical Engineering in Medicine at M.I.T. Professor Cravalho has accepted the position as Associate Director for Medical Engineering and Medical Physics in the Division after having been Associate Dean of the School of Engineering of M.I.T. The Division is extremely fortunate in having the benefit of his leadership in the development of this important aspect of the educational and research activities of the Division.

During the academic year 1977-78 there was further development of the doctoral program in medical engineering and medical physics. Professor Walter H. Olson, an expert in biomedical instrumentation, joined the faculty of the Division in January 1978 and assumed major responsibility for the development of the subject in instrumentation. The Committee on Graduate School Policy (C.G.S.P.) of M.I.T. approved two new subjects, HST 580J Medical Engineering Measurements, and HST 581J Medical Engineering Measurements Laboratory, which will be presented for the first time in the spring of 1979. Professor Olson will be assisted in the presentation of these subjects by Dr. James L. Weaver, formerly of the Research Laboratory of Electronics, who joined the Division as a Lecturer in January 1978.
Professor William Siebert of M.I.T.'s Department of Electrical Engineering and Computer Science developed a new subject, HST 590 Biomedical Engineering Seminar, which was approved by the C.G.S.P. and offered for the first time in spring 1978. This seminar is intended to help provide the appropriate collegial atmosphere for the students in the medical engineering and medical physics program. Through this seminar, these students will have an opportunity to learn about the many clinically oriented research efforts in the Harvard-M.I.T. community and to meet the students and faculty engaged in these research activities.

Development of clinical experiences for students in the doctoral program has continued with particular attention given to possible opportunities at the Peter Bent Brigham Hospital (PBBH) to complement those already under development at the Massachusetts General Hospital. Possible clinical experiences at PBBH and the faculty members who have agreed to assume responsibility for them include Neurology, Dr. Mark Hallett; Pulmonary Unit, Dr. Roland Ingram; Cardiology, Dr. Thomas Smith; Surgical Intensive Care, Dr. Herbert Hechtman; and Thoracic Surgery, Dr. Kenneth Koster. Further detailed planning will continue during the coming year.

The curriculum in medical engineering and medical physics includes formal classroom instruction in technology assessment. Subjects in this area, presently under development by faculty from M.I.T. and Harvard, are intended to educate medical engineers and medical physicists in the most productive and cost-effective ways to utilize technology in the delivery of health services. To provide a basis for educational offerings in this field, a research program is being developed in the methodology of technology assessment that is designed to provide students and faculty members with investigative opportunities in this field. In spring 1978, a symposium entitled "Technology Assessment: Methodology and Medical Applications" was held. As an outgrowth of this effort, a faculty seminar in Technology Assessment has been planned for the academic year 1978-79.

The first class of students admitted as doctoral candidates in medical engineering and medical physics was selected by an Admission Committee consisting of faculty members from M.I.T., Harvard University, and Harvard Medical School and chaired by Professor Cravalho. Thirteen students have been selected for admission. Six of the students will hold Master's degrees upon entering and will have advanced standing in the program; the others will enter after achieving the Bachelor's degree. Eleven of the students are educated in the engineering sciences, and two students have their degrees in physics. Of the 13 entering students, four are women.

RESEARCH ACTIVITIES

Current research programs and their principal investigators are:

- Biomedical Engineering Center for Clinical Instrumentation
  - Roger G. Mark

- Control of Protein Synthesis by Double-Stranded RNA
  - Irving M. London

- Medical Radiological Physics Training Grant
  - Bengt E. Bjarnard

- Nuclear Techniques in the Study of Metabolism and Bone Disease
  - S. James Adelstein
  - Gordon L. Brownell
An Environmental Health Sciences Center for study of potential health effects of combustion of present and potential fossil fuels and an associated long-term interdisciplinary research program are being established by the Harvard-M.I.T. Division of Health Sciences and Technology and the M.I.T. Energy Laboratory under a grant from the National Institute of Environmental Health Sciences. Supported by two grants totaling $3,785,338, the Center and the associated research program will carry out a comprehensive, interdisciplinary five-year study. Key objectives are the development of a data base with which to assess potentially mutagenic and/or carcinogenic species from combustion of fossil fuels, and the identification of possible alternative combustion methods and fuel utilization strategies that could reduce or eliminate health hazards.

Director of the Center and the research program is Gerald N. Wogan, Ph.D., Professor of Toxicology. Professor Jean F. Louis, Associate Director of the Energy Laboratory and Professor of Aeronautics and Astronautics, is Associate Director of the Center. Dr. Irving A. Berstein, Assistant Director for Research Program Development of the Harvard-M.I.T. Division serves as Executive Officer of the Center and Program.

The anticipated shift to increased use of lower grade fossil fuels such as coal, heavy petroleum oils, and liquids derived from coal and shale, could increase undesirable health effects due to the high content of sulphur, nitrogen, aromatic hydrocarbons, and inorganic compounds in these fuels and the consequent potential for emission of harmful combustion products such as soot, polycyclic aromatic compounds, and inorganic particulates. Protection of the public's health while sustaining the nation's ability to utilize its fossil fuel reserves to meet pressing energy requirements in an environmentally and economically acceptable manner depends critically on the availability of sound data on possible health effects of utilization of alternate fossil fuels and on the development of improved methods to minimize hazards. The new Center is designed to provide the framework, organizational structure, and human and physical resources to perform long-term collaborative research in this important field.

A new research program has been established on myocardial perfusion scintigraphy using the mesh chamber for detection of radioactivity. This program is under the direction of Professor Louis S. Osborne, Professor in the Department of Physics and the Laboratory of Nuclear Science at M.I.T., and Dr. D. Leonard Holman, Associate Professor of Radiology at Harvard Medical School.

An interdisciplinary research program on learning disabilities in children and young adults is under development. A task group led by Dr. Leon Eisenberg, Professor of Psychiatry at Harvard Medical School and the Children's Hospital Medical Center, met in a seminar during the past academic year in an effort to define suitable approaches to research in this field. The fields represented in the task group include neurology, pediatrics, clinical psychology, experimental psychology (especially language acquisition and conceptual development),
psycholinguistics, psychiatry, speech pathology, and audiology. The overall objective of this research effort is the development of diagnostic criteria and methods to permit appropriate differentiation and classification of the various learning disorders, and the development of effective preventive and therapeutic measures.

A symposium on "Technology Assessment, Methodology and Application to Health Care" was held on March 13, 1978 at Endicott House. The symposium included presentations on the current status of methods of technology assessment with examples of application to blood banking and diagnostic imaging, and focused on the need for the development of educational offerings in this field. About 60 physicians, engineers, hospital administrators, economists, public policy specialists, and management experts attended the conference. A task group is being organized to develop an integrated interdisciplinary program of research and education in technology assessment as applied to health care. A seminar is being planned to begin in fall 1978. The objective of the seminar is to disseminate more broadly current information in this field and to provide a means of engaging individuals from various disciplines in interdisciplinary research and educational efforts in this field.

During the past 15 years there has been a marked growth in the production and distribution of products and devices that utilize radiation in the microwave frequency range including microwave ovens, radar, industrial processing equipment, and medical communication systems. This widespread use of microwave radiation has led to concern about its potential health hazards. An interdisciplinary task group is being organized by the Division in conjunction with the Francis Bitter National Magnet Laboratory and faculty members of Harvard Medical School to plan a research program on the biological and health effects of microwave radiation, DC magnetic fields, and low frequency magnetic fields.

Recent development of nuclear magnetic resonance techniques for non-invasive cross-sectional imaging of the body has been encouraging and raises the prospect of potential clinical applications. Exploratory efforts are under way to develop a collaborative research program involving the Magnet Laboratory and the Harvard teaching hospitals.

Dr. Irving A. Berstein, Assistant Director for Research Program Development, Dr. H. Frederick Bowman, and Keiko Oh have been principally responsible for the organizational and administrative aspects of these research efforts. Douglas C. Johnston is the Executive Officer for the Rehabilitation Engineering Center, and Edward A. Sadowski is the Administrative Officer for the Biomedical Engineering Center for Clinical Instrumentation.

FINANCIAL RESOURCES

As of June 30, 1978, endowment funds received or pledged totaled approximately $8.6 million, of which $1 million was raised during the year through two gifts. Operating funds received in 1977-78 totaled $192,985 through 22 grants. Since 1970 approximately $25.1 million has been raised, $8.6 million for endowment, $2.6 million for operations and facilities, and $13.9 million for research and development. Dr. Walter L. Koltun, Assistant Director for Resources, is in charge of these activities of the Division.
THE WHITAKER COLLEGE OF HEALTH SCIENCES, TECHNOLOGY, AND MANAGEMENT

In 1977, M.I.T. established the Whitaker College of Health Sciences, Technology, and Management to provide a major academic and administrative focus for the extensive and developing health-related activities at the Institute. The educational and research activities of Whitaker College are expected to include new and enlarged programs in human biology, physiology, experimental medicine, and health care policy and management. The M.I.T. components of the Biomedical Sciences (M.D.) Program and the Medical Engineering and Medical Physics (Ph.D.) Program of the Harvard-M.I.T. Division of Health Sciences and Technology are an integral part of Whitaker College.

The College represents a major commitment by M.I.T. to marshal its resources and strengths in science, engineering, and management in order to foster progress in the health and medical sciences and to improve the quality of health care. Since health-related activities in education and research transcend the concerns of any single department or School of the Institute, the term "College" is being used for the first time at M.I.T.

The program in human biology will include educational and research opportunities for undergraduate and graduate students in human genetics, the biology of human behavior, and environmental biology and toxicology. In the laboratories of human physiology and experimental medicine, research on major human health and medical problems will range from the most fundamental studies to clinical investigation in humans in normal and disease states.

In health care policy and management, the Whitaker College will seek to enhance and complement the activities in the Sloan School of Management and in the Departments of Economics and Political Science. In addition, a new Ph.D. program is being planned which will combine education in health and medical systems with policy analysis and management. The program will include subjects in health policy analysis, management information systems, health economics, government regulation, the sociology of the health professions, epidemiology, human biology, and the elements of clinical medicine.

Planning of the educational and research programs of Whitaker College is being conducted with the help and advice of the Faculty Advisory Council whose members are:

- David Baltimore, Ph.D.
  American Cancer Society
  Professor of Microbiology
  Department of Biology

- Herman N. Eisen, M.D.
  Professor of Immunology
  Department of Biology

- Maurice S. Fox, Ph.D.
  Professor of Genetics
  Department of Biology

- Richard M. Held, Ph.D.
  Professor of Experimental Psychology
  Head, Department of Psychology

- Boris Magasanik, Ph.D.
  Jacques Monod Professor of Microbiology
  Department of Biology

- George B. Benedek, Ph.D.
  Professor of Physics
  Department of Physics

- Ernst G. Cravalho, Ph.D.
  Matsushita Professor of Mechanical Engineering in Medicine
  Department of Mechanical Engineering
  Associate Director of Medical Engineering and Medical Physics, Harvard-M.I.T.
  Division of Health Sciences and Technology
Robert W. Mann, Sc.D.
Uncas A. Whitaker Professor of Biomedical Engineering
Department of Mechanical Engineering

Edward W. Merrill, Sc.D
Carbon P. Dubbs Professor of Chemical Engineering
Department of Chemical Engineering

Walle J. Nauta, M.D., Ph.D.
Institute Professor
Professor of Neuroanatomy
Department of Psychology

Lisa R. Peattie, Ph.D.
Professor of Urban Anthropology
Department of Urban Studies and Planning

Alexander Rich, M.D.
Professor of Biophysics and Sedgwick Professor of Biology
Department of Biology

Edward B. Roberts, Ph.D.
David Sarnoff Professor of Management of Technology
Sloan School of Management

Melvin H. Rodman, M.D.
Professor of Medicine
Director, M.I.T. Medical Department

Harvey M. Sapolsky, Ph.D.
Professor of Public Policy and Organization
Department of Political Science

Peter Temin, Ph.D.
Professor of Economics
Department of Economics

Felix M. H. Villars, Ph.D.
Professor of Physics
Department of Physics

Christopher T. Walsh, Ph.D.
Professor of Biology and Chemistry
Departments of Biology and Chemistry

Thomas F. Weiss, Ph.D.
Professor of Electrical and Bioengineering
Department of Electrical Engineering and Computer Science

Gerald N. Wogan, Ph.D.
Professor of Toxicology
Department of Nutrition and Food Science

Richard J. Wurtman, M.D.
Professor of Endocrinology and Metabolism
Department of Nutrition and Food Science

Laurence R. Young, Sc.D.
Professor of Aeronautics and Astronautics
Department of Aeronautics and Astronautics

Members ex officio of the Faculty Advisory Council are Dr. Jerome B. Wiesner, President; Professor Walter A. Rosenblith, Provost; Professor Robert I. Hulsizer, Jr., Chairman of the Faculty; and Dr. Irving M. London, Director of Whitaker College and Director of the Harvard-M.I.T. Division of Health Sciences and Technology.

Plans for the new health sciences complex to be built on Carleton Street between Main and Amherst streets, made possible by generous gifts from the Pew Memorial Trust, the Whitaker Foundation, the New York Community Trust, and an anonymous corporation, are progressing and it is expected that the facility will be completed by October of 1981.

IRVING M. LONDON
Independent Activities Period (I.A.P.)

By all measurements -- including the results of Institute-wide surveys of faculty and students -- Independent Activities Period remained as strong and vital in 1978 as in previous years. Faculty members and students reported high participation in on-campus projects and events, and they strongly endorsed I.A.P. as being good for the Institute. They also continued to voluntarily lead and attend more than 500 activities on a wide range of topics listed in the Guide.

This year the I.A.P. Policy Committee, with the aid of the I.A.P. Administrative Committee, reviewed its methods for gathering information on I.A.P. Having completed in the spring of 1977 a four-year progress report on I.A.P. for the Committee on Educational Policy, the Policy Committee was charged at that time with continuing to monitor I.A.P. and gathering material for another report in four years. The Committee decided to revise its annual questionnaires to faculty and students in an effort to obtain more specific information on how people allocate their time during January. The Committee also decided to send the questionnaires to all faculty members and students rather than to do random samples as had been done in recent years, so that results would be more meaningful at the department level.

With approximately one-third of the faculty responding to the survey, they reported using an average of over one-fourth of their working time in January on new and different endeavors. This included an average of 14 percent on new aspects of scholarly work within their usual areas of interest, 3 percent on scholarly work outside their usual areas of interest, and a total of 9 percent on activities listed in the I.A.P. Guides, 8 percent on academic-like activities, and 1 percent on nonacademic activities. The remainder of faculty members' time was allocated for activities similar to those of the regular term: an average of 47 percent of the time for continuing academic activities within their usual areas of interest, 15 percent for professional activities, and 9 percent away from M.I.T. Asked about their involvement in Guide activities, 58 percent of the faculty respondents said they participated in (led, contributed to, or attended) at least one activity. Just over half of them reported that they led or contributed to one or more activities, while 30 percent said they attended at least one.

With response rates to the student questionnaire of 26 percent for undergraduate and 15 percent for graduate students, both groups said they spent most of I.A.P. at M.I.T. -- an average of 78 percent of the time for graduate students and 67 percent for undergraduates. Characterizing allocation of their working time, graduate students said they spent an average of 58 percent of their time continuing academic activities within their usual areas of interest during the regular term, 12 percent on new activities within their usual areas of interest, and 4 percent on scholarly work outside their usual areas of interest. Involvement in Guide activities accounted for an average of 13 percent of the graduate students' time -- 8 percent for academic-like activities and 5 percent for nonacademic activities. Undergraduates allocated their working time differently: 15 percent for continuing usual work; 19 percent for new activities in their usual areas of interest; 7 percent for work outside their usual areas of interest; and a total of 22 percent for Guide activities, 10 percent for academic-like activities and 12 percent for nonacademic ones. (While faculty members accounted for an average of 97 percent of their working time and graduate students 87 percent of their time, undergraduates indicated the categories listed on the questionnaire involved only an average of 63 percent of their time.)

Asked to rate I.A.P. on a scale from 1 (poor) to 5 (good), most faculty members, graduate students, and undergraduates gave it ratings of 4 or 5. Just under three-fourths of the faculty
respondents -- 69 percent of the full professors, 73 percent of the associate professors,
and 90 percent of the assistant professors -- gave I.A.P. high ratings. Students were even
more strongly in favor of I.A.P. with 88 percent of the undergraduates and 86 percent of
the graduate students giving it a 4 or 5 rating.

In the questionnaires faculty and students alike indicated they were involved in many projects
other than those listed in the Guide. Yet, the Guide activities continue to play an important
role as the public side of I.A.P. Setting the tone for January, they inspire creativity, give
faculty members and students opportunities to work together informally, and encourage
everyone to pursue new interests or old ones set aside under the pressures of the regular
terms. This I.A.P., 507 activities were listed in the Guide. Of these, 281 or 55 percent
were academic or semi-academic in nature. Faculty members led 141 of the academic and
semi-academic activities and 9 of the nonacademic ones.

As in previous years, Guide activities came in every imaginable form -- mini-courses,
lecture series, laboratory sessions, seminars, round-table discussions, opportunities for
shop experience, field trips, workshops, films, research projects, and contests. These
offerings dealt with an extremely wide range of topics, reflective of the varied interests of
members of the M.I.T. community. Among the serious and technical offerings were four
lectures on "Hemostatic Mechanisms," a class on "Satellite Sensing of Oceanographic and
Meteorological Processes," four discussions of "Scattering Experiments in Condensed Matter
Physics," a lecture followed by laboratory work on "Hybridization of Cultured Animal Cells,"
and a talk on "Mathematics of Galaxies and Plasma." While 35 people met twice a week to
learn modern Irish and 25 people completed "Intensive German," another 90, who perhaps
planned to teach themselves a different language, attended a two-hour lesson on "Methodology
for Learning Languages." Students also worked closely with faculty members on individual
projects such as one on "Modeling of Fluid Dynamics in Nuclear Reactor Containments."

In other academic-related activities, both students and faculty members were able to gain
different perspectives on their disciplines. For example, in the lecture series "Reflections
on Mechanical Engineering," notable faculty members gave personal/historical presentations
on a variety of topics such as "Mechanical Engineering in the Old Days" and "An Engineer
Looks at Life." In "Energy and the Public Attitudes," nuclear engineering students initiated
what they hope will be a continuing dialogue with members of the Clamshell Alliance, opponents
of nuclear power plants.

I.A.P. '78 was a time for some to try imaginative approaches to different topics. In "Soap
Bubble Carnival (Math and Magic)," a lesson in mathematical topology was enlivened by a
contest for the audience, bubble-blowing demonstrations, and a guest appearance by
Harold E. "Doc" Edgerton robed in full wizard's regalia. Sometimes a topic which might
appear frivolous received a straight academic presentation, as in two classes on the boomerang
which were technical discussions of the physics involved in a boomerang's flight. Once in
awhile members of the Institute found their technical skills tested in a light-hearted manner,
as in the "Engineering Challenge," in which contestants had to guess when a 300-pound block
of ice would be completely melted. More than 700 people rose to the challenge -- giving this
activity the highest participation rate for I.A.P. '78.

On the cultural side, musical and theatrical groups continued to use time during I.A.P. for
practicing and performing. In addition, this year saw an increased interest in dance
activities. In a most ambitious project, the Graduate Student Council sponsored a week of
appearances by the Boston Repertory Ballet. Beginning with master lessons for students in
the Athletic Department's ballet classes, the week included two lecture-demonstrations on
how dancers train and how a choreographer creates a ballet; the program culminated in two
performances featuring guest artists from the Dance Company of Harlem. Other dance
activities included Dance Workshop's modern dance classes, ballroom dancing sessions, square
dances, and Indonesian court dances performed by the wife of a visiting scientist.
I.A.P. '78 provided opportunities for people to pick up various practical skills. While 18 people took weekly lessons in Mexican cooking, 50 others were learning vegetarian cooking. Classes on bicycle repair attracted 35 participants. About 20 people earned their Red Cross Advanced Lifesaving Certificates, and approximately 80 attended the Outing Club's ever-popular first aid courses. In what may be the beginning of another yearly tradition of how-to-do-it courses, Physical Plant supervisors offered a series of basic home repair classes. These lunch-hour sessions attracted a large following among employees as well as students.

I.A.P. policy is supervised by a faculty-student committee appointed by the President. Members of the I.A.P. Policy Committee this year were: Professor Michael S. Feld (chairman), Dean James Bishop, Professors Timothy C. Aarset, Kenneth Brecher, Woodie C. Flowers, Harvey Lodish, Robert M. Rose, George Wolf, Theodore Wood, Jr., Mark S. Wrighton; and Richard Caloggero, Paul Hoffman, Joel Orlen, and Cordelia Price.

Responsibility for I.A.P. administration is placed in the Office of the Provost and is accomplished through rotation of staff from departments and other offices of the Institute. This year the I.A.P. Administrative Committee included: Richard J. Caloggero (chairman), Mary Z. Enterline, Edward Gaudiano, John R. Martuccelli, Victor Maslov, Barbara McCarthy, Dr. Louis Menand III, Joel Orlen, Margaret S. Richardson, Jane Sauer, and William Wescott.

JOEL ORLEN

Lowell Institute School (L.I.S.)

The Lowell Institute School was established at the Massachusetts Institute of Technology 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. The general level of 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 an individual's skill level in his or her present job to comprehensive study of new technological areas which will prepare a technician 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 complete a satisfactory program.


Microprocessors continued to be a very popular subject. Six intensive one-week courses were offered this past year in this field, four of which were offered jointly with the Boston Section of the Institute of Electrical and Electronics Engineers (IEEE), and two given in Watertown at the Army Materials and Mechanics Research Center. Three intensive one-week
courses in Introduction to Digital Electronics also were conducted, two for selected technicians sent to L.I.S. from CBS Television Network in New York City, and one for selected personnel from the Watertown Army Materials and Mechanics Research Center. During I.A.P., L.I.S. also provided an instructor and the necessary laboratory equipment to the Department of Electrical Engineering and Computer Science so that a microprocessors course could be offered to the regular M.I.T. students.

L.I.S. admitted a total of 780 students to its courses this year, 635 to the evening classes and 145 to the intensive one-week courses. This represents an 11 percent increase over the 1976-77 figure of 705. Of those who enrolled, 78 percent successfully completed the certificate requirements. Among those who completed courses were 35 M.I.T. employees and four regular M.I.T. students. For the first time, L.I.S. awarded a special certificate in Electronics Technology to 10 students who successfully completed six out of eight courses in the electronics field.

In cooperation with the Departments of Mechanical Engineering and Materials Science and Engineering, L.I.S. organized and conducted a 12-week training program in the field of machine tools under the Comprehensive Employment and Training Act. This Federally funded program is designed to teach employment skills to disadvantaged and hard-core unemployed persons. This is the first time that M.I.T. has made its facilities available for this purpose which is benefiting residents of Cambridge, Somerville, Arlington, and Watertown. The L.I.S. curriculum included not only intensive training on metal cutting machines but also contained instruction in drafting and blueprint reading, metal joining, shop math, and English communications skills in order to maximize the students' future employability.

Enrollment at L.I.S. has increased for the fifth straight year, and 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

Neurosciences Research Program (N.R.P.)

The Neurosciences Research Program is an international, interuniversity, and multidisciplinary organization operating as a research center of M.I.T. Its purpose is to promote progress toward bridging the gaps separating the data and concepts of traditional scientific disciplines engaged in research on the nervous system at various levels of its organization -- molecular, cellular, neurophysiological, and behavioral. Theoretical breakthroughs are essential to transform new information into scientific understanding of how the nervous system mediates behavior, including the mental life of humans.

There are four main elements in the program: the operation of a worldwide communications exchange among scientists, the organization of scientific collaboration and meetings, a program of publications, and a program in graduate and postdoctoral education.

To carry out these activities, some 36 scientists, leaders in major neuroscientific disciplines, are elected to serve as N.R.P. Associates to provide advice and guidance to a small professional staff at the N.R.P. Center in Boston. N.R.P. also enlists participation in N.R.P. activities by scientists from the neuroscientific community at large; over 1500 scientists have served as invited consultants.
The following Work Sessions and/or Conferences (Chairpersons shown in parentheses) were held during the academic year 1977-78:

"Integration and Modulation in the Brain Stem" (A. B. Scheibel and J. A. Hobson); "Central Core Regulation: Monoaminergic Systems" (F. E. Bloom and R. Y. Moore); "The Selection and Modulation of Behavioral Programs" (E. R. Kandel, F. B. Krasne, F. Strumwasser, and J. Truman); "Visual-Vestibular Interaction in Motion Perception and the Generation of Nystagmus" (V. Henn, B. Cohen, and L. R. Young); "Mechanisms of Regulation of Neuronal Sensitivity" (J. W. Daly, B. J. Hoffer, R. K. Dismukes); and "Recent Developments in Theoretical Neurobiology" (W. E. Reichardt, V. B. Mountcastle, and T. Poggio).

The Thirty-Fourth Stated Meeting of N.R.P. Associates, held October 2-5, 1977, will long be remembered for the exciting inaugural lectures given by newly elected Associates, Drs. Axelrod, Hökfelt, Greengard, Keynes, Mueller, Plum, and Snyder.

A feature of the fall Stated Meeting of N.R.P. Associates was the Fifth F. O. Schmitt Lecture in Neuroscience in Huntington Hall, M.I.T. The 1977 medalist, Dr. Roger C. L. Guillemin of The Salk Institute for Biological Studies, San Diego, California, gave an address entitled "The Hypophysiotropic Peptides of the Hypothalamus." This lecture will be published as a supplement to the NRP Bulletin. Considerable interest was attached to the award of this year's prize due to the fact that only five days after Dr. Guillemin gave the lecture he was notified by the Karolinska Institute that he would share the 1977 Nobel Prize in Medicine.

The Thirty-Fifth Stated Meeting, held March 19-22, 1978, included a one-day program, chaired by W. M. Cowan, on functional organization of cortex, with D. Hubel, V. B. Mountcastle, W. J. H. Nauta, and J. Szentágothai. A half day was devoted to cooperativity theory as applied to neuronal systems; M. Eigen chaired this, with participation by J. D. Cowan and J. J. Hopfield. E. Stadtman reviewed, for discussion by the Associates, the role of phosphorylative processes in neuronal metabolic regulation. In addition to these major topics, there was a Farewell Commentary by T. H. Bullock, who transferred from Active to Honorary status.

In the Executive Session of Associates at the Thirty-Fifth Stated Meeting, five Associates were elected, namely, Drs. Ann M. Graybiel, Robert C. L. Guillemin, Richard M. Held, John J. Hopfield, and Hans Thoenen.

During the academic year 1977-78, the following NRP Bulletins were published: "Neuronal Mechanisms in Visual Perception" (E. Pöppel, R. M. Held, and J. E. Dowling); "Depolarization-Release Coupling Systems in Neurons" (R. R. Llinás and J. Heuser); "Pain" (K. L. Casey and F. W. L. Kerr); "Neurobiology of Peptides" (L. L. Iversen, R. Nicoll, and W. Vale); and "Neuron-Glia Interactions" (G. G. Somjen and S. S. Varon).


The M.I.T. graduate seminar 20.515 Seminar in Neuroscience Research Topics continues to attract selected graduate students from M.I.T., Harvard, and other Boston-area institutions. Students attend N.R.P. Work Sessions, Stated Meetings, and Conferences, are required to take notes during Work Sessions, and participate in a review of the Work Session with N.R.P.
Staff and Work Session Chairmen. Each student prepares a written proposal, defining a research topic in neuroscience.

F. G. WORDEN

Northeast Radio Observatory Corporation (NEROC)
Haystack Observatory

M.I.T. is a leading member of NEROC, a consortium of 13 institutions* formed in 1967 to promote radio and radar astronomy research and facilities in the northeastern United States. Through a NEROC-M.I.T. agreement, NEROC uses the administrative services of M.I.T. in the conduct of its business.

The primary current responsibility of NEROC is the operation of M.I.T.'s Haystack Observatory, located at the Millstone Hill Field Station, Westford, Massachusetts. The main instrument at the Observatory is a 120-foot diameter paraboloidal antenna enclosed in a radome. With support primarily from the National Science Foundation, it is used almost continuously by the astronomy community at large as a radio telescope with radiometers in the 18-, 3.8-, 3-, 2-, 1.35-, and 0.7-cm. regions. At 0.7 cm., the telescope has a beamwidth smaller than the 1-arc-minute resolution of the human eye. Observing proposals submitted by prospective users are considered by a review committee, on the basis of scientific merit and suitability for the available instrumentation. In addition to the astronomical observations, a modest fraction of the observing time is scheduled for radar observations of satellites funded by M.I.T. Lincoln Laboratory.

Twenty-eight students are now doing, or have in the past year done research involving Haystack. Four others have earned the Ph.D. within the past year on the basis of research in which Haystack observations were important. Some 5,000-6,000 hours of telescope time continue to be devoted annually to radio astronomy observations, exclusive of maintenance, system tests, etc.

During the period January 1977 to March 1978, 33 journal articles were published on radio astronomy investigations and seven more were based in part upon continuing NASA-supported studies of the lunar mapping and topographical measurements made some time ago with the Haystack planetary radar (now dismantled).

A noteworthy improvement this past year was the replacement of the original (1963) telescope pointing and real-time control computer system with a new system based on a modern minicomputer, the HP1000. The old system had come to be the cause of many failures and user complaints. The replacement was made possible in part through the generosity of Hewlett-Packard Company.

Through the cooperation of the Lincoln Laboratory radar program, it has been possible to use a state-of-the-art cooled parametric amplifier as the heart of a new radiometer system covering 8.7-11.2 GHz. This provides for Haystack a new, high-sensitivity frequency.

*Boston University, Brandeis University, Brown University, Dartmouth College, Harvard University, Massachusetts Institute of Technology, Polytechnic Institute of New York, Smithsonian Astrophysical Observatory, State University of New York at Buffalo, State University of New York at Stony Brook, University of Massachusetts, University of New Hampshire, and Yale University.
coverage which has already proved very fruitful in radio recombination line studies, in continuum work, and in very long baseline interferometer (VLBI) research.

In-house, Haystack continues to emphasize VLBI research. The technique for VLBI involves simultaneous observations of the same object with widely separated radio telescopes, records from which are brought together in a correlation processor to yield interferometric fringes. For astrometry and studies of complex source structure, VLBI provides resolution of an order unavailable by any other means. In November 1977, Haystack successfully tested the prototype of its new "Mark III" VLBI data recording/processing system and demonstrated the expected five-fold sensitivity increase over past systems. This development is supported by NASA primarily for geodetic measurements, but NSF support is being sought to increase its availability for astronomy.

The largest share of observing time continues to be for spectral line studies including both molecular and recombination lines. For this work, a cooled maser receiver at 21-25 GHz, together with a 1024-channel spectrometer provides an instrument unique in this country.

PAUL SEBRING

Office of Minority Education (O.M.E.)

During 1977-78, Professor Wesley L. Harris served as the director of the Office of Minority Education. He also retained his faculty-related academic responsibilities on a half-time basis. Gloria Payne served as administrative assistant. One full-time secretary and one graduate student assisted in the operation of the office.

Advisory Structure

O.M.E. received the counsel of students, faculty, and staff throughout the Institute. This counsel is provided by the Faculty-Staff-Student Advisory Group. The Group is an amalgamation of the Minority Student Advisory Committee and the Faculty-Staff Advisory Group; each of these bodies functioned independently prior to the 1977-78 academic year. Members of the Faculty-Staff-Student Advisory Group for 1977-78 included: Professors Eugene E. Covert, Ernest G. Cravalho, Alan Davison, Willard Johnson, Arthur P. Mattuck, Arthur Smith, Leon Trilling, and James E. Young; Dean Carola Eisenberg; Drs. Alan J. Lazarus, Mary Rowe, and Clarence G. Williams; Nelson Armstrong, Theodore Austell, Rocklyn Clarke, Lisa Egbonu, and Bonny Kellermann.

PROJECTS

A Workshop on Retention of Minority Undergraduate Students in Engineering

Professor Harris, chairman of the workshop planning committee, and Dr. Williams, Special Assistant to the President and Chancellor for Minority Affairs and chairman of the workshop
local arrangements committee, brought approximately 125 university educators, staff members, and students and people from industry and government to M.I.T.'s campus to assess support programs for minority undergraduate students in engineering; they received assistance from the National Research Council's Committee on Minorities in Engineering. The workshop was held October 30, 1977 to November 2, 1977. A strong institutional commitment, deep faculty and staff involvement in academic and social counseling, and a broader funding base emerged as key points in the conclusions of the workshop. An important accomplishment of the workshop is the definition of the minimum conditions necessary for the structuring, implementing, and evaluation of academic support services designed to reduce attrition of the target students.

Project Interphase

Structurally, this program remained unchanged from 1977. The program served 41 students during 1978. Professor Davison and Dr. James Gates served as co-senior academic officers of PROJECT INTERPHASE 1978. A 15-page survey-questionnaire has been prepared and distributed by O.M.E. to student participants of PROJECT INTERPHASE 1976 and 1977. O.M.E. has received an 80 percent or greater return of this survey-questionnaire in 1976 and 1977. Data contained in the returned survey-questionnaire indicate the high quality of the program and the continued need for and appreciation of the primary emphasis on academics in this essential project.

Black Student Union Tutorial Program

During the 1977-78 academic year this program added an academic and social counseling service for first-year minority students to its traditional tutoring services. This counseling service, called the Freshman Buddy System, assigns several first-year students to an upper-class student who contacts his/her assigned students weekly to offer counseling. This student-coordinated counseling service will be continued. During 1977-78, the traditional tutoring program offered tutorial assistance for undergraduate students in more than 50 M.I.T. subjects and in reviews of high school mathematics. The tutorial program logged approximately 4,200 total hours of tutoring during 1977-78.

Freshman Watch

The faculty and staff teaching the science requirement subjects have informed O.M.E. of the academic progress of minority freshmen and some non-minority freshmen. As needed, freshmen have been asked to come to O.M.E. for academic counseling and for tutorial services. The response to this service by freshmen is most intense at mid-term during both the fall and spring.

I.A.P. Activities

During I.A.P. '78, O.M.E. offered a series of lectures to all minority students on systematic heuristic approaches to problem solving. This program was a repeat of a similar program which was offered during I.A.P. '77. The reference texts were How to Solve It by G. Polya and How to Solve Problems by W. A. Wickelgren. Attendance was firm throughout the four one-week sessions.
Tutored Videotaped Instruction (T.V.I.)

Unrehearsed, unedited videotapes of selected science requirement subjects have been used for the instruction of small groups of minority students. This technique was introduced at M.I.T. by O.M.E. during the spring term of 1977 and was shown to be successful. During 1977-78, the technique was offered to any interested student in the subjects 5.41, 8.01, and 8.02. This program continues to be effective.

Residence/Orientation Week 1977 Activities

O.M.E. cosponsored with the Black Student Union a series of events during R/O Week 1977. The sequence of events was directed toward all minority freshmen with an objective of making the transition into M.I.T. as smooth as possible. Minority faculty, staff, and upperclass students as well as minority freshmen participated in the program. The program consisted of discussions, presentations, and films on topics such as subject selection, sources of academic support services, housing, financial aid, fraternities, athletics, security, and peer relationships.

Awards

O.M.E. provided stimulation and guidance to the Monsanto Company in establishing the Monsanto Achievement Award at M.I.T. The objectives of this award as indicated by the Monsanto Company are "to promote academic excellence among minority engineering students at M.I.T. and to promote Monsanto's name among M.I.T. students." The Monsanto Achievement Award is to be granted to a sophomore or junior student and is restricted to a US citizen or permanent resident. O.M.E. selected Heinz Stubblefield as the first recipient of this award. This selection was based on his exemplary scholastic performance.

Gifts

O.M.E. received a gift of $5,000 from E. I. du Pont de Nemours & Company, Inc. This gift may be used in any way that will help M.I.T.'s efforts to increase the number of minority engineering graduates.

WESLEY L. HARRIS

Operations Research Center

The Operations Research Center (O.R.C.) conducts interdepartmental academic and research programs in the field of operations research. The academic staff of the Center is drawn from the Sloan School of Management, and the Departments of Electrical Engineering and Computer Science, Urban Studies and Planning, Aeronautics and Astronautics, Civil Engineering, Mathematics, and Physics. At present, approximately 18 students are in the operations research doctoral program and a comparable number are in the master's program. Most of them come to M.I.T. specifically to study operations research and are admitted directly by the Center, although some learn about the graduate operations research program by attending seminars or subjects.
During the past year, the academic staff of the Center has engaged in a wide range of research activities sponsored directly by the Center. Several of these endeavors represent major new research directions for the Center. These include new work on urban transportation planning (using network analysis), the role of operations research in public program evaluation, the development and use of large-scale mathematical programming models for energy resources planning, and modeling of processes yielding data on crime frequencies. Many of these new efforts, as well as several of the on-going efforts, have required significant new work in the theory and methodology of operations research.

One focus of basic research has been on nondifferentiable optimization. This has been motivated in large part by the Center's work on econometric models containing linear programming subproblems. Linear programs produce nondifferentiable parametric functions because of the abrupt changes in shadow prices as various optimal extreme point solutions are generated. Specifically, normative models for depletable resources with applications to energy planning have been developed and analyzed. Nondifferentiable optimization techniques are required, for example, to estimate derived demand curves for a scarce resource from a dynamic economic sectoral model. Another example is the use of nondifferentiable optimization to compute peak load electricity prices by perturbing peak load demand and reliability constraints in utility capacity expansion models.

A related project with the Brookhaven Energy System Optimization Model (BESOM) was originally funded to study the incorporation of nonlinear supply functions into it. Sensitivity analyses were performed on the Brookhaven model and it was found that the model definitely requires nonlinear supply functions to smooth out derived demand for primary supplies. This work led to the development of a large-scale mathematical programming regional model of coal supply in the US. The coal supply modeling is still under way. In addition, Operations Research staff and students abstracted the features of the Brookhaven model to construct a dynamic US energy sector model for use in their work on depletable resources. The first version of that model is now complete.

Continuing experimental work in integer programming dual methods has produced a large-scale, interactive mixed integer programming code which combines state-of-the-art branch and bound methods with the dual methods. Current experimentation with these methods is under way to try to understand the correct balance to be taken between the various complementary methods. The theoretical work has been focused on methods of multicriterion mixed integer programming and a new approach to these problems called "inverse optimization." Inverse optimization involves the use of Lagrangean duality to quickly generate collections of solutions that are optimal in a family of related problems.

Finally, basic research has continued on the integration of numerical analytical optimization methods with computational schemes for solving nonlinear robust regression problems. A key element in the numerical calculations has been the development of quasi-Newton or update methods for approximating the appropriate Jacobian matrices. The ultimate goal of this research is the development of modular computer systems for a wide variety of statistical problems.

During the past year, there were several research projects focusing operations research methods on public sector problems. The Center's commitment in this area is illustrated, for instance, by a new two-week summer course it is offering for the first time, "Recent Advances in Public Sector Operations Research" (highlighting work in energy planning, transportation, urban systems, health and criminal justice).

Our on-going studies of public attitudes and behavior with regard to blood donation are near completion, with the fifth and last technical report to be published in the summer of 1978. Some simple indications of the findings are 1) about half of the people presently eligible to
donate blood have made at least one donation, 2) donors and eligible nondonors do not differ significantly in their perceptions of the need for blood, 3) even many frequent donors have no occasion to develop consistent positions with regard to blood collection ideology, and 4) the primary reason "so few" people give blood each year is that their contributions provide for an adequate whole blood supply. Extensive documentation is provided by the Center's project reports.

Another public sector project, which was completed this year, focused on evaluating the consumer's interest in merit rating plans for automobile insurance. Auto insurance premiums for individual insureds often depend upon the insured's own claims experience and traffic violation record during previous years. The surcharge and credit schedules used to adjust premiums up or down based on the number of past incidents are called "merit rating" plans. This research project used probabilistic models for claims experience to compare the cost redistribution effects of alternative merit rating plans being considered for use in Massachusetts and to recommend practical designs that treat insureds equitably. The design now being implemented in Massachusetts differs from those customarily used in other states in accordance with some of the project's recommendations.

A major new effort was launched this winter to evaluate program evaluations in criminal justice. Center staff and students are now selecting two samples of criminal justice evaluation -- one from "logistical" programs (such as police patrol) and the other from strictly social service programs. Each sample is to be evaluated as to approach and content, with particular emphasis on current and potential roles of decision analysis and mathematical modeling in evaluation studies. In evaluation methodology, we plan to review currently popular evaluation methodologies and to assess the applicability of each to in-the-field criminal justice evaluations. We then plan to begin the needed methodological research in order to start to bridge the gap between current theory and practice.

A related area of research, started this spring, aims to develop statistical methods that better illuminate the implications of crime statistics, both with respect to the magnitude of the problem and to the effects of public policy decisions related to crime. Initially the work will focus on homicide data, widely believed to be the most accurate crime statistics. Investigations under way now concern the reasons for the drop in the US murder rate in the mid-1970s and the indications of past data about the deterrent effect of capital punishment.

Modeling and analysis of urban vehicular services continued during the past year. It was shown that a classic deterministic location theory problem -- the "p-median" problem -- can be extended to a probabilistic framework in which facilities to be located (e.g., ambulances) can be busy or available for dispatch according to probabilities computed by the Center's hypercube queueing model. This has led to new work in location theory, optimal dispatch of emergency vehicles, and real-time relocation of emergency vehicles. Additional work in the area of urban vehicular services included 1) the development of an algorithm to determine the shortest rectilinear distance between two points in the presence of barriers to travel; 2) models predicting how buses "clump" together when traveling along a bus route; 3) an evaluation of deliberately delaying subway trains at certain stops to facilitate rapid transfers of passengers between trains. Much of the work on urban vehicular services assumed the existence of a new urban technology: automatic vehicle location systems. Knowledge of the real-time location of vehicles, to a specified degree of resolution, allows more effective system control strategies to be implemented.

Motivated by both practical and theoretical concerns, research continued in the area of transportation network analysis and decomposition techniques. This ongoing project, which has involved the application of mathematical optimization modeling and solution techniques to transportation planning, has concentrated this year on rail freight management and urban traffic equilibria. Results in these two problem areas have been a taxonomy of planning issues in rail
management, the formulation of a mixed integer programming routing/blocking model to support decision making for rail applications, an existence proof for an equilibrium to a general traffic flow model, and a new algorithm to solve for equilibria for this general model.

A long-term project on multi-level logistics systems received continued support and attention. Decomposition methods were devised and tested to partition, link, aggregate and disaggregate large-scale production, inventory, and distribution systems. Applications were made to several industrial production planning problems.

Operations Research Center staff and students also were involved in a variety of research activities with other departments and centers within M.I.T. Two students participated in a water resource planning project for Egypt being performed by the Technology Adaptation Program. Center staff and students were involved in projects at the Energy Laboratory on oil exploration and potential uses of geothermal power. Operations research models for airport runways were constructed and analyzed by O.R.C. staff and students working on a Flight Transportation Laboratory project. Finally, members of the O.R.C. staff were active in research programs at the newly created Computer Research Center for Economics and Management Science. Their activities included the further development of methods of robust regression in statistics and modeling languages for mathematical programming.

Support for the Center's research during the past year has come from the National Science Foundation, the Law Enforcement Assistance Administration (US Department of Justice), the US Department of Transportation, the US Office of Naval Research, the US Army Research Office, the Energy Research and Development Administration, the US Public Health Service, the Massachusetts Automobile Rating and Accident Prevention Bureau, and International Business Machines.

RICHARD C. LARSON
JEREMY F. SHAPIRO

R.O.T.C. Programs

Enrollments in the Reserve Officer Training Corps (R.O.T.C.) programs continue to grow at M.I.T. Currently, 297 M.I.T. students are enrolled in our three R.O.T.C. detachments. Of these students 275 receive R.O.T.C. scholarships. An additional 68 students from Harvard University, Northeastern University, Tufts University, and Wellesley College who receive instruction from M.I.T. Army and Air Force instructional staffs are included administratively in the M.I.T. R.O.T.C. units.

The R.O.T.C. Advisory Committee completed its review of the R.O.T.C. curriculum, recommending that the Institute's policy of awarding graduation credit only through its regular academic departments be retained. The Committee believes that the quality of instruction offered by the R.O.T.C. detachments is best enhanced through the forging of close linkages between the R.O.T.C. instructional staff and the regular academic departments at the Institute. R.O.T.C. subjects jointly offered by the R.O.T.C. detachments and regular academic departments are currently eligible for graduation credit.

The growth in R.O.T.C. enrollments requires that there be even more effective cooperation between Institute administrative offices and the R.O.T.C. detachments. The R.O.T.C. Advisory Committee has sought to ensure that this cooperation develop by arranging luncheon
meetings with senior R. O. T. C. officers and various administrative officials. Thus far meetings have been arranged with the Committee on Academic Performance, the Freshman Advisory Council, and the Dean for Student Affairs. This program will continue during the coming year.

The Committee is working with the services to clarify the standards used in nominating officers for R.O.T.C. instructional assignments at the Institute. The Committee's duties include reviewing all officer nominations made by the services to the Institute and advising the Provost on appointments to R.O.T.C. instructional staffs.

HARVEY M. SAPOLSKY

Sea Grant Program

Although men and women for centuries have depended on the earth's vast world of water for physical and spiritual nourishment, until the past several decades interest in exploring the deep ocean and in understanding the symbiosis between land and water has lain dormant. When, in 1972, M.I.T. received its first institutional grant from the Office of Sea Grant through the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce, M.I.T. Sea Grant became an Institute center for marine research and study. Since that time, the Program has striven to help the citizens of the nation and the Commonwealth discover and exploit the ocean's potential wisely and well by drawing upon the rich intellectual and experiential resources of the Institute faculty.

This past year, an award of $1,115,000 from the Office of Sea Grant through the NOAA, matched by $787,306 from the Institute, the Henry L. and Grace Doherty Charitable Foundation, the University of Massachusetts, private organizations, and marine industries, provided financial support for strengthening the relevance and applicability of Sea Grant research projects. The support of these groups also has helped the Program to define long-range management strategies for transferring the results to the nation's marine community, and to train students for future marine work.

The Director of the M.I.T. Sea Grant Program, Mr. Dean A. Horn, has maintained close ties with the Institute faculty as a Senior Lecturer in the Department of Ocean Engineering. As Director of Research, Professor Jerome J. Connor, Jr., of the Department of Civil Engineering, has established coherent, thematic guidelines for selecting research projects well matched to the needs identified by the marine community. During 1977-78, the education facet of the Program broadened its objectives to include curriculum development for pre-university students. Ernst R. Pariser became the Associate Director for Education Coordination. In this new role he will guide the philosophy and direction of an expanded education program. The Program's daily operations were managed by Lawrence W. McKinnon, Administrative Officer.

As more information is gathered and applied to the development and management of the nation's coastal resources, new problems and opportunities emerge. By meeting frequently with the State Industry Advisory Council, the Sea Grant staff remained attuned to the evaluating interest and requirements of Sea Grant's constituents.

The Sea Grant Policy Committee and the Sea Grant Faculty Council, chaired by Professor Emeritus Alfred A. H. Keil, acted as counselors to strengthen the Program's efforts to synthesize marine research with the education of future scientists, engineers, and teachers.
A milestone event for M.I.T. and Sea Grant, in August 1977, was the christening of the Research Vessel EDGERTON. The vessel, converted from an Army T-Boat under the direction of the Sea Grant Program, will provide an invaluable ocean-going laboratory and classroom for the Institute.

**ADVISORY SERVICES**

Sea Grant research, which is initiated in response to actual, identified needs in the marine community, is transmitted into a usable form through its advisory service. The methods employed include the organization of workshops and courses and the publication of all project results. A diverse constituency and the need to attack problems or development potential with a multidisciplinary approach have led M.I.T. to organize a multifaceted advisory service.

The interests of industry are addressed by the Marine Industry Advisory Service Collegium, established in 1975 under the direction of Norman A. Doelling. Each year, significant economic opportunities, based on current marine research, are identified and analyzed in four concise, well-documented briefs. Workshops around each of the briefs bring together business and government representatives with academic researchers to assess the commercial potential of new technology and to elicit new ideas and feedback on unsolved industrial problems and prospects.

For the first time, one of the 1977-78 briefs and collegium workshops was based on a collegium member's research. The study, conducted by Dynatech and supported by the Energy Research and Development Administration (ERDA), focused on using algae as an energy source. The workshop drew over 150 conferees. A second meeting discussed a computer model for investigating costs, rates of return, and economic implications of policy options under consideration by the US government. The model, which is now being employed at the UN Law of the Sea Conference to assess the economic implications of various treaty agreements, attracted both government and industry representatives to M.I.T. Vibration response and the structural integrity of deepwater structures, and the use of computers as an aid in the preliminary design of ships were subjects of other collegium studies completed at the request of a number of the nationally and internationally prominent member companies vitally interested in the development of offshore marine technology.

In 1976, when M.I.T. was given Sea Grant College status, the Institute Sea Grant Program established a partnership with the University of Massachusetts Cooperative Extension Service in an effort to expand Sea Grant's capability for monitoring client needs and for transmitting research results to a broad base of users. During the past year, the Extension Sea Grant Advisory Program (ESGAP), under the direction of Arthur B. Clifton of M.I.T. and John Noyes of the University of Massachusetts, moved to establish areas of specialization for each of its coastal agents and to promote closer links between principal investigators and advisory services through a "friend of the project" program.

Specific coastal needs identified by the advisory agents resulted in several conferences. One, "Minimizing Ice Damage in Small Harbors," brought together researchers from around the US to help New England citizens after the severe winter of 1976-77. A coastal engineer, Andrew L. Gutman, was added to the staff on the recommendation of the State Industry Advisory Council to provide Massachusetts citizens with help in locating sources of information and engineering expertise for coastal erosion problems.

The staff of the Communications/Information project of the advisory services works with all the staff members to translate the results of Sea Grant research into easily applicable form.
The project also provides a critical link to the entire network of Sea Grant universities and their resources. In addition, Communications/Information publishes and disseminates the results of all M.I.T. Sea Grant research projects to identified client groups in government, industry, and coastal communities. During the past year, 12,000 research and advisory reports reached Sea Grant's clients through this facet of the program.

A highlight of the Sea Grant Advisory Services for 1977-78 was the Sixth Annual Sea Grant Lecture, "The Seas and the Waterways: the New Frontier," delivered by Yvonne Brathwaite Burke, congresswoman from California. The panel was comprised of Professor Douglas Carmichael of the Department of Ocean Engineering; Erling D. Naess, chairman of the International Association of Independent Tanker Owners; John P. Sheffey, a special advisor in the Office US Special Representative for Canal Negotiations, Department of State; and Paul E. Atkinson, President of Sun Shipbuilding and Dry Dock Company. They discussed the advisability and ramifications of ratifying the Panama Canal Treaties as well as the economic and environmental implications of differing international tanker safety standards.

ACADEMIC PROGRAM

Sea Grant believes it is important to prepare future scientists, engineers, urban planners, and teachers for managing ocean resources. By integrating marine education into Program research projects, Sea Grant provides opportunities in which students are able to apply classroom knowledge to real-world problems.

The ongoing development of a strong Institute ocean-oriented curriculum has provided a primary focus for Sea Grant support. Each year new courses have been added. During 1977-78 the Department of Ocean Engineering offered for the first time the following subjects: "Issues in Transportation Management," "Seminars in Ocean Engineering," "Advanced Ocean Engineering Laboratory," and "Legal Aspects of Ocean Resource Management." Two subjects were revised: "International Shipping" and "Ocean Engineering and Law Seminar." Professors in the Department of Civil Engineering completed the first phase of a plan to develop an integrated subject and to complete textbooks for advanced undergraduates and graduate students on the design and construction of offshore structures.

Students in the M.I.T. Sea Grant Program's summer ocean engineering laboratory gain practical experience in developing, building, and testing equipment for use in the oceans. In 1977, they tested and refined a height measuring device and a variable depth current measuring and recording instrument under the guidance of Professor Ira Dyer, Head of the Department of Ocean Engineering.

Professor William W. Seifert of the Department of Civil Engineering engages M.I.T. students in an interdisciplinary systems design course to give them the experience of solving complex, real-world problems requiring technical, managerial, economic, sociopolitical, and legal disciplines. The class, divided into two teams, completed recommendations for revitalizing the Lynn Harbor and continued to study methods for resolving conflicts in the use of Gloucester Harbor.

In addition to fulfilling its commitment to the students of the Institute, M.I.T. Sea Grant also promotes educational programs for men and women working as professionals in ocean-related fields.

In cooperation with the Office of Summer Session, Sea Grant sponsored courses for scientists and engineers from industry, government, and academia. The courses held in the summer of

A joint project with the Massachusetts Maritime Academy to train upperclass students as qualified, licensed commercial fishing professionals was expanded. In addition, active fishermen were offered courses in navigation, safety, and management to give them an opportunity for improving their skills.

With growing congressional awareness and support for marine education at the elementary level, M.I.T. has initiated a long-term, intensive effort to develop innovative marine education materials for use in classes from kindergarten through grade 12. The Program has asked leading faculty members to serve as advisors as it proceeds enthusiastically and thoughtfully into this new area.

**RESEARCH**

An intensifying interest in recovering minerals from the ocean, recognition that coastal resource development needs to be planned, and a growing desire to minimize waste are trends that have all demanded from the research community new information and technologies.

M.I.T. Sea Grant's research program has evolved in response to these identified needs. Greater thematic definition has given the program a stronger focus and direction. And concerted efforts to attract scientists and engineers from many Institute departments have allowed Sea Grant to serve a larger constituency and to more effectively address the complex, interrelated problems and opportunities of marine resource development and management.

The expansion of deep sea resources poses a particularly difficult and exciting challenge to the research community. The physical territory is unknown; the political and economic implications complex. M.I.T. Sea Grant supported research to aid the government in developing a rational national and international policy that would both ensure economic stability for business and provide fair sharing of the resource recovery benefits among the worldwide joint claimants of the ocean's riches. The research completed during the academic year 1976-77 by Professor J. D. Nyhart of the Department of Ocean Engineering and the Alfred P. Sloan School of Management was published during this past year.

As land supplies of oil and gas diminish, the world is turning to the oceans for novel as well as familiar sources of energy. With Sea Grant support, Professor Chiang C. Mei of the Department of Civil Engineering and Alexander D. Carmichael of the Department of Ocean Engineering completed an engineering and economic feasibility study of using a Salter cam to convert the force and power of waves into an energy source.

Although eventually the ocean's waves, tides, and temperature variations will be part of a multiple energy source system, the recovery of oil and gas from the ocean provides the most immediately usable supply of fuel. To tap these reserves it is necessary, however, to develop new construction and maintenance techniques for building in a marine environment. Professor Koichi Masubuchi of the Department of Ocean Engineering undertook the third phase of an M.I.T. Sea Grant project to devise an underwater welding method and design tools which would enable the owners of offshore structures to build and maintain installations safely and economically.
Many construction and exploratory tasks, currently performed by divers and manned submersibles, are extremely dangerous and, consequently, costly. Therefore, the use of a telemanipulator with general purpose arms, hands, and video/sonar/tactile sensors is being explored by Professor Thomas B. Sheridan of the Department of Mechanical Engineering. This past year, Professor Sheridan expanded the range of tasks a human being and a programmed computer could command the telemanipulator to perform on the ocean floor from a post on the ocean's surface.

At the present time, inadequate soil and structure performance data exist to allow engineers and government regulatory agencies to make expert and knowledgeable siting and design decisions in the extremities of the offshore environment. Using probabilistic reliability analysis, Professor Gregory B. Baecher of the Department of Civil Engineering concentrated on developing a methodology to logically organize uncertainties -- events occurring in sequence which are related so that aggregate risk may be deductively analyzed.

In another project in the Department of Civil Engineering, Sea Grant is supporting the efforts of Professors Mohsen Baligh and Charles Ladd to devise a method that will enable a more rapid and economical assessment of site suitability and structure performance. They are experimenting with a cone penetration device for in situ evaluation of marine properties.

Sea Grant promotes research that encourages development of ocean resources, but that also helps to provide environmental safeguards. Fatigue and eventual structure failure from the battering of random ocean waves is of great concern to offshore designers. Professor J. Kim Vandiver of the Department of Ocean Engineering and the second Henry L. Doherty Professor in Ocean Utilization, is working to help solve this problem. He has developed a non-destructive analytic technique that could help predict the dynamic response of a structure to wave excitation without the use of gross approximations and cumbersome computations. In a related study, Professor Vandiver studied ways of employing liquids contained on board offshore structures to reduce the dynamic response at the structural natural frequency.

The ocean environment, in addition to demanding new analytic methodology and construction technology, also requires materials to be available that are capable of surviving in circumstances differing from those on land. Professors Richard Donnelly and Robert Cohen of the Department of Chemical Engineering are modifying the surface of common polymers, particularly polyethylene, to serve as a nondegradable, inexpensive insulator in undersea electrical cables.

With oil transport recovery efforts increasing, spills present an inevitable and difficult-to-solve problem. M.I.T. Sea Grant continued during 1977-78 to support research addressing the development of techniques for cleaning up oil spilled at sea. Professor Jerome H. Milgram of the Department of Ocean Engineering has been actively involved in cleanup technology for several years. Employing a flume he designed in a previous Sea Grant project, he studied the role that the surface chemical properties of oil play in its break up and escape as it is being collected by a moving cleanup barrier.

In a related study, Professor Richard G. Donnelly of the Department of Chemical Engineering compiled an extensive data base that he will use in future analyses of the influence of ambient water on the dispersion of various oils at sea.

Social leaders have turned to the oceans for sources of protein, and until recently the supplies of fish seemed inexhaustible. Unfortunately, nonproductive fishing grounds and more sophisticated assessment techniques have proved otherwise. It has become necessary to husband existing stocks that have been depleted and to seek ways for exploiting species that have been considered undesirable in the past. In the Department of Mechanical Engineering, Professor David Gordon Wilson completed the conceptual design phase for producing a machine
that will mechanically skin the underutilized, abundant spiny dogfish shark, which will then make it possible for American fishermen to exploit an unused but potentially profitable resource.

Economic benefits to the fishing industry govern the objectives of another M.I.T. Sea Grant project. Professor Vandiver and Mr. Clifton have redesigned and streamlined the trawl door to reduce the towing resistance (or drag) and thereby help to reduce fuel costs.

Eliminating waste and maximizing the use of existing resources is a contemporary concern being addressed by Professor Benjamin L. Averbach of the Department of Materials Science and Engineering. Currently, Professor Averbach is investigating ways to extract and process chitin, a cellulose-like substance present in crustacean shells, from the shellfish wastes. Chitin and its derivative chitosan have wide applicability in the manufacture of products, including films and paper, and in recovering chemicals from polluted waters.

Sea Grant is interested in the critical role that the natural processes of wind, waves, and tides play in shaping the outline of a coastline. Professor Ole Secher Madsen of the Department of Civil Engineering, and the third Henry L. Doherty Professor in Ocean Utilization, is creating an analytic model to help engineers predict how installation of manufactured coastal and nearshore structures will affect naturally occurring erosion and deposition. He also is designing an instrumentation system which will help collect data, at present not available, for his studies of surf zone hydrodynamics.

Coastal development can affect the fragile coexistence of sea and fresh water beneath the land's surface. Conferring with government officials on Martha's Vineyard to collect information, Professor John L. Wilson of the Department of Civil Engineering is creating a numerical model that could be used to estimate whether or not increased demands on fresh water supplies might result in saltwater intrusion.

M.I.T. Sea Grant has been interested in research into the causes of New England's "red tides" because of the health hazard they represent, and the work of Professor Francois M. M. Morel of the Department of Civil Engineering and the first Henry L. Doherty Professor continued to receive program support. In the past year, Professor Morel has identified dormant cysts in salt pond sediments as the potential seed population of the algal blooms and has studied the correlation between the rising and falling water temperatures and the revival of dormant cysts.

M.I.T. Sea Grant hopes that by encouraging and promoting the cooperation of industry, private citizens, government, and academia, society will benefit now and in the future from the thoughtful development of the ocean and coastal resources.

DEAN A. HORN
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. The activity showed a continuation of the recovery from the recession year of 1975.

Of the 64 programs planned for the 1977 session, only two were cancelled because of projected low enrollments. The total registration of 1,914 in 1977 was an increase over the 1,811 for 1976.

An interesting experiment was the presentation of a "package" of 12 programs by the Center for Transportation Studies. Registrants were free to attend lectures in any one of the six programs which were presented simultaneously each week. Even though the total registration was somewhat marginal, faculty and participants were enthusiastic about the flexibility in the format. The experiment will be repeated in the 1978 session.

REGULAR SUBJECTS

Graduate students comprise over 80 percent of the student body in the summer term. The 1977 registration of 2,321 students was essentially identical with the 2,317 in 1976.

JAMES M. AUSTIN

Technology Adaptation Program (T.A.P.)

The Technology Adaptation Program was initiated in 1971 under a grant from the Office of Science and Technology of the US Agency for International Development (AID), and is concerned with issues involved in the transfer and adaptation of technology to the conditions prevailing in developing countries. Its objectives are to determine the characteristics of technologies that are appropriate to countries in various stages of development; to identify criteria for the selection and adaptation of appropriate technologies; and to derive an understanding of the processes by which technological knowledge and skills can be effectively introduced, disseminated, and used in developing nations. The Program is concerned with promoting an awareness of and expertise in the technological problems facing developing countries on the part of both faculty and students at M.I.T., especially including those from developing countries who are seeking knowledge useful to their countries.
To pursue the above objectives, the T.A.P. has conducted a wide range of academic and research activities which include the following:

- Research projects involving faculty, staff, and students.
- Institutional ties between M.I.T. and universities, government agencies, and other organizations in developing countries.
- Educational opportunities at M.I.T. for those interested in issues of technology adaptation and transfer, including: interdisciplinary master's degree program, research assistantships, curriculum and course development, visits by foreign scholars, travel by M.I.T. faculty and staff, and conferences, workshops, and seminars.

The research activities of the program have focused principally on those developing countries which already have created the basic prerequisites for a sound technological base and are in the process of developing more sophisticated technical capabilities. T.A.P. cooperation with certain universities and institutions in these countries has provided the catalytic effect required for the introduction of new technology.

The Program also publishes and distributes a series of reports and papers based on its activities, and maintains a library of publications related to science, technology, and development.

TECHNOLOGICAL PLANNING PROGRAM IN EGYPT

During the past 18 months, the Technology Adaptation Program has developed a collaborative program with Cairo University entitled "M.I.T. /Cairo University Technological Planning Program." This program is currently funded by the AID Mission in Egypt. Its overall objective is to assist Cairo University in developing capabilities which could contribute to the formulation and implementation of science- and technology-related policies designed to aid in the realization of Egyptian development goals. To this end, three specific objectives have been pursued: 1) mobilization of academic interest in research on specific development plans; 2) organization of technical research in collaboration with Egyptian government ministries; and 3) establishment of an institutional framework through which permanent research and training capability can be organized.

The specific research projects organized so far employ three general analytic approaches: 1) engineering analysis and technical project evaluation, addressing specifically technical issues, including field and laboratory studies, design, training requirements, etc.; 2) economic analysis, focusing on project, sector, and national planning issues, and micro- and macro-economic studies related to specific Egyptian development programs; and 3) social science analysis based on an interdisciplinary approach for the development programs focusing on social issues, overall economic policy formulation, and specific projects on population and labor force issues, socioeconomic change including urbanization, social services, technology transfer, and development administration strategies.

Each individual research project within the program utilizes these approaches to the extent required for attaining its specific objectives, and invariably some consideration of the issues raised by each approach is incorporated into the planning and evaluation phases of both the project and the program.
Over the past 18 months, 13 collaborative projects have been developed between M.I.T. faculty members and their counterparts at Cairo University and the appropriate ministry or government agencies. They focus on a broad range of engineering, economic, and social science topics, as described below. The key element in each of these efforts is the interdisciplinary team drawn from faculty and staff from M.I.T., Cairo University, and government ministry personnel responsible for planning development projects in the topic area. Effective utilization of the Egyptian academic and government resources has been one of the principal reasons for the success of the program to date. In addition to the specific research activities, emphasis has been placed on the training of in-country personnel in the techniques of project identification, evaluation, and management, and the development and maintenance of the data necessary to design and monitor their projects.

To fulfill the program objectives and to institutionalize the activities in Egypt, T.A.P. is currently assisting Cairo University in the establishment of an Institute for Transfer and Adaptation of Technology. The purpose of the Institute is to develop a body of technical, economic, and social science expertise in the general area of technological development. It is intended to provide short- and long-term research and educational capabilities in the following four areas: 1) public works, including transportation, housing and water; 2) manufacturing, including small-scale industries, petrochemical industries, plastics, and building materials; 3) energy, including electric generation and distribution, and solar energy; and 4) socioeconomic development, including migration, health care delivery, macroeconomic planning, and telecommunications issues.

This program will also contribute to the advancement of theoretical and practical applications of planning methodologies, a better understanding of the processes underlying technology transfer and adaptation in Egypt, and the development of insight into the appropriate institutional arrangements within the Egyptian academic community necessary for responding to national needs in technological fields. Information developed in the specific project assessments, as well as the background information developed on the Egyptian economic environment, will expand the data base for policy decisions. The program is designed, therefore, to contribute to an improved understanding of both the specific and general issues of national development and exemplify the interaction of technical, economic, and social issues in project planning.

**RESEARCH PROJECTS**

**Public Works**

Housing and the Construction Industry. The objective of the Housing and the Construction Industry project is to provide a set of pragmatic recommendations/guidelines for the public agencies concerned with housing and to construct a methodology through which these agencies can organize and monitor performance in this sector. The interdisciplinary team has organized these related subprojects: the Housing Economy and Public Policy, the Housing Construction Industry and Materials Supply, and Housing Construction Systems and Design Norms. The project is under the overall direction of Professor N. John Habraken, Head, Department of Architecture.

The objective of the Housing Economy and Public Policy subproject is to develop a model of the Egyptian housing economy, and evaluate a range of policy options of current interest: relaxation of rent control, redesign of public housing, rent increases, expanding labor supply, and other factors. The model will investigate the status and impact changes in the formal factor markets, as well as the "black markets."
The Housing and Construction Industry and Materials Supply subproject will focus on the current shortages and inefficiencies in the building materials industry. The goal is to determine priorities for the allocation of resources and investments in order to increase the availability of building materials.

The Housing Construction Systems and Design Norms subproject will develop guidelines and recommendations related to industrialized building systems currently being developed in Egypt and the best use of these systems in Egypt, and for the planning of new settlement areas. It is hoped to maximize the government's effort in these areas given present investments and administrative, technical, and financial constraints. Professor Albert G. H. Dietz of the Department of Architecture and Professor William C. Wheaton of the Department of Economics are also participating in this project.

Transport Investment Policy. Professor Fred Moavenzadeh of the Department of Civil Engineering is directing a study on transport investment policy in Egypt. The objective of this study is to strengthen the capabilities of Egyptian institutions and public agencies concerned with transportation in the area of the analysis, planning, and programming of the transport investments, and to develop methodologies by which these agencies can monitor the performance of the transport sector. The project consists of three specific phases. Phase 1 is concerned with the development of an understanding of transportation policies and regulations in Egypt. In Phase 2, a set of unimodal models will be developed to estimate the transportation costs and level of services offered by various transportation modes in Egypt. In Phase 3, a multimodal model using quasi-disaggregate demand estimation procedure is being developed. Professor Terry Friesz, Research Associate Michael J. Markow, and Research Engineer Brian Brademeyer in the Department of Civil Engineering are contributing to various phases of this project.

Urban Transportation Policy. Under the direction of Professor Ralph A. Gakenheimer of the Department of Urban Studies and Planning, this project will assist the Transport Planning Authority and other agencies in strengthening their project implementation and policy-making processes in the area of urban transportation. The activities during the first year have included three major elements: implementation programming, urban travel survey analysis, and auto ownership analysis. A traffic survey was undertaken to identify major flows and sources of congestion in the Cairo area. Professor Steven Lerman of the Department of Civil Engineering is also participating in this project.

Water Resource Planning Models for the Nile River Basin. Under the direction of Professor David H. Marks of the Department of Civil Engineering, optimization screening models and river basin simulation models based on M.I.T.'s previous extensive experience in river basin planning throughout the world are being developed to help identify and evaluate alternative water resource development plans and their economic, physical, and social impacts. Through interaction with local planners, a thorough examination of the complex implications of water investment and allocation will be fully explored within the initial master water planning process and revised in the future with changing conditions. Professor Daniel P. Loucks of the Department of Civil Engineering is also participating in this project.

Stochastic Model of Nile Inflows to Lake Nasser. Under the direction of Professors Rafael Bras, and Peter S. Eagleson, both of the Department of Civil Engineering, a stochastic model of Nile inflows at several key locations above Lake Nasser is being developed which will provide the Ministry of Irrigation with an extended and better organized data base for studies of reservoir and diversion operating policies. It will provide the basis for accurate river discharge forecasting, essential for efficient operation of river structures and optimal planning of irrigation activities, and will be an integral part of any future extended basin simulations.
Technology Adaptation Program

Regional Groundwater Studies. Computer models of the Nile Delta aquifer and desert aquifer are being developed under the direction of Professor John L. Wilson of the Department of Civil Engineering. The Nile Delta modeling effort which has been under way for almost a year is designed to help evaluate the aquifer's safe yield, its capability to act as a storage reservoir, and the impact of groundwater development on agricultural drainage. The desert aquifer study is initially oriented toward an analysis of the impact of the Qattara Depression and Toshka Depression projects on the aquifer.

Manufacturing

Government Incentives for Small-Scale Industry. The principal objective of this project, under the direction of Professor Suzanne Berger of the Department of Political Science, is to analyze the ways that government policy encourages or discourages innovation and expansion in small industrial firms. On the basis of this analysis, recommendations will be developed for policies, organizational and structural changes to increase incentives for innovation, and expansion in the small to medium private industrial sector.

Engineering Applications for the Plastics Industry. Professor Frederick J. McGarry of the Department of Materials Science and Engineering is directing this project, the objective of which is to develop a capability in plastics technology at Cairo University and in several private and public companies that will support the ministries' plans to expand the applications for plastics. Project participants from M.I.T. and Cairo University will select a set of case studies and work directly with industrial firms in identifying and solving technical problems in product and mold design, applicable standards, and quality assurance. Raw material and product testing methods and equipment will be developed. A training program in these aspects of plastics technology will be organized at the University and made available to industry engineers. Other faculty participants in this project are Professor Robert Cohen of the Department of Chemical Engineering and Professor David Roylance of the Department of Materials Science and Engineering.

Energy

Long-Term Investment Planning for the Egyptian Electric Power System. The Ministry of Electricity is confronted with the tasks of selecting electric generation projects from a wide range of hydroelectric, fossil fuel, and possibly nuclear options. The technical staff of the ministry is well trained in the engineering requirements and difficulties of the alternate projects, but are not conversant in the techniques for economic assessment and ranking of these alternatives for the number of economic and social objectives which confront them. The objective of this project is to develop a methodology for performing these assessments on a regular basis and to train ministry personnel in its use. A simplified model will be developed for the capacity expansion problem, and data on the alternate projects applied to it. If warranted, more sophisticated models will be applied to account for the characteristics of the individual projects. This project is under the direction of Professor Martin Weitzman of the Department of Economics; Professor James Kirtley of the Department of Electrical Engineering and Computer Science participates in the research.

Socioeconomic Development

Egyptian Labor Migration. Professor Nazli Choucri of the Department of Political Science is directing a survey of several aspects of the migration issue including available demographic data, current educational and labor requirements, demographic profiles of other Arab countries, and present policies. A model of the Egyptian migration will be developed as a conceptual framework for assessing the social/economic/political benefits and costs to Egypt.
The Development of Improved Macroeconomic and Sectoral Planning Methods. Under the direction of Professor Richard S. Eckaus of the Department of Economics, the objective of this project is the development, in several stages, of improving methods and skills required for overall and sectorally specific methods for economic planning. The first task is to collect and make consistent the national accounts and input-output data needed for a simple multi-sectoral planning model. The consistency of proposed sectoral output targets with investment and export plans and the effects of various tax and subsidy programs are being examined by means of the model. Professor Lance Taylor of the Department of Economics is also participating in the project.

Communications Needs for Rural Development. Under the direction of Professor Ithiel Pool of the Department of Political Science, this project involves evaluation of communication needs for rural development in Egypt and the technologies available to meet these needs. This will be accomplished by examining alternative communications facilities and how they could assist information flow in a developmental context, and by examining the available options in existing communications facilities. The study will focus on rural communications in the areas of health care delivery, family planning, national informational efforts on social issues, and certain aspects of local administration.

Health Care Delivery Systems. Under the direction of Professors Eckaus and Taylor, this project is developing an overview analysis of the public health system in Egypt as it affects health status as indicated by the type and degree of malnutrition. The study will provide the Ministry of Health with recommendations on ways to improve the delivery of public health services to better cope with overall delivery of services. It focuses on the organizational management responsibilities of the Ministry rather than the specific hardware needed to upgrade the delivery system. Dr. John O. Field, Research Associate in the Center for International Studies, is taking major responsibilities in this project.

EDUCATIONAL OPPORTUNITIES

T.A.P. has expanded educational opportunities at both M.I.T. and in Egypt. Opportunities for learning have been made available for 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.

Research Assistantships

During the first phase of the program, 19 graduate research assistantships were offered, and several other students at the graduate and undergraduate level participated in project research. Several have indicated that they will be using their experience as the basis for their Master's and Ph.D. theses.

Curriculum and Subject Development

Although no funds are available at this time specifically for the development of new subjects, several faculty members have incorporated material from their project work into regular
subjects taught during the academic year. For example, Professor Wheaton presented a short course during the Independent Activities Period entitled "The Housing Economy of Egypt," which was based on his program research.

**Visits by Foreign Scholars**

To date 36 Egyptian participants from Cairo University and various government agencies have visited M.I.T. 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 the specific research projects in collaboration with their M.I.T. counterparts. In addition, several have had the opportunity to meet with other M.I.T. staff members interested in similar problems of technology adaptation and development.

**Travel by M.I.T. Staff**

M.I.T. faculty, staff, and students spent a total of four person-years in Egypt during the first phase of the program. Several staff members were also able to visit other locations overseas to meet with experts working on similar development problems, or to attend conferences relevant to project research. In addition to the T.A.P. research and administrative staff, Robert J. Long of the Comptroller's Accounting Office and James J. Culliton, Assistant to the Vice President for Administration and Personnel, traveled to Cairo to assist in the organization of the Liaison Office. During the next phase of the program and development of the Institute for Transfer and Adaptation of Technology it is anticipated that other M.I.T. administrative staff may be asked to travel to Cairo to assist in this effort.

**Conferences, Workshops, and Seminars**

During the past year, five major meetings were held in Cairo sponsored by the program, at which M.I.T. faculty and staff, Cairo University and ministry personnel participated;

In January 1978, Professor Habraken and Professor Moavenzadeh, Director of the Technology Adaptation Program, chaired a conference on "Development of New Approaches to Housing Policy and Production in Egypt," which was cosponsored by the Ministry of Housing and Construction. The conference discussed alternative approaches in housing economics, construction techniques, manufacturing of prefabricated houses, and planning of site and services projects. Presentations were made by M.I.T. faculty and staff and by Ministry officials and Cairo University faculty. Workshops were conducted after each day's presentation and focused on user needs, minimum standards, and performance criteria; planning, organization, and production; and construction and building technology.

A week-long workshop in Polymer Science and Technology, chaired by Professor McGarry, was presented in January 1978 at Cairo University. Specific workshop topics included plastics engineering, fiber reinforced plastics, and deformation and fracture of polymers.

A conference on Transportation Planning Policy cosponsored with the Transport Planning Authority, Ministry of Transport was held in June 1978. This conference was chaired by Professor Moavenzadeh and Professor Gakenheimer. Issues discussed included transport investment policy, transport and social development, transport innovation and research policy, supply and demand, project evaluation, network analysis, urban transportation, and para-transit systems.
A month-long workshop on Water Resources Planning covering both fundamentals and applications was conducted by Cairo University and M.I.T. faculty in May-June 1978. This workshop was organized by Professor Marks, and other participants included Professors Eagleson, Bras, Wilson, and Loucks. Session topics included groundwater hydrology and modeling, statistics and the role of uncertainty in hydrology, stochastic hydrology, water balance and dynamic hydrology, simulation models, reservoir operation models, and network optimization evaluation criteria.

A one-day workshop on government incentives for small-scale industries chaired by Professor Berger was held in June 1978. Results of the joint M.I.T./Cairo University research on this topic were discussed and recommendations presented to government officials and private sector representatives.

Several one-day seminars were conducted in conjunction with visits by M.I.T. and Cairo University faculty to Cairo and Cambridge, respectively. These included:

- "Water Development Issues in Egypt" by Professor I. El-Assiouti of Cairo University at M.I.T., March 1978;
- "Use of Computer Models in Reservoir Operation" by Professor Loucks, Department of Civil Engineering, at Cairo University, March 1978;
- "Techniques to be used in Water Balance Determination for the Bahr El Ghazal Region" by Professor Eagleson, Department of Civil Engineering, at Cairo University, January 1978;
- "Techniques to be used in Water Balance Determination for the Bahr El Ghazal Region" by Professor Bras, Department of Civil Engineering, at Cairo University, January 1978;
- "Numerical Modeling of Groundwater Systems" by Professor Wilson, Department of Civil Engineering, at Cairo University, December 1977.

Review Meeting at Endicott House

In April of 1978, it was considered useful to have the participating faculty review the program's accomplishments, problems, and concerns, and determine how the objectives of this type of program can be fulfilled more effectively and its administration improved. Since opportunities for this type of project on the part of M.I.T. appear to be increasing, the Provost considered it useful to promote the formation of a group of peers at M.I.T. to evaluate such programs and create guidelines to ensure that these programs serve the best interests of M.I.T. A review meeting of all project participants was therefore held on April 15; invited were the Provost, Chancellor, T.A.P. Steering Committee members, the members of the Committee on International Institutional Commitments, the Deans of the Schools of Engineering, Humanities and Social Science, and Architecture and Planning, and the Heads of the relevant academic departments. This review process was considered especially important given the then ongoing negotiations for a multi-year extension of the program.

To provide a focus for the meeting, a questionnaire was distributed and the results used as the basis for discussion during four sessions covering the following topics:

- academic contributions to M.I.T.;
- contributions to Cairo University and the Government of Egypt;
Following is a brief discussion of some of the views, opinions, and conclusions drawn from this meeting.

It was concluded that since this is an effort involving faculty from many departments and a small but active group of administrators, it resembles in many ways other centers at M.I.T., but is different in the sense that it is focused on the broad subject of development rather than on an intellectual discipline. Therefore, it has brought together several faculty members from diverse backgrounds, thus achieving synergistic benefits from interdisciplinary interaction.

The program's contributions to academic life at M.I.T. were regarded as varied. Several faculty members, especially those concerned with policy formation, commented that their work had a direct theoretical interest; the program has been successful in matching the problems vital to the development of Egypt to the basic research interests of faculty members at M.I.T. in such diverse areas as transportation, housing, water resources, economics, and political science. In comparing the research being done under the auspices of this program to other types of research, many faculty members noted that the program had freed them from several constraints they had felt when performing similar work in a different context. Specifically, the scope of the program and nature of its administration has provided the project leaders with a large degree of flexibility and independence, allowing them to concentrate more on the theoretical aspects of their work rather than being committed to producing a specific output or set of results.

In conclusion, it was proposed that the Institute should pursue this type of research experience more actively and regard it not only as an activity that a few have undertaken and found useful, but as one that is of positive value in encouraging and facilitating the interest of both faculty and students in this area.

ORGANIZATION

The Technology Adaptation Program is directed by Professor Moavenzadeh of the Department of Civil Engineering. An Executive Committee composed of Dr. Choucri, Professor of Political Science; Dr. Eckaus, Ford International Professor of Economics; and Professor Moavenzadeh, has the responsibility for the management of the program. A Steering Committee which oversees the activities of the program consists of Professors Choucri, Eckaus, Jack P. Ruina of the Department of Electrical Engineering and Computer Science, George W. Rathjens of the Department of Political Science, Dean William F. Pounds of the Sloan School of Management, and Professor Eugene B. Skolnikoff of the Department of Political Science and Director of the Center for International Studies; the Committee is chaired by Professor Moavenzadeh. Jeanne DePass is the Program's Administrative Officer, and Arthur J. Collias serves as Technical Officer. Robert P. Greene is the Administrative Officer of the M.I.T./Cairo University Liaison Office in Cairo.
PUBLICATIONS

During the past year, the Technology Adaptation Program published 10 technical reports on issues of technology adaptation and development. More than 20 working papers have been written by faculty and staff on the M.I.T./Cairo University Technological Planning Program, several of which will be published by T.A.P. in the near future.

FRED MOAVENZADEH

Upward Bound Program

The M.I.T.-Wellesley Upward Bound program is a coeducational, multiracial, multiethnic educational program for Cambridge high-school aged youth. Now in its eleventh year, the program serves 70 academically promising young men and women who have low achievement aspiration and who come from low income families. The goal of the program is to motivate these youths to attend college and to provide them with the necessary academic and social skills needed to succeed in college. To a large extent the program is influenced by the research done by Kurt Lewin and his associates, particularly in the area of goal setting or level of aspiration. The program has operated on the assumption that ego growth and academic performance are closely related, and has met with good success. A developing ego needs to experience success and it will develop more strongly, in both a personal and social sense, in a warm and personal but structured environment. This development can be brought about through intervention outside of the family and the school.

Upward Bound represents such a controlled field intervention. It has established that the effects of failure can be reversed by presenting the young person with real success and that further success leads to an increase in his or her level of aspiration. In this process, the people around the students -- fellow students, teachers, and other program staff -- play a crucial role because what students think they can do is dependent on what others think they can do. Consequently, the students' perceptions of their abilities, and therefore what they will try to accomplish, are to a large extent determined by the program staff, who are often the first and only people to see real academic promise in the youngsters.

THE 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, Wellesley College and M.I.T. students, and Upward Bound alumni now attending college. Each Upward Bound student carries three classes, each of which meets for 50 minutes, five days per week during the six-week summer program. Classes are small and of a seminar nature. Each student is required to take one mathematics and one humanities course and one elective. Humanities offerings include reading and writing, teens and law, studies in inner city living, government and contemporary issues, and sociology. Science courses include biology, physics, and chemistry and are supported in part by a grant from the M.I.T. chapter of Sigma Xi. The mathematics program includes an enrichment section for students who are going to take
Upward Bound Program

Algebra I or II, Geometry, or Math IV; a review section for students who have done poorly in Algebra I or II, Geometry, or Math IV; and a pre-calculus course for students who will be attending college in the fall.

THE ACADEMIC YEAR

The academic year program, while ostensibly less intense and dramatic, has importance at least equal to that of the summer. Building on the motivation and enthusiasm developed over the summer, the academic year program is designed to help the student cope with the myriad academic, social, and family problems that confront him or her in Cambridge. To achieve this, the following programs, staffed primarily by M.I.T. and Wellesley College undergraduates, have been developed and implemented.

Study Skills

The M.I.T. Upward Bound offices are open for study five afternoons a week from 3:30 to 5 p.m. and four evenings per week from 7 to 9:30 p.m. Students are asked to spend at least one afternoon or evening per week at one of these study sessions. Each session has a team of two part-time staff as leaders and, in addition, about four undergraduate volunteers. They work individually or in small groups with students on school-related problems.

Tutoring

Whenever requested or needed, tutors are assigned to individual students. Tutors are typically M.I.T. or Wellesley College undergraduates who arrange to meet on a mutually convenient and regular basis with the Upward Bound student and then report back to project staff. For 1978-79, for the second time, space for meetings and tutoring will be available in the Cambridge Public High School during the day.

The Saturday Program

The goal of the Saturday program is to furnish a miniature replication of the Wellesley summer experience. Students attend during the fall, winter, and spring on a regular basis on Saturdays for six hours. The Saturday program includes an arts and crafts class, drama, and a mathematics class as well as the use of the pool and gym.

College Report, Class of 1978

Fourteen of the 15 graduating seniors have been placed in colleges as follows: Bay State College, Boston College (2), Fitchburg State College, Northeastern University (2), Salem State College, University of Bridgeport, University of Massachusetts at Amherst (4), Virginia Union College, and Yale University.

JOHN P. TERRY
Wellesley-M.I.T. Exchange Program

The academic year 1977-78 marks the 10th anniversary of the Wellesley-M.I.T. Exchange Program. The Exchange began in 1968 as an experiment in student cross-registration for the purpose of curriculum enrichment and diversification. The experiment was successful and the Exchange has become a permanent and important feature of the educational programs of both schools. Though it began and established itself primarily as a student cross-registration program, in recent years an increased level of faculty interaction has become an equally important element of the program.

In the teaching of French, Chinese, German and most recently Spanish, we are now exchanging faculty as well as students. This involves faculty members from one school teaching at the other campus, and two-person teams teaching with the class meetings alternating weekly between campuses. Teaching-laboratory materials are shared, and faculty members with overlapping interests are cooperating on research and sharing of research resources. Faculty exchanges for the teaching of courses and team-teaching also have been used by the faculties in political science.

Wellesley and M.I.T. faculty members from several disciplines in the humanities, arts, and social sciences are active in a four-institution interdisciplinary faculty seminar known as the Cambridge Humanities Seminar. In addition to the faculty development opportunities it provides, the Seminar leads to the creation of new courses in the catalogues of each of the four schools involved; frequently these subjects are taught by joint M.I.T.-Wellesley teaching teams.

The respective faculties from each school in anthropology and archaeology meet jointly to plan curricula and the scheduling of subjects to be taught each year, and are actively cooperating in developing a new nine-institution consortium, known as the Center for Materials Research in Archaeology and Ethnology. This consortium conducts a four-year cycle of faculty/student seminars, and has built and operates a special teaching laboratory for the analysis of the various materials encountered by students of archaeology.

M.I.T. engineering faculty are active in developing advisory mechanisms at Wellesley for students interested in engineering. In part, this activity has led to the introduction into the Wellesley College catalogue of a section on "engineering opportunities." Several Wellesley students have pursued academic degree programs heavily dependent on M.I.T. engineering subjects leading to a two-discipline Wellesley College degree (e.g. physics and biology) in applied science.

In recent years, Wellesley students have begun doing UROP (Undergraduate Research Opportunities Program) projects at M.I.T. during the academic year, and Wellesley College now provides support for up to four students from each school for UROP projects during the summer. There has been at least one UROP project which was the joint effort of an M.I.T. and a Wellesley student, both working at Wellesley under the supervision of an M.I.T. faculty member.

Finally, there is an overlap in spirit and arrangements between the M.I.T. January Independent Activities Period (I.A.P.) and the Wellesley College Winter Term, leading to active participation by students on each other's campuses.
The M.I.T.-Wellesley Exchange Program has diversified and enriched the curricula at both schools, and has given rise to innovative opportunities for faculty development. But the unique contribution of the Exchange has been that it makes it possible for each school to be more responsive to the evolving academic needs of contemporary students without depleting the resources each school has for continued growth in their respective areas of strength.

KENNETH M. HOFFMAN

American Journal of Physics

In 1973 the Institute became the home of the American Journal of Physics, a journal "devoted to the instructional and cultural aspects of physical science," sponsored by the American Association of Physics Teachers. Dr. Edwin F. Taylor, Senior Research Scientist in the Department of Physics and the Division for Study and Research in Education, is Editor. Professor Anthony B. French is Consulting Editor, Dr. Steven Berger is Assistant Editor, and Carol Frakes and K. Toni Ramos assist in the editorial office.

Dr. Taylor resigned his position as Editor, effective June 1, 1978 and the Journal editorial offices have relocated to the institution of the new Editor, John S. Rigden, at the University of Missouri at St. Louis.

EDWIN F. TAYLOR

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. The research program includes work on computer vision and manipulation, intelligent personal assistance, English language understanding, learning and automatic debugging, common sense reasoning, expert engineering problem solving, manufacturing productivity, computer architecture, human development, and human education.

During 1977-78, Professor Patrick H. Winston was responsible for the general direction of the Laboratory. Professors Marvin Minsky and Seymour Papert worked on the development of general theories of artificial and natural intelligence. Professors Berthold K. P. Horn and David Marr led work on computer vision. Professor Horn also supervised work on computer-controlled, multiple-joint manipulators and other problems in manufacturing productivity. Professor Ira Goldstein directed research on automatic news analysis, commonsense resource scheduling, and user-sensitive computer interfaces. Professor Gerald Sussman worked on programs that reason about electronic circuits. Professor Carl Hewitt investigated new programming models and developed the ACTOR language. Professors Jeanne Bamberger, Andrea di Sessa, and Harold Abelson worked with Professor Papert to develop uses of technology in education and to construct corollary cognitive theories. Richard Greenblatt, Thomas Knight, and Jack Holloway led work on computer systems including the development of a high-performance processor oriented toward the symbol manipulation required by intelligent programs.
The Laboratory's 92 members included a total of 12 faculty, six visiting scientists and engineers, 28 research and support staff, 39 graduate students, and seven undergraduates. They were involved in research activities which were funded during fiscal year 1977 by the Defense Advanced Research Projects Agency, the Office of Naval Research, the National Science Foundation, the National Institute of Education, the International Business Machines Corporation, and the National Aeronautics and Space Administration.

During the year, the Fifth International Joint Conference on Artificial Intelligence (IJCAI-77) was held at M.I.T., attended by about 1,000 people. Local arrangements for the conference were handled by Professor Edward Fredkin and Dr. Eva I. Kampits.

Image Understanding

Professor Horn's group has spent a considerable part of the last two years working on the automatic understanding of aerial photographs. In particular, Professor Horn has devised a representation called the "reflectance map" to describe how reflected intensity is controlled by surface material, surface orientation, and light-source position. Reflectance maps enable the generation of synthetic high-altitude images from terrain models. Correlating a real image with a synthetic one can establish the proper registration of the real image with a terrain model in preparation for various sorts of automated cartography and improved crop forecasting. To keep computational time within reasonable bounds, Professor Horn correlates reduced real and synthetic images in translation, rotation, and scale space to give approximate registration. Then the process is repeated with high resolution images to achieve high accuracy.

Once the registration problem was under control, Professor Horn proceeded to make the first images in which intensity is determined by the ratio of real image intensity to synthetic image intensity. These albedo maps offer a new way of doing crop analysis inasmuch as intensity varies only with ground cover and not with changes in ground slope or sun position.

Work with real satellite images requires attention to many details. One is the need to remove the striping effect caused by the slightly different characteristics of the six sensors used for image scanning in LANDSAT. Another is the need to determine the details of the image transformation process. Both problems were solved during the past year.

Reflectance maps enable the analysis of images as well as the production of synthetic images. During the past year Professor Horn began work on another idea that makes it possible to recover shape by using only one camera position together with multiple light sources. Normally, the intensity of a point in an ordinary black-and-white image is not sufficient to determine the surface normal at that point. There is constraint, however, and one black-and-white intensity does limit the normal to lie on a definite isointensity curve in the reflectance map. Using multiple light sources, however, two or more separate curves in reflectance-map space are obtained. Their intersection gives the surface normal unambiguously. Professor Horn calls this photometric stereo.

Once surface normals are known, there remain the problems of shape reconstruction and recognition. For these, Professor Horn uses the surface normals to create what he calls the extended Gaussian representation. He has developed an algorithm that reconstructs three-dimensional shape from the extended Gaussian descriptions, and he has proved its result is unique, thus enabling recognition.

In quite a different area, Professor Horn worked out the mathematics required for both fan-beam and variable-resolution computer-aided tomography. This enables better use of tomography in that the images of critical organs can be displayed with considerable
improvement in resolution. Professor Horn's paper on this subject, appearing in the Proceedings of the IEEE, was the first to use computer-generated halftones of synthetic images.

Professor Marr's group continued to work on vision from a complementary perspective. Believing that an overall theory of vision must rely on explicit descriptions at the right levels, he has concentrated on three representations: the "primal sketch" which records information about intensity changes and local two-dimensional geometry; the "2 1/2-D sketch" which is a viewer-centered representation of the depth and orientation of visible surface and includes contours of discontinuities in these quantities; and the "3-D model representation" which makes information about shape explicit. The most important features of the 3-D model representation are that its coordinate system is object-centered, that it includes volumetric primitives which make explicit the space occupied by an object and not just its visible surfaces, and that primitives of various sizes are included, arranged in a modular, hierarchical organization.

Stereopsis has received a great deal of attention since it is one key to the creation of the 2 1/2-D sketch. During the past year a new algorithm was devised that has caused considerable excitement because it provides a theoretical framework for most existing psychophysical and neurophysiological data about stereopsis. The algorithm consists of five steps: each image is filtered with bar masks of four sizes that vary with eccentricity; zero-crossings of the mask values are localized, and positions that correspond to terminations are found; for each mask size, matching takes place between pairs of zero-crossings or terminations of the same sign in the two images for a range of disparities up to about the width of the mask's central region; wide masks control vergence movements, thus causing small masks to come into correspondence; and when a correspondence is achieved, it is written into a dynamic buffer, the 2 1/2-D sketch.

Stereopsis work is an example of many efforts directed at understanding the constraints on the way the world behaves that enable vision processors to recover various aspects of the physical characteristics of the objects in a scene from images. The stereopsis work exploited the fact that depth is continuous nearly everywhere. In work last year on motion vision, Dr. Shimon Ullman assumed collections of moving features lie on rigid objects to derive their relative positions from three snapshots. Professor Marr believes the discovery of such constraints that are valid and sufficiently universal leads to results about vision that have the same quality of permanence as results in other branches of science.

Intelligent Personal Assistant Systems

Professor Goldstein's group has concentrated on coaching and consulting programs. The overall objective is to understand the theoretical and applied issues that arise in delivering computer expertise to the user. The experimental focus has been on consulting programs for office activities and travel planning and on coaching programs for programming and logical reasoning.

The major theoretical accomplishment of the past year has been a formalization of the corpus of procedural knowledge of the coaching programs as a lattice of rules linked by various symbolic relationships such as analogy and specialization. The graph structure has improved the advice generated by Professor Goldstein's coaching programs and provided a superstructure for designing coaching programs for other domains. Experiments conducted with the new coaching programs demonstrate that they are successful with students and appeal to them.

Successful delivery of computer expertise requires natural language interfaces. Work has proceeded on systems that comprehend connected discourse, properly processing pronouns, and definite noun phrases.
Expert Problem Solving

Traditional automated synthesis techniques for circuit design are restricted to small classes of circuit functions for which exact mathematical methods exist. Professor Sussman and his group have developed a computer-aided design tool that can be of much broader assistance.

It is an obvious idea to determine component values by solving the set of equations and inequalities which result from matching a symbolic analysis of the circuit with the given design criteria. Unfortunately, this is algebraically infeasible in general. A complete symbolic analysis of even simple circuits containing nonlinear components is usually difficult. But even for circuits whose behavior is linear in voltages and currents, the equations are badly nonlinear in the component parameter values.

Professor Sussman's synthesis aid is based, instead, on analysis by propagation of constraints. This analysis method guides the use of symbolic algebraic methods in combining constraints which describe circuit elements and their interconnections to determine the behavior of a circuit. He has shown how propagation analysis can be inverted to determine constraints on the individual parts from the desired behavior of the circuit. The method is based on the observation that locally, analysis and synthesis are very similar: the problem of finding the resistance which permits a given current flow at a given potential is equivalent to the problem of determining the current that flows given a resistance and a potential.

One aspect of human problem solving that has been of particular concern is the way expert circuit designers use terminal equivalence and power arguments to reduce the apparent synergy in a circuit so that their computational power can be focused. To account for this ability in computational terms, Professor Sussman has introduced a new descriptive mechanism, called "slices," that combines the notion of equivalence with identification of parameters. Armed with appropriate "slices," Professor Sussman's automatic analysis procedure uses analysis by propagation of constraints to assign component values.

Basic Theory

Professors Minsky and Papert are attempting to combine some ideas from developmental, psychoanalytic, and cognitive theories with ideas from artificial intelligence. In this "society theory," intelligence emerges from the interaction of large "societies" of rather simple individual "agents," in a parallel computational structure. Because each agent is relatively simple, communication between agents must be very restricted, both in amount and complexity.

It is hoped that the approach may illuminate the psychological theories of Piaget and Freud, as well as the coherence of artificial intelligence theories, which have not previously attempted to consider the kinds of problems that must be confronted by a whole "personality." The limitations of inter-agent communication make it necessary for the mind to develop hierarchies of control structures that we may be able to identify with developmental stages. The censors and critics of the hierarchy must settle conflicts by referring to early-developed self-images.

Whether or not the theory is psychologically productive, the work already has suggested new ways to organize very large knowledge-based computer programs and, perhaps, some ideas about building large, active computer memories. Several students are implementing computer models of their own versions of the theory.
Manufacturing Productivity

To advance the state of the art in automation, Professor Horn is doing long-term research in computer vision, computer-controlled manipulation, and high-level programming languages.

Manipulator control has been a major concern. Some time ago Professor Horn solved the intricate problem of calculating the forces needed to move a six-joint arm along a prescribed trajectory using an Euler-Lagrange approach, but the resulting formulas are much too large to use in real-time control. One alternative that Professor Horn has explored during the past year is to combine table look-up with some real-time computation. The method, which Professor Horn calls configuration-space control, promises to reduce the dimensionality of the necessary table from 12 to six, thereby dramatically reducing the storage needed. Still, the method correctly deals with Coriolis forces, varying inertia, and link interaction.

Working with Matthew Mason, Professor Horn has also done a mathematical analysis of manipulator control in situations where the terminal "hand" is constrained, as in assembly.

Computer Systems Development

Intelligent information processing places unusual demands on computers. Consequently, Richard Greenblatt, Thomas Knight, and their colleagues have designed a computer that gives its users more symbol-manipulation and list-processing power than ever available before. Through careful design, this so-called LISP machine performs much better and costs much less than the best usable commercial computers. The processor's features include hardware data types, interleaved processing and garbage collection, a very large address space, and a very general microcode that enables, among other things, a uniquely powerful function-calling instruction.

During the past year, lessons learned by running large programs on the first prototype were incorporated into the design for a second machine, now nearly finished. The current plan is to use the second machine's design for eight more, all to be linked together to form an experimental testbed. The purpose of the testbed is to demonstrate that collections of inexpensive "personal" computers connected together in local networks are superior to large, expensive time-shared machines.

The linking will be through an eight-megabit packet-oriented cable system that has already been developed, designed, and tested. At the moment the network consists of three sites and .3 miles of cable. The technology is such that the system can support as many as 100 communicating computers before reaching intolerable performance deterioration.

Other work in the computer development area included the design and construction of a machine for fast, parallel correlation computations of the kind required to compute Marr's primal sketches. In operation, this new machine accumulates products of corresponding entries from two fast buffer memories, each of 1,024 elements, to affect the correlation of an image fragment with a two-dimensional mask.

Work on software for the vision machine has just begun. Work on software for the LISP machine and the cable system has been a major activity for the entire past year.

Education

Professor Papert's education group is dedicated to learning how students can develop their own problem-solving procedures using computer programs as models. Experimental work is conducted at the Learning Laboratory of the Division for Study and Research in Education.
During the past year, the activities of a group of 16 sixth-grade students, representing a full spectrum of ability, were documented with a view toward developing ways of capturing the learning possibilities of such an environment. The first group of eight subjects has completed 25 closely observed hours, extending over seven weeks, in a Brookline school. An interim report has been prepared to document what has been learned from these observations in terms of the variety of cognitive styles of the pupils and the variety of teaching options available to a teacher with which to respond to different pupil styles and abilities.

PATRICK H. WINSTON

Cell Culture Center

The Cell Culture Center at M.I.T. 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 primarily, but not exclusively, in the northeastern part of the United States; applications from other parts of the country, however, are welcomed.

The Center is headed by Professor Phillips W. Robbins of M.I.T., Dr. Richard L. Davidson from the Harvard Medical School and the Massachusetts General Hospital, 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 January 1, 1977 to December 31, 1977, the Cell Culture Center provided cells and/or virus material to 34 research groups in New England as well as other parts of the country. Examples of projects completed during this period include: 360 roller bottles of BH3H1 cells for Salk Institute, San Diego, California; 500 roller bottles of SV 80 cells for Stony Brook; RSV from 100 roller bottles of 2OCE. for Princeton University; 248 Liters of C-19 cells for Johns Hopkins University; MuLv from 602 roller bottles of Cl-1 cells and RSV from 600 roller bottles of 2OCEF for the Sidney Farber Cancer Center, Boston; and RSV from 100 roller bottles of 2OCE and MuLv from 920 roller bottles of Cl-1 cells for M.I.T.

Cost Apportioning Program

The Cost Apportioning Program continues to be a successful operation. Under this policy, all users are required to pay for the cost of all consumable materials used for their projects. The Center is receiving nearly 100 percent return on all expendable materials billed.

Research and Development

The Cell Culture Center has continued its active program in the development of new techniques for large-scale cell and virus production. Small-scale virus production with cells grown on
microcarriers was continued and results were recently published in the article "Virus Production with a Newly Developed Microcarrier System" D. J. Giard, et al. in the December 1977 issue of Applied and Environmental Microbiology, pp. 668-672.

The low virus yield on a per cell basis seen with Moloney Murine leukemia virus and sindbis virus has slowed our progress toward using the microcarriers for large-scale production with on-going Cell Culture Center projects. In addition, conditions still need to be optimized for cell growth on microcarriers in large volumes. Both these problems are being addressed in the Research and Development Laboratory. Feasibility studies on the use of microcarriers to grow human fibroblast cell for interferon production continue and results to date are encouraging. Results are now in press.

Education

The Cell Culture Center sponsors a Master's Program in Animal Cell and Tissue Culture Sciences being offered under the auspices of the Interdisciplinary Science Program (Course XXV) in the School of Science. The program offers course work in the Departments of Biology and Nutrition and Food Science, and laboratory experience in the Cell Culture Center. The program provided students with excellent preparation for vocations that require a broad knowledge of the techniques of cell culture and animal virology. During the past academic year, three students successfully completed the program and two are enrolled for the current term.

PHILLIPS WESLEY ROBBINS

Committee on the Visual Arts (C.V.A.)

The Committee on the Visual Arts is a faculty committee which was established in 1966 to set general policy and procedural guidelines for those non-curricular activities under its jurisdiction: the exhibitions program in Hayden Gallery and Hayden Corridor Gallery, the M.I.T. Permanent Collection, and related educational projects. In addition, the Committee acts as an advisory body to the C.V.A. staff on exhibition and special programming in the visual arts, and makes recommendations on acquisitions and loans to the M.I.T. Permanent Collection and on the siting of large-scale works of art in public spaces.

The staff of the Committee on the Visual Arts is responsible for the formulation and administration of the exhibitions schedule for Hayden Gallery and Hayden Corridor Gallery; the procedures for registering, siting, and maintaining all artworks acquired for the M.I.T. Permanent Collection; an extensive publications program which includes catalogues, brochures, informative texts, and press releases; and the planning and administration of supplementary educational and special projects such as lectures, symposia, film and video offerings, an artist-in-residency program, and an art-lending service for M.I.T. students.

Committee Action

Committee meetings during 1977-78 were devoted primarily to an evaluation of M.I.T. community response to the Committee on the Visual Arts' programs, and explorations of various approaches that might be adopted to address these concerns. The continued defacement of the
Louise Nevelson sculpture in spite of the efforts to establish better communication that were initiated last year has been a focus of weighty discussions. Although there was no clear path to resolution of this specific problem, the need to engage the M.I.T. community in more intensive educational activities was seen as a priority.

As in the past, the Committee reiterated its view that the Collection and exhibitions programming should concentrate on 20th-century art and its late 19th-century antecedents with special reference to recent contemporary expressions. The major factors underlying this attitude are that the academic offerings in the arts at M.I.T. fall in these periods and that the Institute can be most effective in collecting significant holdings in contemporary American art that will enlarge and enrich rather than compete with the resources of other Boston area institutions. The problems in acceptance of the Committee's programs by some groups or individuals seem to stem from a general lack of exposure to or engagement with contemporary art at the Institute. This resistance to certain of our programs is accentuated by the fact that while the Committee on the Visual Arts policy stipulates that works in the Collection be located in public spaces where they are likely to be encountered on a daily basis, many passersby seem to regard them as visual violations of public rights of access to those spaces. Some of the actions and proposals that have resulted from these discussions are outlined below.

New House Residence

Extended preliminary meetings were held with representatives of the New House residence to help create a climate of understanding for the acceptance of a group of prints offered for the residence's public spaces. Informational materials and slides were presented to these living groups on several choices of artwork. Follow-up meetings were then scheduled with representatives to determine selections based on votes of members of the living groups.

Richard Smith Proposal for Lobby 10

The renovation of the space including the Alumni Center stimulated the notion of a commission for the Building 10 lobby which would not only serve as an identifying emblem for the new Alumni area, but provide an environmental enhancement to this well-traveled space and a significant addition to the M.I.T. Collection. The physical characteristics of the lobby necessitated the proposal of a work that would not conflict with heavy traffic yet have visible presence. Other considerations included the war memorial associations, the stately physical surroundings of the space, and the contrasting student activities that frequently take place in that lobby.

These requirements seemed to agree with the visual attitudes of Richard Smith, whose recent work had been scheduled for an exhibition at Hayden Gallery. Smith was asked to make a proposal for Lobby 10 that took account of these diverse elements. His model proposal for a "kitework" was placed on view in Hayden Gallery during the exhibition to afford the community a more comprehensive understanding of the artist's concerns. The model was accompanied by explanatory text prepared by the Committee on the Visual Arts staff and set up in Lobby 10 at specific times with Committee on the Visual Arts members answering queries and soliciting commentary. Several M.I.T. newspapers covered the exhibit. The results of this quasi-forum seemed to indicate that the majority of those vocal in expressing what they judged to be community sentiment were: 1) against modern art in general and 2) opposed to the particular work's suitability for the location.

This process led to a special meeting attended by not only Committee on the Visual Arts members but representatives of a wide spectrum of special interest groups at the Institute.
The discussion stimulated by the community's commentary on the Smith proposal was helpful in identifying the need for many more such meetings, and several particular suggestions are being explored. The mandate is clear: an ongoing educational program that is designed to reach small groups of students as well as the broadest segment of alumni must be expanded. A series of "fireside chats" delivered by prominent professionals in the visual arts and a feature in each issue of Technology Review highlighting a particular aspect of C.V.A. efforts are planned for 1978-79 to augment those educational activities that are already in effect. Committee on the Visual Arts members will be asked to play a larger role in this program by meeting with student groups to discuss issues of mutual concern.

Among the other important issues discussed in C.V.A. meetings were the critical storage space shortage, the exhibition and office spaces of the planned arts facility, the appropriation of one percent funds for future buildings, viable candidates for C.V.A. Chairperson as Professor Donlyn Lyndon is leaving M.I.T., the relationship of the C.V.A. to the M.I.T. Council for the Arts Museum and Acquisitions Committee, and the compilation of a list of preferred artists that the Committee would like to have represented in the Collection.

C.V.A. PROJECTS AND PROGRAMS

List and Stratton Student Loan Collections

The Student Loan Collections were inventoried and refurbished over the summer for an exhibition and lottery, which was held at the Student Center from September 19 to September 21, 1977. This was an expansion of the Stratton Student Loan Program, which had been abandoned for the past four years because of lack of funding. A work-study student was engaged to assist with the project; the C.V.A. staff organized the procedure for displaying and disseminating the Collection. The work-study student worked all summer under the supervision of the Gallery Manager and Registrar to gather the Loan Collection into one location, inspect and categorize, and make minor repairs. Those prints that need major conservation were stored until a fund for this purpose can be established. In addition, over 100 framed works on paper that were presented to this Collection under the List program were registered. One hundred twenty-five fine art prints and posters by many modern masters were placed in students' private living quarters, but many more students had requested works than were available. Student response to the reinstitution of this valuable program was very positive and although we were unsuccessful in obtaining outside funding for additional acquisitions and maintenance of the Collection, the works will be available again this fall.

Because the Collection has come to represent a profile of the best American printmaking of recent decades, the Student Loan exhibition will be held for the first time in Hayden Gallery and Hayden Corridor Gallery. Students and the community at-large will have an opportunity to view the works for two weeks. At the end of this period, a lottery available only to M.I.T. students will be held in the usual manner.

Acquisitions and Loans

In addition to the List donations, which include paintings and prints for the Permanent Collection as well as for the Student Loan Program, several major works have been acquired. Locating these works throughout the Institute has been a priority.Very little that does not require refurbishing is kept in storage for long periods of time.
The Committee on the Visual Arts is particularly interested in acquiring preliminary studies related to pieces in the Collection that illuminate the creative steps leading up to a fully realized work. In this area, two major pieces, both valuable as teaching tools and having intrinsic aesthetic merit, were accepted into the Collection: Alexander Calder's seven-foot high working model for *The Big Sail* was presented to M.I.T. by Dr. and Mrs. Julius Stratton and installed on the Massachusetts Avenue plaza of Building 9; a large-scale pastel and charcoal drawing of a surface detail for the M.I.T. Chapel Bell Tower by Theodore Roszak was acquired along with several sketches, models, and photographs for the sculpture. Other important additions to our holdings recommended by the C.V.A. included Isaac Witkin's *Angola*, Jack Youngerman's *Black Diamond*, Victor Vasarely's *Surke*, Umberto Mastroianni's *Enchantment*, and two series of etchings by Brice Marden.

Many works also were received on long-term loan: Ellsworth Kelly's cor-ten steel sculpture, *Untitled 1974*, James Rosenquist's painting *Sheer Line*, Gary Bower's *Hochmon*, and six aquatints by Robert Ryman.

To supplement special funds provided for shipping, major restoration, and installation, the Committee has received aid from many departments in which works are placed. In this way some money for framing materials, lighting, and small incidental expenses is obtained.

The M.I.T. Collection now contains about 1,000 works.

**Loans to Other Institutions**

Larry Bell's *The Iceberg* and *Its Shadow* was a pivotal work in the Federal Reserve Bank's inaugural exhibition which opened on April 11, 1978. Sited in the main entrance lobby of the new building, the monumental sculpture is a testament to responsible corporate art programming as well as to M.I.T.'s leadership in collecting artworks of high quality and encouraging the relationship between business and the arts. The work is on loan until late September 1978.

Previous to its installation at the Federal Reserve Bank, the Bell sculpture was loaned to the University of Massachusetts at Amherst for their first exhibition of the season. Other loans included Charles Scheeler's *General Motors No. 2 (The Spirit of Research)* to the Detroit Institute of Arts and Howard Mehring's *And Again* to the Corcoran Gallery of Art in Washington, DC for a retrospective of his work.

**Artist-in-Residency**

As an expansion of the successful example provided by artist Larry Bell's interchanges at the Institute in conjunction with his *Iceberg* sculpture last year, the Committee on the Visual Arts applied for and was awarded a National Endowment for the Arts grant of $1,500 to bring artist Charles Ross to M.I.T. to develop a project based on astronomical phenomena. Meeting with members of the Architecture Machine, astrophysicists, scientists, artists, and students at the Institute during last fall, Mr. Ross began to take steps toward the realization of a large-scale work, which consisted of charting the apparent annual paths of each planet during this century; data contained on tapes obtained from the US Naval Observatory was plotted on equipment located in the Architecture Machine and at Computervision, Inc. The 100 lines for each planet will be etched on stainless steel tablets donated by the Allegheny Ludlum Corporation. The artist has offered to give the Institute a suite of etchings made from the tablets. Upon hearing of Ross's project, Harvard's Center for Astrophysics invited him to give a lecture there. Funding was obtained from the Undergraduate Research Opportunities Program to enable a student to work with Ross; computer time was made available; and an exhibition providing examples of Mr. Ross's art projects to date was presented in Hayden Gallery.
Mr. Ross spoke to students in Professor Whitney Chadwick's seminar, and he participated in the Committee on the Visual Arts I.A.P. offering.

I.A.P. Offering

"The Artist's View of the Cosmos" was the subject of a series of three lectures and film events sponsored by the Committee on the Visual Arts. I.A.P. funding in the amount of $200 supported the program in part. A special mailing was made in the Boston area.

Charles Ross's artist-in-residency provided the impetus for the series. Mr. Ross showed films and lectured in Hayden Gallery. Lowry Burgess, a Fellow at the Center for Advanced Visual Studies, showed a film describing his sky-related environmental project in Bamiyan, Afghanistan, and Dr. Littleton Meeks, Director of the Haystack Observatory, made a slide presentation of his visualizations of astronomical systems. The program was extremely well attended and enthusiastically received. We are in the process of discussing with Dr. Meeks the possibility of future collaborations with artists in his area of interest; his meetings with Mr. Ross were the stimulus for further explorations in this area.

Other Activities

Comprehensive Employment and Training Act Gallery Assistant. The Committee on the Visual Arts proposal for a CETA-supported Gallery Assistant was approved, and an individual was hired to begin in July 1978. The CETA trainee is virtually financed by the government and will be apprenticed to the Gallery Manager. He will learn all the skills associated with installation of exhibitions, siting of works, and repair and curatorial checks. This is the first CETA person to be employed by a department at M.I.T.

Internship Program. The Committee on the Visual Arts has participated this year in two internship programs to provide on-the-job training for students and support to the C.V.A. staff. Three women from the Massachusetts College of Art assisted in the gallery and a Wheaton College student did research for exhibitions catalogues in progress. A Newton North High School senior who was participating in "Transition," an alternative educational project, spent a month working on special assignments in the office. Also, a high school student from Cambridge was hired to assist in the gallery this summer under a Cambridge city-funded job program for secondary school youths.

Tours and Gallery Lectures. During the year, the Committee on the Visual Arts staff hosted a number of local groups, providing tours of the art sited throughout the campus and informal discussions on the art exhibited in Hayden Gallery. Among the groups which made use of this service were: a class of graduate students in art history from Boston University; a group of alumni from Tufts University involved in a continuing education program related to trends in contemporary art; a docent training program from Wellesley College; and a number of elementary and secondary school classes from local schools. Professors from a number of regional colleges have brought their classes to the Gallery, using particular exhibitions as primary source material.

MIT Press. A contractual arrangement with the MIT Press now provides for the international distribution of all catalogues produced under the direction of the Committee on the Visual Arts staff. Both the Richard Smith and Gyorgy Kepes catalogues are featured in the MIT Press fall brochure.

Publicity. Posters, mailers, or postcards designed by M.I.T.'s Office of Design Services for C.V.A. activities are mailed to our list of approximately 3,000 individuals and institutions.
throughout the country. Posters are distributed in several Boston-area locations. Calendar listings and press releases are sent to all the major newspapers, magazines, and radio and TV stations. A visual arts bulletin board located near the Dean for Student Affairs Office is maintained to keep the community abreast of arts events.

Walking Tour/Catalogue. An advisory committee consisting of Katharine Jones (Resource Planning), Frieda Cohen (alumna, Class of 1945), Paula Korn (News Office), Kathryn Lombardi (Campus Information Services), Harry Portnoy (Campus Architect), Peter Spackman (Council for the Arts), Nancy Wheatley (Alumni Association), and Professor Lyndon as well as Committee on the Visual Arts staff met to discuss the content of and possible formats for the Walking Tour/Catalogue to be funded by the National Endowment for the Arts and the M.I.T. Council for the Arts. Issues discussed included: how to document the shifting placement and accessibility of works in a publicly sited collection; how to keep the publication up-to-date at a minimal annual expense; and how to tailor the publication to a variety of users' needs.

MARGARET HUTCHINSON COMPTON GALLERY

The Margaret Hutchinson Compton Gallery opened in the fall of 1977 in the Maclaurin Building, adjacent to the new Alumni Center. A gift of the Class of 1938, the gallery was named to honor Mrs. Margaret Compton, widow of Karl Taylor Compton, ninth president of M.I.T.

Located at the heart of the campus, the Gallery presents exhibitions reflecting the wide range of Institute programs and activities. The gallery is intended to link the interests of faculty, students, and alumni, and to provide a special opportunity to prospective students and visitors to learn more about M.I.T.

The schedule of diverse exhibitions will illuminate the range of professional and avocational activities of the community, and will allow presentations within frameworks of history, science, technology, and the arts. The exhibition themes are developed with artifacts, documents, photographs, and objects and call upon the resources of academic departments, M.I.T. Historical Collections, and outside institutions.

Overall responsibility for the Gallery during 1977-78 was shared by the Compton Gallery Committee composed of James Champy, Executive Vice President of the Alumni Association; Kathryn Lombardi, Manager of Campus Information Services; Warren Seamans, Director of Historical Collections; and Marjory Supovitz, Projects Director of the Committee on the Visual Arts. The Compton Gallery Committee met regularly to evaluate programming suggestions and to identify problems and needs of the fledgling operation. In November 1977, Virginia Gunter was appointed manager of the Gallery with responsibility for curating, designing, and installing the exhibitions.

The first exhibition of the Gallery schedule was The Compton Years, a photographic essay on the lives of Dr. and Mrs. Karl T. Compton, organized by M.I.T. Historical Collections.

On February 24, 1978, the exhibition Edgerton's Stroboscopic Projects opened with a special reception for Dr. and Mrs. Harold Edgerton and an open house in the Alumni Association offices. The exhibition, coordinated by Ms. Gunter, presented a group of photographs selected from 40 years of investigations of natural phenomena. Also included were two strobe demonstration machines and a continuously projected group of Edgerton's slides. On the evening of March 9, the Compton Gallery sponsored a high-speed film presentation and talk by Dr. Edgerton in the Bush Room. The Gallery was visited before and after the films by an enthusiastic audience of M.I.T. students and the general public. During this exhibition
Committee on the Visual Arts

the gallery was open evenings and weekends for special Institute events such as "Freshman Welcome" and Alumni Association events.

The next exhibition was organized in conjunction with the Hayden Gallery presentation Gyorgy Kepes: The M.I.T. Years 1945-1977. The Compton Gallery focus was on Professor Kepes's influence as a teacher at the Institute and as founder of the Center for Advanced Visual Studies. It displayed photographs and slides of work by students in light and color courses during the past 30 years. Also included were text excerpts and photographs from The New Landscape; essay reprints and other publications by Kepes; and drawings, prints, models, and sculpture by Fellows of the Center for Advanced Visual Studies. As a special contribution to the Institute Archives, over 50 past and present Fellows, former students, and colleagues were contacted about the exhibition. In particular they were asked to tape record comments about their time at the Center for Advanced Visual Studies and their interaction with Professor Kepes. Excerpts from these tapes were combined on one 8-track tape to run continuously at the exhibition with a selected group of slides. The original tapes and other submitted material will be turned over to the Institute Archives.

Again, the exhibition hours have been extended in connection with Institute events such as Open House weekend and Technology Day activities. The location of the Compton Gallery adjacent to the Alumni Center and the Bush Room provides an apt environment for group visiting. During regular hours it has a healthy and constant stream of students interested in the presentations.

EXHIBITIONS PROGRAM

This year's exhibition program was especially ambitious. Conceived to serve various interests of the M.I.T. community, the schedule also took into consideration a number of areas that had special relevance to the regional art public. All exhibitions were organized at M.I.T. by the Committee on the Visual Arts staff. Two shows, "Richard Smith" and "Gyorgy Kepes," were accompanied by extensive catalogues; all others were supported with informative wall texts and well-documented brochures. The MIT Press is distributing all C.V.A.-produced catalogues, and the "Paper Forms" brochure was listed in Print Collector's Newsletter.

Works from C.V.A. exhibitions have been displayed in other galleries. The Cunningham exhibition which coincided with his state residency last February went on to be seen at the University of Massachusetts at Amherst. Marc van der Marck's work was featured in two important New York galleries as a result of his introduction at M.I.T. The Richard Smith exhibition will travel to three other art institutions: the Walker Art Center in Minneapolis, the Hudson River Museum in New York, and the Saskatoon Gallery in Saskatchewan, Canada.

The current nationwide interest in handmade paper prompted the organization of Paper Forms. The exhibition was motivated by a desire to present mature work that incorporates the use of handmade paper into an artist's total statement, rather than concentrating on the craft aspects of the material. This attitude led to the choice of some of the most sophisticated expressions in the mode and the show was hailed as important for its unique focus. Eye of the West was a teaching exhibition, purposely selected and displayed to draw parallels between photographic and cultural attitudes of this century. Although controversial, the show was informative and provocative. The interaction between art and science was the theme of Charles Ross's exhibition, artist-in-residency, and the concurrent I.A.P. offering. This program was very successful both in terms of the artist's interaction with students, faculty, and staff at the Institute and his reception by the local community. The Richard Smith exhibition was the first retrospective of his recent work in this country, and represented an attempt to bring an internationally significant
talent not only to local audiences but, through its tour, to a broader segment of the viewing public.

The Gyorgy Kepes exhibition was a monumental tribute to the man who has not only made a seminal and vital contribution to the visual arts at M.I.T. but to the understanding of the relations between art and science as creative activities.

Both the Alice Lyndon photography show and the presentation of Art of the State: 1978 represented the program's commitment to the fostering of local talent. All exhibitions were reviewed by local newspapers, many as features in the Boston Globe, The Phoenix, the Herald American, the Christian Science Monitor, the Cambridge Chronicle, the Newton Times and the Boston Ledger. Lectures or gallery talks by either the artist or curator were held in conjunction with every presentation. Unique installation designs were generated for each exhibition utilizing Hayden Gallery's flexible partition system, and the C.V.A. staff prepared all labels, matting, and other routine procedures as well as some complicated video and film incorporations.

All in all, this year's visual arts program was vibrant, rewarding to the staff, and responsive to the needs of many different constituencies both at M.I.T. and in the greater Boston area. We look forward to the maintenance of the standards of professionalism and excellence next year in the context of expanded support activities and more fully documented exhibitions.

DONLYN LYNDON

Division for Study and Research in Education (D.S.R.E.)

The D.S.R.E.'s fifth year was one of steady progress toward developing a critical mass sufficient to sustain a variety of activities simultaneously: development of a sophisticated research agenda on several related issues of learning; development of active collaboration with M.I.T.'s Schools, departments, laboratories, and centers; and development of ties with other education-related groups outside the Institute. These three classes of activity are necessary for the Division to adequately conduct its particular kind of inquiry into the nature of human learning -- an inquiry having an intellectual kinship with other efforts under way at M.I.T. but also having its own unique strengths and perspectives.

The Division occupies a crucial piece of intellectual territory at the intersection of the controlled environment of basic research in the cognitive sciences, the intellectual paradigms of artificial intelligence, and the messy real world of educational practice. Its work is "applied" in the sense that its ultimate goal is not only increased understanding of the workings of the human mind, but in particular increased understanding of, and hence influence over, learning processes as they occur in everyday life. While there is a great deal of work to be done to develop the Division's potential for significant influence on the world of education, it is now receiving encouraging support for its efforts from a variety of quarters. For example, the Division this year received a grant of $160,000 from the Ford Foundation to support activities specifically directed at defining new approaches to research in education. Support will go to research into cognitive/intuitive thinking, institutional studies, adult development, computer curriculum, and the writing of the history of the D.S.R.E.

The Division's weekly seminars are a critical element in the development of the Division's research agenda. This year the seminars were largely devoted to topics related to psychology. Professor Hermina Sinclair-de Zwart of Geneva gave six talks on language acquisition. Others
who spoke were: Professors Howard E. Gruber of Rutgers University, Sheldon H. White of Harvard University, Peter Marris of the University of California at Los Angeles, Adele Abrahamson and Daniel Osherson of the University of Pennsylvania, and Daniel Dennett of Tufts University. Professors Michael Pengelley and John Richmond of the Open University in England and Dame Kathleen Ollerenshaw, University of Lancaster, England, presented seminars on mathematics. New methods of physics education were discussed by Professors George Delacote of France and Gyorgy Marx of Hungary. Several seminars presented the developing research into the use of computers in education. Professors Bertrand Schwartz of Paris, and Seymour Papert and Andrea di Sessa of D.S.R.E. spoke of their plans for an overall use of computers in establishing a computer environment.

Two of our visitors will assume a more formal relation to the Division next year. Professor Sheldon H. White, Professor of Psychology at Harvard, will spend his sabbatical year at the Division where his research will focus primarily on the social organization of children's cognition. He also will continue his collaboration with Professor Martin Rein on the topic of knowledge and practice. Professor Howard E. Gruber of the Institute for Cognitive Studies at Rutgers University will also be a visitor next year, when he will continue his work on a study of the intellectual development of Jean Piaget, and will study the cognitive structure, strategies, and modes of representation involved with certain phenomena of physics.

In addition to Division-wide activities, several significant activities have been undertaken by faculty members on an individual basis. Professor Papert has been working on an analysis of the different modes of using computers in instruction. Today, school computers are used in many different ways and for many different purposes. At the same time, industry's plans for small but powerful computers which are inexpensive enough to reach schools and homes could dramatically change the educational landscape if our society could organize itself to take maximal advantage of them. Professor Papert's analysis is designed to allow educators and planners to come to grips with these issues.

In a related project, Professor Papert has begun adapting the computer language LOGO, developed at M.I.T., to computers built by Texas Instruments. This collaborative project with Texas Instruments will enhance LOGO's accessibility for use in schools. Addressing the social system side of these issues, a group consisting of Professor Papert, Dr. Sylvia Weir, Dr. Daniel H. Watt, and others developed a pilot project in the Brookline Public Schools to study fifth graders in the process of learning LOGO. Such studies are illuminative of children's cognitive development, à la Piaget, and the natural classroom setting seems a promising context in which to study the ways in which educational innovations like the introduction of computers influence the mental representations held by both teachers and students.

Professors Harold Abelson and Andrea di Sessa again conducted a Student Science Training Program in mathematics, physics, and computer science for high-ability high school students sponsored by the National Science Foundation (NSF), and an M.I.T. freshman seminar. This work, currently in its fourth year, has resulted in a manuscript, "Turtle Geometry: The Computer as a Medium for Exploring Mathematics," and a substantial proposal for developing an alternative mode of instruction for M.I.T. freshmen.

Professors Jeanne Bamberger and Donald Schon continued their collaboration on a seminar on metaphor, in particular on a study of the process by which an individual restructures or takes a new view of a problem, situation, or idea. This collaboration has yielded several published papers and two substantial proposals to the NIE for further research on the related topics of intuitive knowing and its restructuring; they also have initiated an experiment in teacher development in which teachers are trained to be researchers into the development of knowledge about their own professional practice.
Professor Judah L. Schwartz was granted funds by the Ford Foundation to devise new strategies for assessing competence in response to evolving social purposes. Assessment and testing are used in our society for accountability, diagnosis, instruction, selection, and licensure. Although the psychometric paradigm used for testing is increasingly criticized on methodological grounds, changing social conditions have made the purposes of testing at least as important as they have ever been. The study, which will last several years, has as its goal the setting of guidelines for the future development of assessment instruments and strategies consistent with our various social purposes.

Drs. Weir and Benson R. Snyder conducted a series of explorations into the feasibility of isolating a suitable corpus of interview data with college students which could form the basis for an analysis -- combining Piagetian epistemology and Freudian psychodynamics with ideas from artificial intelligence -- of complex knowledge structures and sophisticated control mechanisms.

Professor Snyder and Dr. Barbara Scott Nelson collaborated with Professor Merton Kahne, Professor of Social Psychiatry, on the development of a monograph setting out the research interests incorporated under the label "Institutional Learning." The central issue is to determine the conditions under which organizations, particularly educational organizations, maintain stability in the face of a changing environment or change -- i.e., "learn" to incorporate some new set of values or procedures into their daily practices.

Dr. Edwina Michener has made good progress in developing protocols for studying the cognitive process by which one (teacher or student) generates mathematical examples. When one understands a mathematical theory one is in command of much intuitive knowledge that is outside the formal deductive framework of the theory. In generating examples of mathematical concepts the cognitive processes of remembering, searching, and retrieving knowledge as well as the representation and manipulation of images and objects are involved.

Professor Sherry Turkle has begun work on a major research project on the impact of the computer presence on the individual. Funded by NSF and conducted under the joint auspices of the Education Division and the Laboratory for Computer Science, Professor Turkle's work aims at obtaining for the first time systematic and controlled data about the relationships among types of individuals, kinds of computer cultures, kinds of relationships with the machine, and the influence of the computer in non-computational spheres of life.

ACADEMIC PROGRAM

Twenty-one subjects were offered this year. New subjects included: Education and Society (Professor Wayne O'Neil), and Computational Theories of Teaching and Learning (Professor Ira Goldstein).

Four new graduate students were admitted, bringing the total enrollment to 16. Four are joint with the Department of Electrical Engineering and Computer Science, three with Urban Studies and Planning, two with both the Sloan School of Management and the Department of Mathematics, one each with Architecture, Linguistics and Philosophy, Physics, Psychology, and the Interdisciplinary Science Program. Andree Green was awarded the Ph.D. jointly through the Division and the Department of Architecture for her thesis entitled, "An Inquiry into Interactive Elements of Thinking in the Arts and the Sciences: A Pedagogical Experience."
INTERACTION WITHIN M.I.T.

The work of Professors Abelson and di Sessa in developing more intuitive and learnable representations of scientific knowledge, in particular taking advantage of computers, has attracted the interest of the Committee on Engineering Education and the Department of Mathematics. With the counsel of Dr. Bertrand Schwartz and support from the Laboratory for Computer Science, Professors Abelson and di Sessa are pursuing discussions with others at M.I.T. toward the development of an integrated freshman program which would incorporate a unified approach to calculus, physics, and computer science. A five-year plan has been developed through which the Institute can explore the viability of offering an alternative educational mode for M.I.T. students.

Professor Snyder, together with Professors Lotte Bailyn and Edgar Schein of the Sloan School of Management, has been developing a joint study in the area of the dynamics of adult development -- particularly on cognitive and adaptive style in relation to life experiences. The ultimate intent is to improve our understanding of the interaction between individuals and the institutional and ecological settings in which they find themselves, and to unravel the mutual influences which operate when people move from one setting to another.

Several members of the Division have been regular participants in a year-long Learning Disabilities Task Group convened by the Harvard-M.I.T. Division of Health Sciences and Technology. Drs. Snyder and Weir were regular participants. Discussions about future plans continue at this writing, including the development of a proposal for joint work on dyslexia and LOGO with Dr. Martha Denckla and Dr. Jane Holmes at Children's Hospital. This work will exploit the known superiority for spatial tasks displayed by people who have dyslexia.

Throughout the past five years there has been increasing collaboration among the Division and the Departments of Psychology, and Linguistics and Philosophy. Professor Susan Carey's (Psychology) membership in D.S.R.E. has been of inestimable help to both faculty and students as the Division developed its sense of intellectual identity. However, it has become clear in recent years that substantially more time and energy than was possible for Professor Carey to contribute was desired by all members of the Division.

This year all three departments were represented on the search committee for a cognitive psychologist and are pleased with the decision of Professor Daniel Osherson, an outstanding young cognitive psychologist from the University of Pennsylvania, to join M.I.T. as Associate Professor of Education and Psychology. Professor Osherson's presence will strengthen the Division's links with cognitive and developmental psychology and linguistics, while maintaining the importance of the perspective of artificial intelligence.

In addition, several members of the Division have been regular participants in the series of Workshops on Mental Representation being organized by the Department of Linguistics and Philosophy. Sponsored by the Sloan Foundation, the Workshop series is designed to draw together strands of research in cognitive science and to explore avenues of interdisciplinary collaboration in the emerging study of human mental processes. Drs. Snyder, Nelson, and Weir attended the first two workshops, held in January and June at M.I.T.'s Endicott House, at which Professor Carey was a major contributor and Professor Osherson an invited participant.
INTERACTION OUTSIDE M.I.T.

The M.I.T. program on Work in Technology and Science (WiTS) sponsored professional development programs for public school teachers, counselors, and administrators to increase their understanding of issues and careers in technology and science. During the summer, 10 teacher/counselors from six school systems participated in an internship program to provide them with first-hand experience in local technological and scientific industries. Public lectures on transportation technology, nutrition and health, and lifestyles brought together teachers, counselors, and students to discuss careers and public policy issues. A day-long forum was held in March to discuss careers and issues involving energy and water resources. Site visits to communicate the long-term relevance of schoolwork to employment were made to several places including Avco Research Laboratory, Raytheon, Peter Bent Brigham Hospital, and Polaroid.

The Division continued to provide support for the Secondary Technical Education Project, directed by Dr. Stanley Russell. Pursuant to a remedial order set out by the Federal District Court three years ago to desegregate Boston's public schools, the Project has orchestrated the involvement of several dozen members of the M.I.T. community -- faculty, administrative staff, and students -- in helping the Boston School Department develop a new secondary school of science and technology.

The Division has held several sets of discussions with the Education Development Center, Inc. (EDC) of Newton, Massachusetts about particular projects around which collaboration might be mutually beneficial. Both EDC and the Division have expressed interest in the problem of training classroom teachers to use computers as part of their regular classroom activity. In view of the likelihood that rapid advances in microcomputer technology will shortly make it possible for the widespread use of computers as an integral part of many classrooms at all levels of education, and in view of the decision of the Brookline Public Schools to embark on a scheduled acquisition of microcomputers for instructional use, an experiment was designed by Dr. Daniel H. Watt to determine the effect of such a decision on classroom teachers who are given the opportunity to use LOGO with children.

Another independent set of discussions between EDC and the Division was begun around the issue of improving mathematics education. Such discussions are the continuation of a long relationship between M.I.T. and the EDC but the beginnings of a new relationship for the Division to which we look forward.

The Division's Institutional Learning Group hosted a conference on case studies of institutional learning at Endicott House in August 1977, to which were invited a number of senior scholars with consonant interests: from M.I.T., Professors Bailyn and Schein and Drs. Kahne, Nelson, and Snyder; from elsewhere Professors Tony Becher, Geoffrey Caston, A. H. Halsey, Bertrand Schwartz, John Seeley, Martin Trow; Dr. Harry Judge; Dr. Laura Bornholdt of the Lilly Endowment; Stuart Maclure, Editor of the (London) Times Educational Supplement, and Edward Meade, Jr. of the Ford Foundation. The three-day conference centered around discussion of the research implications of the particular model of individual-institutional interaction being developed by the Division's Institutional Learning Group. The Conference explored such issues as the criteria of selection of a case for study, research as intervention, intervention as a form of inquiry, data validation techniques in an inter-subjective field, the prospects for generalization, etc. The Conference proceedings have been prepared and are available upon request.
PERSONNEL

New members of the Division include: Benjamin Kuipers, Research Associate; Edwina Michener, Research Associate jointly with the Department of Mathematics; John Terry, Lecturer; and Sylvia Weir, Research Associate. Professor William T. Martin served as Visiting Professor of Mathematics from the University of Science and Technology, Kumasi, Ghana, from January to March. Visitors to the Division included: Dr. Harry Judge, Director of the Department of Educational Studies, University of Oxford, England; Dr. Bertrand Schwartz, Professor of Engineering Education, University of Paris, France; and Dr. Hermina Sinclair-de Zwart, Professor of Psychology, University of Geneva, Switzerland.

BENSON R. SNYDER

Center for Advanced Visual Studies (C.A.V.S.)

The Center for Advanced Visual Studies will celebrate the first decade of its existence during summer 1978 by joining all of its artistic, technical, and administrative forces to exhibit "Centerbeam" for the first time in the United States. Sponsored by M.I.T. in cooperation with the Smithsonian Institution, the National Park Service, and the National Endowment for the Arts, "Centerbeam" will be exhibited in Washington, DC on the Mall, adjacent to the National Air and Space Museum.

Centerbeam incorporates such new technological art developments as daylight holograms and floating sky sculptures. Other components, notably a 144-foot water prism, a kalliroscopic "river," and a "drawing with your eyes" machine offer visitor participation.

In a summer-long celebration of art which uses scientific and technological tools, this art project will also present the fairy-tale opera "The Bremen Town Musicians" and "Icarus" which will use flying inflatable costumes and characters. Nightly laser, sound, and steam performances will be highlighted by special sculptural events: a 100-foot high black silk rose (helium lifted) and a 200-foot high red flower. Some of the artists will present lectures and workshops at various Smithsonian Institution museums throughout the summer.

The Centerbeam artists include: Otto Piene, director of C.A.V.S., Centerbeam project director, and inflatables artist; Joan Brigham, steam artist; Lowry Burgess, artistic director, concept for Centerbeam, water prism; Harriet Casdin-Silver, holography; Alva Couch, computer-controlled laser drawing; Paul Earls, laser, music, multimedia performances; Derith Glover, "drawing with your eyes;" Elizabeth Goldring, project coordinator; Chris Janney, soundwalk; Paul Matisse, kalliroscopic river; Mark Mendel, poetry; Alejandro Sina, neon-argon. The video group includes Antonio Muntadas with Mark Chow, Betsy Connors, Mike Moser, and Aldo Tambellini. Other participating artists are Karin Bacon, Gyorgy Kepes, Charlotte Moorman, Mike Naimark, and Don Thornton. Richard Leacock, head of M.I.T.'s Film Section, and Jon Rubin, a C.A.V.S. experimental filmmaker, will collaborate on a Centerbeam film.

A brochure to be published will document Centerbeam's development through its stages and exhibitions, and acknowledge C.A.V.S.'s goals and its commitment to collaborative work among artists, scientists, and engineers.
During the academic year 1977-78, Professor Piene and Fellows again taught 10 courses each semester, which attracted 215 graduate, undergraduate, and special students from various M.I.T. Schools, Harvard University, Wellesley College, the School of the Museum of Fine Arts, and Massachusetts College of Art.

Christopher Janney and Harel Kedem received the Master of Science in Visual Studies and the Master of Architecture in Advanced Studies respectively in June 1978 and will be appointed junior Research Fellows at C.A.V.S. (The Center supports the growing Master of Science program in Visual Studies.) Collaborative teaching efforts between the Creative Photography Laboratory and C.A.V.S. have been successful during the past two semesters.

The Center for Advanced Engineering Study (C.A.E.S.) supported the course Image Processing and Manipulation, a video and experimental TV course. Through a Sloan Foundation Grant awarded to C.A.E.S., several artist/Fellows also received financial support which made the following video projects possible: the video version of Paul Earls's chamber opera, "Bremen Town Musicians;" Betsy Connors's "Batteries Not Included," a collaboration among C.A.V.S., C.A.E.S., WGBH-TV, and WNET-TV; Ellen Kozak's "Waiting;" Antonio Muntadas's "On Subjectivity;" and Mike Naimark's "Three Generations," the taping of an Indian dance performance at Asia House in New York City.

In addition to funding contributions to C.A.V.S. from the School of Architecture and Planning and the Department of Architecture, various foundations allocated monies to the Center and several artist/Fellows received individual grants from a number of sources.

Joan Brigham performed "Golem," a steam theatre piece with a mobile Golem sculpture, steam screens, slide projections, dancers, music and sound score, text, and narrator. The performance took place in conjunction with the second Cambridge River Festival, on M.I.T.'s Student Union Plaza. It was funded by Bradley Higgins Foundation and New England Touring Programs.

Derith Glover received support for continued research and improvement of her "drawing with your eyes" machine through a grant to C.A.V.S. from the Seth Sprague Educational and Charitable Foundation.

Harriet Casdin-Silver was given a 1978-79 fellowship by the Rockefeller Foundation for continued work in her field of holography. Close collaboration for coming years among C.A.V.S., its artists, and the foundation is being negotiated. Ms. Casdin-Silver also received an M.I.T. Council for the Arts grant to expand a student holography laboratory at the Center.

Individual artist's grants from the National Endowment for the Arts (NEA) were received by Lowry Burgess for an environmental art project called the "Quiet Axis" and by Paul Earls for a new opera composition, the sky opera "Icarus." The opera will be premiered as a Centerbeam performance during summer 1978 in Washington, DC. Dan Dailey received an NEA 1978-79 Craftsmen's Fellowship.

Jon Rubin produced a 40-minute sound film "At Home and Away.....in the Late Seventies" with his 1977 Guggenheim Foundation grant.

Mark Chow produced a documentary videotape about Midwest Chinese families, entitled "Family Camp," which was funded by the Midwest Chinese Students and Alumni Association of Illinois.

Peter Campus will work in Germany for several months in 1978-79 with the support of a DAAD grant (Deutscher Akademischer Austausch Dienst).
Professor Piene's professional activities this past year included a lecturing tour of Japan upon invitation by the University of Arts in Osaka, where his three-week journey originated. He later shared his impressions with students and Fellows at the Center in a Japan evening in honor of Fellow Toshiro Itakura.

Professor Piene's other activities included additional lectures, consulting work, exhibitions, sky events, and publications; a keynote lecture at the GAS Conference in Madison, Wisconsin; a lecture and consultation on the 1978 Arcosanti Festival for the Cosanti Foundation, Phoenix, Arizona; the opening lecture for Centerbeam for the Smithsonian Associates at the Museum of Natural History in Washington, DC; and a one-man exhibition of paintings and gouache at Galerie Heimeshoff, Essen, Germany. He participated in numerous group exhibitions including "Art of the Space Age," Huntsville, Alabama and the Norwegian Graphics Biennale. He staged sky events for the Milwaukee Art Center ("Lakefront Anemone"); for C.A.V.S. 's Centerbeam at documenta 6, Kassel, Germany ("Flower"); and "Black Rose" and "Flower" events for Centerbeam, DC.


Outside activities of artist/Fellows were manifold: Mr. Burgess exhibited "Artist and the Cosmos" at the Center and the Hayden Gallery and concurrently premiered part one of the film "Quiet Axis," which was filmed in Bamiyan, Afghanistan.

Mr. Campus received invitations for video installations from the University of Michigan at Ann Arbor; the Whitney Museum, New York City; the Sarah Lawrence College Gallery, Bronxville, New York; and the Venice Biennale, Venice, Italy.

Mira Cantor Piene participated in group shows at the Sharon Arts Center, Peterborough, New Hampshire and the Brockton Art Center, Brockton, Massachusetts. She is preparing a one-woman show of soft sculptures at Galerie Loehrl, Dusseldorf, Germany.

Ms. Casdin-Silver delivered presentations of her work in holography during this past year at the Chicago Institute of Art, Chicago, Illinois; Pennsylvania State University, University Park, Pennsylvania, and Radcliffe Institute, Cambridge, Massachusetts.

Michael Moser's group shows, in conjunction with his 1978 Artist's Fellowship in Video from the Massachusetts Arts and Humanities Foundation, included presentations at Center Screen and the University of Massachusetts, Harbor Campus in Boston. His work became part of a traveling exhibition of the Ithaca Video Project.

Mr. Earls's music work during 1977-78 included the music for "Rainbow Shards" (Gyorgy Kepes's music and light show); a composition of brass fanfares for the Boston First Night 1978 celebration; "Storm at Sea" for Spring Revels, Sanders Theater, Harvard University; and "Heaven," a setting of a George Herbert poem for the Columbus Boychoir, Princeton, New Jersey. He redesigned and constructed the traveling show "Dreamstage," (with Harvard University Neurophysiologist Allan Hobson and photographer Ted Spagna) and wrote and edited the new catalogue for the exhibition. "Dreamstage" was later awarded the gold medal for scientific/educational exhibits at the American Psychiatric Association's annual meeting in Atlanta, Georgia.
Antonio Muntadas had installations of video screenings at the Everson Museum of Art, Syracuse, New York; Anthology Film Archives, New York City; P.S.1, Queens, New York; and the Museum of Modern Art, New York City. He also participated in group shows at Museu Arte Contemporanea da USP, São Paulo, Brazil; Galeria Joan Prats, Barcelona, Spain; and Galerie Gaetan, Geneva, Switzerland.

Carl Nesjar spent the first part of 1978 in Moss, Norway to realize a fountain and park for the town of Moss.

John Avery Newman exhibited at the Suzanne Lember Usdan Gallery at Bennington College, Bennington, Vermont with "Architectural Drawings and Sculpture exhibition: 1977" during the time of his teaching appointment as a sculptor in the College's Art Department. He also showed at the City University of New York. He participated in group shows at the Worcester Art Museum -- "Between Painting and Sculpture" -- and at the Thomas Segal Gallery, Boston -- "Sculpture."

Mr. Rubin's film screenings at the Carnegie Museum, Pittsburgh, Pennsylvania and the High Museum of Art, Atlanta, Georgia, were well received.

Alejandro Sina showed at the Theo Portnoy Gallery in New York City with "Gas Light Phenomena II" and is now preparing for a show in the fall.

Judith Wechsler was involved in producing two films, "Daumier, Paris, and the Spectator" and "Cezanne: The Late Work." She also participated in panel discussions at the University of Pennsylvania, "The Spectator as Genre in 19th Century Paris" and "Art and the Audio Visual Languages" in Cannes, France.

Aldo Tambellini had one-man exhibitions of photographs and video work at the Everson Museum of Art, Syracuse, New York, a film showing at the Art Resource Center, Kansas City, Missouri, and a live media performance with Sarah Dickinson at Global Village, New York City.

Paul Matisse was commissioned to design, construct, and execute Alexander Calder's mobile for the new East Wing of the National Gallery of Art in Washington, DC.

Mr. Sina received commissions for a large-scale kinetic, gas discharge sculpture in Santiago, Chile and from the National Shopping Centers in Rye, New York, for a computer-animated neon sculpture.


In addition to extensive newspaper coverage and TV and radio interviews of the Center and its artists in connection with the Centerbeam, DC exhibition, Videography writers Alan Kaplan and Victor Ancona published lengthy articles, "A Close Encounter with Ron Hays" and "Antonio Muntadas: the Iberian Influence." Other articles on Muntadas appeared in a book, Kunst und Medien, Kassel, Germany, by Kelvin Clarke and Kunst Forum, "the last ten minutes" by Wulf Herzogenrath.

OTTO PIENE
School of Architecture and Planning

During the past five years, schools of architecture and planning in the United States have been confronted by shrinking resources for their academic programs, on the one hand, and the redistribution of professional opportunities for their graduates and faculty on the other. M.I.T.'s School of Architecture and Planning has responded to this bilateral confrontation by reexamining its intellectual strengths and weaknesses and renewing its commitment to its students, its faculty, and the professions they serve. In 1977-78, the School emerged from the stage of reexamination and renewal with a more sharply defined image and a clearer statement of its objectives.

A major objective of the School involves providing students with a rigorous and nearly unique educational experience that will prepare them for influential roles on the frontiers of professions that shape public policies and determine the quality of physical environments. Toward achieving that objective, we have drawn on well-established educational approaches developed by previous generations of architects and planners. At the same time, we have sought novel and untried techniques for experiments in planning and design. In formulating core curricula, we acknowledge the value of traditional approaches from the past. In embarking on innovative research in energy planning and building, the faculty and students have demonstrated the courage to try the untried.

With a recently appointed Associate Director of the Laboratory of Architecture and Planning, Michael Joroff; with a carefully chosen Department Head for the Department of Urban Studies and Planning, Lawrence Susskind; and with the steady support of N. John Habraken, as Head of the Department of Architecture, the School anticipates a stable period in which its faculty and students will expand its contributions in the United States and abroad to teaching, research, and practice in planning, architecture, and the environmental arts.

SCHOOL NEWS

School Council

During the fall term, there were weekly meetings of a subcommittee of the School Council which included the Dean, Assistant Dean, and the Heads of the Departments of Architecture and Urban Studies and Planning. The recently appointed Associate Director of the Laboratory of Architecture and Planning and the Rotch Librarian provide the full complement of the School Council's membership. The entire Council now meets on a weekly basis.

Among the major items considered in School Council meetings in 1977-78 were the following: clarification of the scope and direction of the Departments of Architecture and Urban Studies and Planning; agenda and management of the Laboratory of Architecture and Planning; proposal and approval of the S. M. Architecture Degree Program in the Department of
Architecture; status of minority students in the Department of Urban Studies and Planning; and increasing contacts with alumni.

In addition to developing consensus and policy around such issues, the School Council serves as an advisory committee to the Laboratory of Architecture and Planning, reviewing its projects and appointments.

Transitions: Appointments, Resignations, and Retirement

The search for a Department Head for the Department of Urban Studies and Planning resulted in the selection of Associate Professor Lawrence E. Susskind, who has served previously as Assistant Department Head. He succeeds Professor Langley C. Keyes who is returning to teaching and research after four years of department leadership.

We salute Professor Kevin Lynch on the occasion of his premature retirement. His work has brought distinction to the planning and urban design professions and to the Institute. It is hoped that Professor Lynch will continue to contribute to the intellectual life of the School and somehow still enjoy the advantages his new status affords.

THE VISITING COMMITTEE

In November 1977, a subcommittee of the Visiting Committee spent two days inquiring into the program of the Department of Architecture. They found the Department rich and extensive, its offerings and activities including computerized architecture, photography, printmaking, a solar energy demonstration project, and relatively traditional design studies.

A visit to the Department of Urban Studies and Planning by another subcommittee of the Visiting Committee occurred in April. The visit provided an occasion for introducing the then Department Head-designate, Professor Susskind. It afforded an opportunity to review candidly before the committee issues raised in a report prepared by the Minority Community of the Department of Urban Studies and Planning and Professor Donald Schon's analysis of issues that influence the climate of education in the Department.

Several subcommittee members left with better understanding of the operations and objectives of the Departments than they recalled achieving through previous visits.

BUILDING TECHNOLOGY

The need to reestablish the prominence of M.I.T. in building technology has contributed to a series of productive dialogues between Dean William Porter and Dean James Bruce and between faculty members of the Departments of Architecture and Civil Engineering. The dialogues have contributed to the formulation of a new program in building technology and a slate of faculty positions essential to the development of the program.
With the successful completion of a second year of participation in the International Laboratory of Architecture and Urban Design (ILAUD) at Urbino, the Department of Architecture organized another group to study at the ILAUD in 1978-79. Furthermore, the Department hopes to pledge its participation in the ILAUD program for an additional three-year period beyond 1978-79. Toward this end, the Office of the Dean has joined the Department in its search for funds that will support M.I.T.'s continued participation in the program.

**SPACE AND FACILITIES**

The School's needs for space are continually pressing. We are gratified by the prospect of support for our proposal to remodel and upgrade some of the space the School presently occupies. We acknowledge our appreciation of the cooperation between the Department of Architecture and Physical Plant that resulted in the transformation of the fourth floor corridor in Building 7 which now serves as an exhibit area. It is a modest demonstration of what might be accomplished through major cooperative efforts in the future. We recognize the need to seek financial resources outside the Institute to complete the remodeling that is necessary to improve significantly the environmental quality of the School.

**PLACEMENT**

It has been disturbing to realize that alumni of the undergraduate and graduate programs have been permitted to leave M.I.T. without the assistance of someone trained in career placement. The efforts on the part of faculty and staff to provide career counseling and a suitable range of job opportunities to students have been earnest and energetic, yet insufficient. It is, therefore, gratifying to learn that a placement officer who will serve the School of Architecture and Planning will be recruited soon. We look forward to the development of a pattern of collaboration with the Career Planning and Placement Office that will result in matching graduates with appropriate jobs.

**ALUMNI RELATIONS**

Thanks to the conscientious efforts of staff, faculty, and students in both departments, we have contacted a substantial number of alumni and have ascertained their current affiliations. We are seeking new ways of maintaining contact with alumni through educational programs and research opportunities. Through the Harvard-M.I.T. continuing education program, the School shares recent developments in architecture and planning with alumni who are practitioners. In the future we expect to benefit from their experience in practice by engaging them in research projects, workshops, and colloquia. The Neighborhood Colloquium series, which attracted alumni in the Boston area, served as a demonstration forum for engaging alumni in the study of current planning and design problems.
SCHOOL PUBLICATION: PLAN

Plan, a biannual publication of original articles by M.I.T. students, staff, faculty, and alumni, has become an attractive magazine that enjoys a wide readership. Under the editorship of Maijaleena Elkins, Plan has developed a coherent style. Ms. Elkins has resigned as editor to pursue her career as a writer abroad.

DEGREE PROGRAMS AND ADMISSIONS

In the academic year 1977-78, there were 840 applications for 163 targeted places in the graduate programs in the School. Actual enrollment of new students in the degree programs in the fall term totaled 128 (107 last year). This year's number of applications decreased by 157 from last year's 997. The Ph.D. program in the Department of Architecture received 34 applications (for 7 targeted places); they had received 29 (for 5 targeted places) last year.

There was a decrease of applications for the M.C.P. program in the Department of Urban Studies and Planning (D.U.S.P.) from 267 last year to 242 this year. D.U.S.P. had a targeted 60 places and 33 students enrolled. The D.U.S.P. Ph.D. program received 91 applications for 31 targeted places, and 23 students enrolled. The number of applications to the other degree programs remained relatively even, producing an overall ratio of applications to targeted places of about 8 to 1, a slight decline from the 9 to 1 ratio that had remained consistent over the last few years.

The degrees awarded to the School's students in September 1977, February 1978, and June 1978 totaled 174, of which 134 were in Architecture and 40 in D.U.S.P. Certificates were given to 17 Fellows (10 last year) in the Special Program for Urban and Regional Studies of Developing Countries (SPURS). These students completed a year of study in the Department of Urban Studies, where SPURS is a special non-degree program.

In the Department of Architecture, the 134 degrees were distributed as follows: 78 students received a B.S.A.D. and S.B.; 34 students received an M.Arch; 21 an M.Arch.A.S. In its third year, the Department's Ph.D. program awarded 1 degree.

The D.U.S.P. awarded a total of 40 degrees. Ten students received an S.B.; 23 students received an M.C.P.; and 7 students received a Ph.D.

WILLIAM L. PORTER
## STUDENT ENROLLMENT AND COMPOSITION 1977-78

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+ Enrollment figures are a five-week count of students registered in the fall
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*** 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 (C. F. P.), established in 1971.
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*2 foreign
Department of Architecture

Change and implementation characterized the educational programs and major events of the Department.

The year ended with the faculty and Corporation approving a proposal to replace the existing Master of Architecture in Advanced Studies with a more comprehensive research-teaching degree to be called the Master of Science in Architecture Studies. During the year a committee, chaired by Professor Julian Beinart, developed the proposed program, discussed it with the Policy Committee and Departmental faculty, and finally presented it to the Institute faculty and Corporation for approval. The new degree will build upon our well-established three major areas of study: environmental design; housing and settlement; and building systems. The first students will be admitted in September 1979, and the first degrees will be awarded in 1981.

Also approved was the name change for the successful and growing Master of Science (Unspecified) in visual studies, film, and video and computer graphics. The new name, Master of Science in Visual Studies, becomes effective in September 1978. The name more accurately describes the content of the degree and clarifies its relationship with the new S.M. in Architecture Studies.

This year a change in the format of the Corporation Visiting Committee proved to be very effective. The two-day visit of the newly established subcommittee enabled the members to visit all discipline groups in the Department, and also gave them sufficient time to understand the professional program in the context of the whole Department. The subcommittee chaired by Norman Leventhal included Denise Scott Brown, Frederick Stahl, Earl Flansburgh, William Caudill, George White, and Ada Louise Huxtable.

During spring the National Architectural Accrediting Board (NAAB) reviewed our Master of Architecture program as part of their process for accreditation of first professional degrees. The four-member team, chaired by Professor John Spencer of Hampton Institute, found our program to be diverse and rich. The terms of accreditation will be determined by the NAAB later in the year.

The Creative Photography Laboratory, under the direction of Professor Starr Ockenga, has been reorganized and expanded its program over the last year. The quality and diversity of its lecture series and exhibitions have strengthened its reputation in Boston and nationally. The past year has been a formative one for the Film/Video Section. The curriculum was redesigned, new research interests flowered, enrollments increased, the graduate program matured, experiments were carried out in alternative transmission and dissemination forms, and a series of highly original films and videotapes was made. For the Visible Language Workshop the year was generative and exciting. It was marked by Institute support of the faculty, a growing national reputation in the fields of innovative graphics, graphic design, and photography, collaborative courses with the Creative Photography Laboratory, an intensive set of I.A.P. offerings, accelerated computer research, and an increase in enrolled students from 45 to 96.

In late February, Solar House V opened on Vassar Street. The research and design team headed by Timothy Johnson, Research Associate, included Professors Edward Allen, Sean Wellesley-Miller and graduate students Stephen Hale and Christopher Benton. The
School of Architecture and Planning

project, funded by the US Energy Research and Development Administration and the M.I.T. Godfrey L. Cabot Research in Solar Energy Fund, is being used as a classroom and studio. The 900 square-foot "passive" solar heated building collects, stores, and radiates heat without any special equipment. It is expected to supply more than 85 percent of its own heat using its own building materials developed at M.I.T. and various industries over the recent years. The principal new materials being utilized are:

1) a new type of window that loses one-fourth the amount of heat of ordinary double-pane glass, with only 20 percent reduction in transparency;

2) a thin ceiling tile, with a chemical core, that stores a day's heat at constant temperature and then releases the retained heat at night; and

3) a sunlight reflecting louver built into the south window assembly.

Supplemental heating is supplied by electrical baseboard heat. The building is completely instrumented and has been designed to thermally mimic either a detached house or an apartment so that solar heating for high rise construction can also be studied.

Throughout the fall the architectural design faculty met on a weekly basis to discuss appropriate directions for the architectural design curriculum. These meetings culminated in a proposal that suggested ways of coordinating the various studios and developing an evaluation system for faculty and students. Faculty and students reviewed the proposal, and during the summer curriculum development funds will be used to restructure the curriculum.

The degree committees met frequently throughout the year. Recommendations for curriculum review and subject revisions were made to the Policy Committee. The Master of Architecture Committee chaired by Professor Imre Halasz deliberated the appropriate method for teaching communications skills and a suitable alternative to the current structures subject. The Bachelor of Science in Art and Design Committee, chaired by Professor Allen, explored ways of strengthening the design experience of undergraduates. The Policy Committee examined the introductory courses for undergraduate students. It also agreed that an internship for undergraduate design students will be arranged during I.A.P. 1979. For this the cooperation of alumni will be sought.

Several new courses or seminars were successfully offered this year by the different discipline groups:

An innovative way of teaching building technology to architecture students was carried out this spring by Professor Allen. Structural engineering and building detailing were taught as architectural design activities in a studio setting. This method enabled the students to use structural design information immediately in their individual projects.

During the fall and spring the thesis workshop, initiated by Professors Halasz and Chester Sprague was implemented. Based on this year's results, this preparatory course for Master of Architecture students' theses will continue next year.

A special subject, Models Toward Professional Action in Architecture, was offered to the Master of Architecture students this spring by Professors Halasz and Shun Kanda. The relationship between professional education and professional practice was explored by introducing extant role models actualized in the professional field today.

Professor Sandra Howell developed an experimental proseminar for faculty and students in architecture. An objective of the seminar was to increase the visibility of behavioral science issues as they relate to changes in design processes. The focus of the seminar was on understanding the concept of density.
In the past year undergraduate enrollment in film and video courses has greatly increased. To this resurgence of interest in moviemaking the Film/Video Section developed a new and better equipped introductory video course with broad exposure to movie genres, a video special effects class, an introductory filmmaking class, and an intermediate production course with its own cable transmission outlet.

The Visible Language Workshop (V.L.W.) introduced two new courses to its curriculum: Color by Professor Ronald MacNeil, is an in-depth study of color theory and practice (both traditional and electronic, transmitted and reflected light) and their relevance to image making and manipulation. Typographics by Professor Muriel Cooper stressed theory and practice of verbal communication as embodied in visual forms, the implication of message making in print environments, and technologies influencing communication forms.

Besides the V.L.W. course work, Professors Cooper and MacNeil collaborated with Professor Ockenga of the Creative Photography Laboratory in two innovative interdisciplinary subjects. The subject entitled Total Exposure introduced beginning students to an understanding of photography and photographically-based image and word making. The Graduate Seminar was designed for advanced students of graphics, photographic printing and photography. It provided a forum for issues, criticism, and exchange of philosophies.

During I.A.P., for which Professor MacNeil served as department coordinator, the V.L.W. explored many educational interests. Among the courses offered by the V.L.W. were:


Lectures and Events

Apart from the traditional student-organized lecture series, the Film/Video and Photography sections developed some exceptional lecture series and workshops.

The Film Section was awarded a grant by the National Endowment for the Arts to fund two artist-in-residence workshops. The first of these workshops was conducted this spring by Jonas Mekas, filmmaker and founder of Anthology Film Archives. In a series of three-day screening sessions, Mr. Mekas presented a history of personal cinema to a class of nine advanced students with whom he also worked on individual projects.

A Colloquium on Public Access and Community Television was held for two days in October 1977 with members of the National Federation of Local Cable Programmers. Guests included Jean Rice, Cable TV in Amherst; Victor Sanchez, Downtown Community TV, New York City; Red Burns, Alternate Media Center, New York City and coordinator of the Reading, Pennsylvania Access Project; Nancy Cain, Mediabus, Lanesville, New York; and Tim Kennedy, Sky River Project, Alaska. The Colloquium was moderated by Lecturer Anne McIntosh.

A Seminar on Film, TV, and the Performing Arts was held during I.A.P. Participants included Richard Leacock, filmmaker and Professor of Cinema in the Department; Amy Greenfield, dancer and film/video maker; and Nancy Mason, a producer of the "Dance in America" series at WGBH-TV, Boston. Performance works by Professor Otto Piene, Nam June Paik, and Hilary Harris were screened, in addition to works by each of the guests.

During the spring the Photography Laboratory ran two lecture series. One of the series, funded by the Minolta Corporation, enabled the Department and the community at-large to benefit from the presence of lecturers of national reputation such as George Krause,
Emeritus Professor Gyorgy Kepes, and Jerome Liebling. The other series entitled "In Search of Photography" was presented by Visiting Professor Charles Harbutt. Although students of his were required to attend the series, the lectures were open to the public and were exceptionally well attended by the Boston photographic community.

**FACULTY**

Among the visiting faculty this year we welcomed Jean-Francois Gabriel, Professor of Architecture from Syracuse University who taught Level II studio; Sam Bass Warner, Professor in History, Theory and Criticism from Boston University who taught urban history; Carolyn Dry, Professor of Architecture from Miami University who taught Level I studio; Shun Kanda, Professor of Architecture from North Carolina State who also taught Level I studio; Werner Oechslin, Professor of Architectural History from Switzerland who conducted a class in 18th-century architecture; and Charles Harbutt, President of Magnum Photos, Inc. in New York and Paris, who held an advanced course in photography.

New appointments this year included: Donald Corner and Jenny Young, appointed jointly as Assistant Professor of Architecture Design and Arno Minkkinen, Assistant Professor of Photography.

In the fall Professor Henry Millon returned after four years' absence, during which time he was Director of the American Academy in Rome. During the spring Professor Donlyn Lyndon returned from Urbino where he had led the M.I.T. group in the International Laboratory of Architecture and Urban Design.

During the spring several faculty members were on leave: Professor Dolores Hayden was a visiting professor at the University of California at Los Angeles; and Professor Whitney Chadwick was a visiting professor at the University of California at Berkeley.

Professors Jan Wampler, Stanford Anderson, and Tunney Lee were on sabbatical leaves.

National awards were bestowed upon four professors: Professor Emeritus Lawrence Anderson received the 1978 Association of Collegiate Schools of Architecture-American Institute of Architects (ACSA-AIA) Award for Excellence in Architecture Education. Professor Lyndon was elected to the College of Fellows of the AIA. Professor Leacock was elected a Fellow of the American Academy of Arts and Sciences. Professor Millon was elected to the Accademia delle Science, Turin, Italy. The alternate National Institute for Architectural 1978 Faculty Grant was received by Professor Allen.

Professor Anne Vernez-Moudon was appointed for two years to the Ford International Career Development Chair.

Professor Cooper was a visiting critic at Yale Graphic Design graduate review; was a member of a panel "Pluralism of the 70's" held at Boston University; and headed a panel on "Graphic Futures" at Pubmart in New York during the spring.

**Grants and Awards**

In recognition of the high caliber of our students' work, the following students received grants or awards:
The Albert J. Hinckley, Jr. Traveling Fellowship was awarded to Blain Brown, Shelley Burton, Mark Crosley, and Gayle Pinderhughes for outstanding proposals.

American Institute of Architects Scholarship Awards for 1978-79 were presented to two Master of Architecture candidates, Bonita Roche and Sally Harrison.

Six special prizes for Master of Architecture candidates were awarded: for excellence in architecture studies the AIA Medal was awarded to Lisa Heschong; AIA Certificate to George Tremblay; Chamberlain Prize to Julie Moir, and the Chandler Prize to Rosemary Grimshaw and Patricia Bjorklund. For services to the Department the Alpha Rho Chi Medal was presented to Leah Greenwald.

Artist Fellowships, awarded by the Massachusetts Arts and Humanities Foundation, were received by two graduate students in the S.M. program in recognition of their thesis projects. Ross McElween for his cinema verite portrait of his mother, entitled "Mom," and Mark Rance for "Charleen," a portrait of Charleen Whisnant, protegee of Ezra Pound.

Master of Architecture student, John Suk Burke was awarded the school prize in the 1978 annual Reynolds Aluminum Prize for Architectural Students competition.

James L. Bidigare, a senior in the Bachelor of Science in Art and Design program received two awards for his services to the M.I.T. community: the Karl Taylor Compton Prize and the Frederick Gardiner Fasset, Jr. Award.

**Space**

Physical conditions in the Department continue to be a problem, with a major overhaul of our facilities being long overdue. In spite of various attempts by the School and central administration to improve the environment of the Architecture Machine Group, so far no satisfactory solution has been found. However, combined efforts of students and the Physical Plant personnel have made modest improvements to some studios and public corridors connecting the studios.

During I.A.P. a group of undergraduate students, supported by Undergraduate Research Opportunities Program (UROP) funds, cleaned out and repaired some of the mezzanines in studio 7-438. This "band-aid" project, while helpful in itself, obviously is no solution to the deteriorating condition of our studios.

During spring vacation the fourth floor corridors of Buildings 7 and 5 were transformed into exhibition spaces. The first exhibition displayed work from all the discipline groups in the Department; another was of the 27 submitted entries for an interschool's sketch competition initiated by Harvard Graduate School of Design; the final exhibition of the year was in honor of Professor Emeritus Albert Dietz's 70th year. An exhibition program is being developed by faculty and students for next year.

**Research**

Faculty and research associates involved in new investigations and continuing research on other contracts follow.
Professor Allen is investigating "Enforced Disclosure of Residential Heating Costs" for the State of Maryland. Professor Stanford Anderson is working on the Savannah Project funded by the Grunsfeld Memorial Fund. The project is a study of physical environment at urban and architecture scales as a resource interacting with socioeconomic organization under the condition of different rates of temporal change. Also, under an American Council of Learned Societies Grant for 1978 he is developing a historiography of modern architecture.

Professor Dietz, and research associates Dr. Eric Dluhosch and Reinhard Goethert are members of the Technology Adaptation Program's Cairo University/M.I.T. "Housing and Construction Industry" project. This research on housing policies for Egypt is funded by the Agency for International Development. Professor John Habraken is conducting an "Investigation of Regulatory Barriers to the Rehabilitation of Existing Buildings" for the National Bureau of Standards. He is also the principal investigator for the Technology Adaptation Program's Cairo University/M.I.T. "Housing and Construction Industry" project.

Professor Howell's "New Community" is an evaluation of a low density congregate setting for the Department of Health, Education and Welfare's Administration on Aging. Research Associate Timothy Johnson's "Solar Building No. V" is funded by the Department of Energy and the M.I.T. Cabot Fund. Professor Donlyn Lyndon with Alice Lyndon is studying "Fragments of Order, Signs of Inhabitation" with grants from the Graham Foundation.

Professor MacNeil is developing a computerized system for producing large-scale imagery in color. Grants have been received from the Outdoor Advertising Association of America. Professor Millon's research has included Peinzena; Guarini in Turin; Michelangelo and St. Peter; Jurarra drawings; and Italian fascist architecture and urban planning. Professor John Myer with Margaret Myer is studying the use of certain psychological concepts in environmental design with funds from the Grunsfeld Foundation.

Professor Nicholas Negroponte's "Spatial Data Management System" and "Mapping by Yourself" projects develop a relational data base system for building design. A grant was received from the Advanced Research Projects Agency. He also worked on "Exploiting Use Presence" for the US Army Research Institute; "Personalized Perspectives" for Navy-ONR; and "Sound Synch Computer Graphics" sponsored by International Business Machines.

Lecturer Gunter Nitschke investigated "Indian Architecture and Urbanism -- Architecture in arid zones." Professor Edward Pincus is editing a five-year diary film supported by a grant from the National Endowment for the Arts. Professor Sprague is conducting research on selected housing elements, on congregate residences, and on de-institutionalization of physical facilities.

Lecturer Rachel Strickland is experimenting in super-8 documentary production, exploring new forms which result from combinations of film, video, and live media. She also has conducted experiments in low-cost production techniques, developing alternative possibilities of information exchange for special and decentralized audiences. Professor Anne Vernez-Moudon researched "Urban Form and Change," a systematic description of structure and the related physical elements of Victorian San Francisco, funded by the National Endowment for the Arts. Professor Jan Wampler's "Frameworks" is a study of Berkeley, California, and "Froebell Blocks" is a study of teaching tools. Research Associate Guy Weinzapfel and Professor Steven Gregory worked on "Mapping by Yourself" sponsored by the Advanced Research Projects Agency. Professor Sean Wellesley-Miller monitored Solar House V.
**Faculty Publications**


Richard Smith, exhibition catalogue, Hayden Gallery, M.I.T.


"Own Work in Developing Countries 1960-70" IDCA, Aspen, 1977.


*The Golden Labyrinth: Myth and Surrealist Painting* (book)

"Rene Magritte and the Liberation of the Image," article submitted to *Art Journal*.


"Cluster Layouts in High Density Urban Situations," presented at NATO Symposium, "Human Consequences of Crowding," Antalya, Turkey, 6-11 November 1977, with Mark and Negred Butler, and Bulent Tokman, Turkish architects; published in Proceedings.
"Sites and Services as a Prerequisite for Orderly Housing Development," presented at Seminar on Development of New Approaches to Housing Policy and Production in Egypt, Cairo, January 2-24, published in Proceedings.


"Housing Cultivation," Proceedings Conference on Housing and Building Industry in Egypt, Cairo.

"To Build as We Used To," Introduction to SAR Study on Rehabilitation, SAR Publication.


"Melusina Fay Pierce" paper for American Studies Meeting.

"Charlotte Perkins Gilman" paper for Berkshire Conference.


Department of Architecture


Lyndon, Donlyn. Five Maryland Towns, University of Maryland School of Architecture. Boston, The Visible City, (with Alice Lyndon), Random House.


Myer, John and M. Myer. "Patterns of Association" (manuscript).


"Using New Clues to Find Data" (with Craig Fields), Proceedings of the Third International VLDB Conference, Tokyo, 1977.


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Faculty Films

Centerbeam. Filmmakers: Leacock, Rubin. Editor: Arbuckle. 16mm. Impressions of an environmental sculpture created by M.I.T.'s Center for Advanced Visual Studies for the Documenta Exhibition in Kassel, Germany.


Life and Other Anxieties. Filmmakers: Pincus, Ascher. 16mm. A friend, David Hancock, dies of cancer. Subsequently, we are invited to Minneapolis, where we spend the winter filming everyday life until spring.

N. JOHN HABRAKEN

Department of Urban Studies and Planning (D.U.S.P.)

The Department of Urban Studies and Planning started the fall term of 1977 on a note of cautious optimism. While the theme of that optimism was difficult to hear at times during the course of the academic year, it seems fair to say that as we enter the summer of 1978, strains of the melody linger on.

Three major enterprises are worth noting as constituting special events in the life of the Department during the year: 1) our extended look at the professional degree program; 2) graduate student recruitment, and 3) the Minority Student Report.

Professional Degree Program

Five summers ago the Department undertook a comprehensive review of its two-year master's program. The most central of the substantive changes initiated at that time were: the development of a set of required "core" courses; the structuring of course offerings into three main program areas (community and regional development, environmental design and planning, and public policy analysis); and the commitment to sequences of courses in each program area.

The Department has put into place many of the recommendations of the summer study. But despite best and serious efforts on many fronts, there has been the persistent sense on the part of many of us that the effort of the past few years had not been successfully completed and that a need existed to look at the professional degree program again with a view to
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answering the following set of questions: 1) What is the comparative advantage of the M.I.T. Department of Urban Studies and Planning in an increasingly competitive environment? (Schools of policy analysis and public management are now vying with planning schools for the best graduate students). 2) What are the substantive areas in which we have and will continue to have strength even in a period of academic non-expansion? 3) For what kinds of jobs are we preparing our students and what skills should students have as they enter those work situations?

Put another way, the questions being asked were: How is our product, the student who graduates from the professional degree program, different from the graduate of the public policy school, the school of public management, or even the Harvard Department of City and Regional Planning, our increasingly aggressive and competitive rival down the street? How do we make clear to the student shopping around for the right graduate school what he or she can expect from M.I.T., and how do we ensure that we can deliver on that expectation?

The academic year 1977-78 seemed the appropriate time to deliberate such basic issues. A new Head would be appointed during the year to replace Professor Langley Keyes who was retiring from that position after four years of service. The senior faculty felt the need to frame an agenda for the new Head that would set a context for work over the next three or four years. The collective commitment to setting that agenda was strong; and a provocative memo written during the great Blizzard of 1978 by Professor Donald Schon provided a backdrop against which to discuss these questions.

The Schon memo, a synthesis of a number of "ideas in good currency," served as the basis of several senior faculty discussions during the months of February and March. The meetings focused on two of the memo's central themes. One was the view that students and faculty in the M.C.P. program divide into two sorts: "research practitioners" and "planning practitioners," the former concerned centrally with studies and research, the latter with actual planning practice. The other theme was that the Department should focus on those areas in which it has comparative advantage, competence, and depth and that those areas include Community and Regional Development, Environmental Policy and Design, and Housing, and not necessarily a separate area called Public Policy Analysis.

At a meeting in late March the senior faculty agreed that we should not create parallel or diverging streams of types of practitioners but rather to make highly explicit a single stream in the M.C.P. program: that of the planning practitioner.

Having agreed that we are all planning practitioners, we discussed the issue of comparative advantage and agreed that at the M.C.P. level we should organize our program areas around subjects in which we have comparative marketing and personnel advantage: Community and Regional Development (C.R.D.), Environmental Design and Policy (E.D.P.), and Housing (H).

We elevated housing from one-of-three in the Public Policy Analysis (P.P.A.) sequence to make it equal with the other two program areas. By doing so and eliminating P.P.A. as a separate program area, we make it clear that we are no longer in the public policy business per se at the M.C.P. level, but rather are focusing public policy on three areas in which we have special competence: C.R.D., E.D.P., and H.

Throughout April and May there was extended departmental discussion at a variety of levels about the changes proposed by the senior faculty. There seemed to be universal support among students and junior faculty for the planning practitioner approach, i.e. that the essence of an education in the Department was to prepare people for roles in decision-making environments and not for highly specialized research roles. There was also support for the concept of comparative advantage, course sequencing, and skill building. The greatest heat was generated in the discussion around the issue of public policy analysis and how and where
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it stood in the new scheme of things. We are all concerned that our very real comparative advantage in a particular kind of policy analysis not be lost as we reorganize the groups and, that changing the names of "boxes" not be confused with developing an integrated and functional sequence of activities in the education of a professional planner.

As a consequence of these discussions we see an agenda for the M.C.P. Committee for work over the next several years. That agenda should focus on the development of an integrated yet flexible program of professional education. The issues to be resolved are how one best equips an individual for practice in the planning profession in the late 70s. While critical means of identifying the substantive areas in which the Department has comparative advantage, areas of specialization must be seen within the context of a more generic set of practice skills which lie at the center of our definition of planning education.

Graduate Student Recruitment

Since the early 1970s, the Department has vigorously recruited highly qualified minority students. Having a Minority Intern Program funded by the Department of Housing and Urban Development has helped considerably during this period to overcome the financial problems posed by M.I.T.'s ever-rising tuition. Historically, recruiting has meant organizing faculty and student visits to select campuses, a number of specialized mailings, utilization of the local media including radio, and the "network" of former minority students in the Department now constituting a significant group working nationally in a variety of planning-related jobs. Orchestrating these efforts to produce a sizable pool of highly qualified applicants is no small effort. As opportunities for financial support have become more and more desirable at other kinds of institutions -- specifically business and law -- the competition for such candidates has stiffened.

With able staff work from our new recruitment and admissions assistant, Norma Reiss, we undertook this year not only a reorganized minority recruitment campaign, but also a systematic effort to make non-minority students aware of our program. We started to build a network of faculty connections in social science programs at other universities; and we began to utilize our alumni contacts in a more systematic way.

The results of this effort were encouraging. Overall applications for admissions to the professional degree program were up by about 60, this in a year when practically all other planning schools suffered a decline in applications. Most significantly our minority pool was the second highest we have had, 61, up 34 from last year. In addition to the size of the pool, there was general agreement that the quality of applicants was impressive. Moreover, the rate of acceptance stayed high even though the financial packages we were able to offer were less desirable than those of former, lower-tuition years.

The one soft spot in this otherwise encouraging picture is at the Ph.D. level where the size of the pool has in fact declined somewhat from last year (83 as against 91). While the quality of applicants in the doctoral program has remained high, we need to get a better understanding of the market, in particular minority doctoral students. Efforts will be made in the coming recruitment year to remedy this problem.

Minority Student Report

During the summer of 1977, a group of D.U.S.P. minority students working under the direction of Harry Minor, one of our Ph.D. candidates, undertook a detailed study of issues affecting minority students in the Department. The report, made available in the late fall, was a careful and considered look at issues of minority faculty, finances, course substance, advising,
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recruitment, and placement as they related to the minority community. A set of specific recommendations was developed in each of these areas. While the document constituted a balanced critique of the D.U.S.P. from the perspective of one group of students, many of the issues raised had general applicability to the Department as a whole: the tuition crunch, job placement, quality of advising, the role of field work and internships, core course grading, etc.

The document served as an agenda of items for the Department's Policy Committee for a number of meetings during the winter. There was general support for most of the recommendations; and the report served as a means of identifying department-wide issues requiring administrative attention as well as articulating the particular concerns of an important community of students.

Undergraduate Program

During the summer and fall of 1977, the Undergraduate Committee under the leadership of Professor Robert Hollister undertook a major effort to rethink the goals and content of the undergraduate curriculum. The revisions which they proposed to the Department's Policy Committee and which were approved in December 1977 were derived from a variety of explorations: course evaluations data, a 1975 survey of students who graduated with the S.B. in Urban Studies between 1971 and 1975, and two surveys of students in the program.

The changes seek to address the following goals:

1) To focus the program on pre-professional and professional training in public policy analysis, urban and environmental planning, and urban and regional planning in developing countries. To date, we have tried to offer liberal arts as well as pre-professional and professional training. It is impossible to do all of these well. Our present and long-term strength lies in the professional area and the desires of students are strongly in that direction.

2) To provide clearer guidance of students' course work, while maintaining flexibility. The present curriculum is too open ended. It works well only for students with a clear sense of what they want and with especially conscientious advisors.

3) To use our teaching resources more efficiently and to reduce overlap among the present set of courses.

In order to carry out those goals the undergraduate curriculum in 1978-79 will reflect the following changes:

1) A move from the present unlimited choice among Restricted Electives ("take 4 of 13") to a structured set of choices. This change would ask majors to take one of two introductory subjects, a subject in research and analytical methods, and one in each of four disciplines -- sociology, politics, history, and economics.

2) The addition of two introductory subjects. At present we lack adequate entry-level subjects. This makes it difficult for prospective students to explore the field of planning and our program. Requiring an introductory subject would enable subsequent subjects to assume basic knowledge.

3) Revision of the Restricted Electives so that they focus more on the applied aspects of the academic disciplines that contribute to Urban Studies. The present Restricted Electives include both discipline-based and problem-focused subjects, plus ones that are closely tied to individual areas of specialization.
4) A move from six to three areas of specialization. Listing six areas of specialization (as we presently do in Courses and Degree Programs) has the advantage of communicating to students the major sub-areas in which we offer advanced courses. It has several disadvantages as well: a) the array confuses students and contributes to a very unclear image of what constitutes Urban Studies; b) the list obscures the fact that students at present actually specialize in a much smaller number of areas; c) the spread makes inefficient use of faculty resources and limits the depth we are able to offer in any one area; d) the spread provides no incentives or pressure for faculty teaching the subjects in each area to address curriculum alternatives across specialization lines. The proposed move to three main areas of specialization responds to these problems with the present system. It is essential, however, that in addition we maintain an option, whereby students can build their own specialization that cuts across the three defined areas.

5) Replacement of the junior and senior colloquia with a single senior colloquium, offered in the fall term of the senior year, which makes the senior colloquium an integrative experience and also a lead-in to the senior project.

6) Renaming of the senior thesis requirement as the senior project requirement to recognize more clearly the variety of ways in which one can meet the requirement. "Thesis" connotes a research activity, which is just one of the acceptable options.

In addition to the major curriculum changes noted above, time was spent in seeking out ways of making the Department more accessible and understood by undergraduates at the Institute. The results of a carefully run UROP program under the direction of Chuck Wexler and an effort to seek out those freshmen who had indicated Urban Studies as one of their interests in their applications resulted in the highest number of freshmen in five years declaring the Urban Studies major.

M.C.P. Program

The M.C.P. Committee, under the chairmanship of Professor Ralph Gakenheimer, was kept busy by a variety of internal tasks while the more general issue of professional education was being discussed by the senior faculty and the Department at large. Those tasks were not insignificant and constituted a full work load for the 12-person committee made up of seven faculty members and five students.

The Committee gave considerable attention to means of easing students' difficulty in dealing with the thesis requirement at a time when the project is moving toward a role as a professional document rather than as a conventional master's thesis. A memorandum intended to help students begin on the task of thesis problem identification was distributed as was a list of model theses for consultation by categories in which students might be interested in writing.

Some of this discussion was carried on with one of our Ph.D. students, William Ronco, who agreed to teach a thesis writing seminar for the coming year (supplementary to the environmental design thesis seminar) in which thesis writers would find a supportive environment.

The admissions process was conducted in roughly the same manner as last year, with the scoring and record-keeping system somewhat elaborated. The procedure is fully documented by a report in the M.C.P. program files and materials retained by Professor Joseph Ferreira.

Creation of the Institutional Analysis Core Course was taken up as an important matter for this year. A committee consisting of Professors Schon, and Gakenheimer, Leonard and Suzann Buckle met during the year to design the format and content of the course. A report was produced by Professors Leonard and Suzann Buckle describing the intended pattern of the course.
The Committee approved the offering of the methods core course in the form of a sequence of modules, of which the first is obligatory and two more must be taken on an elective basis. The format emerged after extended review of the past three years' experience with the required methods course.

The Committee decided not to categorically prohibit students from entering the Department as Special Students when they fail to be admitted to the M. C. P. or Ph. D. programs. The provisos are that they take a maximum of two subjects per term, stay only two terms, must be competitive in quality to those admitted to the degree programs, and must not receive the impression that this is to facilitate their chances of being admitted as degree candidates in the following year.

The Committee worked hard to keep in touch with the discussions of the senior faculty and the considerations for curriculum change implied by those deliberations. It is clear that the coming year will be an important one in terms of putting the conclusions of those discussions into the format of the M. C. P. program.

Ph.D. Committee

The Ph.D. Committee was composed of five faculty members and three students during 1978. In the fall term, the committee was headed by Professor Robert Fogelson and in the spring term by Professor Karen R. Polenske.

Work on the determination of a coherent leave-of-absence policy constitutes a major activity. The need for review of the leave-of-absence policy and its implications for the Ph.D. program are evident when it is noted that 51 Ph.D. students were registered in the spring term and 49 Ph.D. students were on leave of absence. The lack of students in residence naturally affects the quality and quantity of our teaching and research activities.

The Institute's tuition policy for doctoral students also affects our ability to capture students, many of whom are being lured to other universities by attractive fellowship offers or reduced tuition policies for students after their second year of residence. As of June 1978, of the 25 Ph.D. students admitted, nine have rejected our offer, half of these based on financial reasons. Several of the remaining incoming students are concerned about the lack of financial assistance and the high tuition and living costs and may have to decide before September that they cannot come. The rate of attrition would probably have been higher had we not made an effort to talk by phone or in person with each person admitted. Only one of the students admitted had full financial assistance at the time of the admissions decision in April. Because students are now being admitted from the waiting list, we still anticipate a class of 20 students for September 1978.

The main new activities of the Ph.D. Committee this year were to review and revise the guidelines for the general examinations and thesis proposals and to determine the structure of the Ph.D. statistics class.

Work on a set of general examination guidelines was begun in the spring of 1977. After lengthy discussions by the Committee, a set of new guidelines was given to all current Ph.D. students. It will now be required that general examination proposals as well as general examination questions be reviewed and approved by the Ph.D. Committee. Previously, only the general examination questions had been reviewed and approved by the Committee. Because this review occurred directly prior to a student's taking the examination, a few traumatic experiences resulted. The review of general examination proposals is designed to address major issues of content and format of the examination sufficiently early for the student and faculty committee to cope with the suggestions without creating tremendous personal anxieties. The brief
experience we have had this spring with the general examinations indicates that the new guidelines are far better than the old.

Another change we are making is designed to assist incoming students in structuring the content of the general examination. Students will now be required to prepare an examination in three areas of expertise. One area must be a fairly general intellectual approach to social problem solving. A second field must be a broad topic or problem area. The third field should be a specific issue (presumably within the above two) in which the student may wish to do detailed research.

A set of guidelines was also established for students and their faculty committees to follow for the submission of a thesis proposal.

Starting in the fall of 1978, a Ph. D. statistics course will be offered by the Department. Doctoral students will be able to pass their statistics requirement either by passing a test-out examination to be given prior to the beginning of classes or by receiving a grade of B or A in the departmental course.

The new general examination format and thesis guidelines also mean that the work load of Committee members will be increased considerably because of the number of Ph. D. students submitting proposals for review.

Community Fellows

The Community Fellows Program underwent its second year with the revised format which included representatives from both public and private-based organizations. The group once again was split evenly between the two: five from the public sector (one person's tuition and stipend were paid through his Bush Fellowship) and six from the public sector including Federal, state, and local government.

There were some major changes in staffing of the Program during 1977-78. Professor Melvin H. King assumed the directorship after many years as associate director. Alma C. Armstrong, a Ph.D. student in D.U.S.P., took on the assistant directorship--half time. Frances C. Berry, an experienced administrator, assumed the position of administrative assistant. E. Gregory George, a Ph.D. student, served as the teaching assistant for the Community Fellows Seminar. Myron Emanuel, an M.C.P. student, served as the Program's research assistant in gathering materials from the first year of the Program to the present for a "community development manual." Two interns were recruited from the Harvard Graduate School of Education. They were utilized in: 1) helping to formalize an admissions procedure, put together new materials, and suggest ways to improve the admissions process; and 2) helping to put together the Community Fellows Reference Materials Resource Book.

The Tuesday Evening Seminars, which constitute the weekly setting within which the Fellows meet as a group, was devoted this past fall to an overview of the economic and social situation in Third World Countries. Speakers both from within the Institute and outside were called upon to participate. This year the spring session was changed from its previous format and was structured to allow each Fellow to take responsibility for one session to make a presentation of his or her own choosing.

In addition to structuring the seminars and ensuring supervision and help for Fellows, a major responsibility and concern of the Fellow staff has been fund raising. It is clear that finding the necessary support for the Program from the Greater Boston Community is a major occupation, and one which of necessity occupies a significant part of the Director's time.
Having a clear sense of where foundation support is likely to be achieved and a long-term plan for getting it is critical to the Fellows' future as a Program.

**SPURS Program**

The year 1977-78 has been one of unusual activity for SPURS. Altogether 17 Fellows and two Associates participated in the Program, the highest number since it started 10 years ago. They included five urban planners, five public administrators, five architects, two economists, a political scientist, and a business executive. Of these, two came from each of the following countries: Chile, Ghana, Korea, Nigeria, the Philippines, and the United States, and one from Brazil, Britain, France, Malaysia, Mexico, Portugal, and Venezuela.

During the course of the year, Fellows initiated a weekly SPURS seminar for the presentation and discussion of papers relating to individual research interests and professional experience. They visited a number of state and local planning agencies in the Boston metropolitan area, and made a highly successful week-long field trip to international development agencies in New York and Washington. These included among others the Centre for Housing, Building and Planning, the Development Planning Advisory Services of the United Nations, and the Urban Projects Division of the World Bank. In addition, Fellows formed an M.I.T. SPURS Association to provide an information network and to foster communication among the growing number of SPURS alumni scattered around the world.

The faculty members associated with SPURS continued as before -- Professors Gakenheimer, Polenske, Lloyd Rodwin (Director), Alan Strout, and Lisa Peattie -- with this year's addition of Professor William Wheaton. Dr. David Wheeler, recently appointed Assistant Professor of Developmental Economics, will join the SPURS faculty next year. Several new courses of particular interest to SPURS Fellows were introduced, among them: 11.483 Regional Economic Planning in Developing Countries by Professor Polenske; 11.944 Theory and Problems of Economic Development by Professor Richard Eckaus of the Department of Economics; and 11.462 Housing Problems, Goals and Policies in Developing Countries by Professor Rodwin.

One major problem continues to be the lack of financial resources to aid potential participants. As a result, our intake is largely restricted to those with their own financing. (This year five Fellows were supported by their governments, three by the Agency for International Development, one by the United Nations Development Program, one by a private US Foundation in Paris, and two came on Fulbright Fellowships; two others were partially aided by ourselves). This means that each year we lose a number of highly qualified people, whom we are eager to have, and who could make an excellent contribution to the Program. This is not only a loss to SPURS (and D.U.S.P.) but is also inequitable to those concerned, especially those who for some reason are politically or ideologically out of favor with their own governments or international agencies. To remedy this, we have continued our efforts to secure funding from outside sources, and are currently in discussion with the National Institutes of Mental Health.

Despite the discouraging rise in tuition fees and living expenses, however, the number and overall quality of applicants remains high. At the latest count, we anticipate at least 18-20 Fellows next year.
APPPOINTMENTS AND RETIREMENTS

Professor Kevin Lynch retired this spring after 30 years of service to the Institute. Professor Lynch is unique in the Department and in the world of environmental design and programming in which he is held in universal respect. He will be greatly missed not only as an inspirational teacher but also as a devoted advisor and colleague who has made a singular mark on the character of urban design education. Our one solace is that we may be able to lure him back as an emeritus professor. We have our fingers crossed.

Two new faculty appointments were made during the year. Professor David Wheeler will join the Department in the fall of 1978 as an assistant professor in development and development economics. He comes from Boston University but is not a stranger to M.I.T., as he earned his Ph.D. in the combined M.I.T. Planning and Economics program in 1974. Professor Gary Hack will be rejoining our environmental design and policy group after three years as a senior policy and program officer at the Central Mortgage and Housing Corporation in Canada.

As mentioned earlier, Professor Keyes is retiring from the position as Department Head and will be in England next year on sabbatical leave. Professor Lawrence Susskind will replace him as Head of the Department. Professor Susskind brings to the job eight years of devoted service to the Department first as assistant under Professor Rodwin's headship and then as Assistant Head under Professor Keyes. Professor Susskind has a keen understanding of the planning profession in both its academic and professional contexts and comes to the leadership at a time when the Department is faced with key issues of self-definition and some strong competition for students at both the undergraduate and graduate levels.

In addition, Professor Susskind must deal with the ever tightening economic squeeze which our students are experiencing. We bemoan the financial crunch with each passing annual report. We have held on so far; but without additional resources to ease the burden of graduate tuition, the pressure may become too great for many of our students. Already the quality of graduate life has been seriously impaired by the need for most students to hold down major job commitments in order to finance their education.

Professor Susskind will also have to deal with the problem of space, another perennial issue which has major impact on the life of the Department. At present, the Department is spread across four buildings and as many floors. Physical separation makes for social and intellectual estrangement as our Visiting Committee emphatically noted. We must find a way of physically pulling the pieces of the Department together. The implications of failing to do so are most serious over the long run; but not having a clear sense of how the resolution is going to be worked out or when makes even the short run difficult sledding.

For all the issues of space, finances, course content, and intellectual integrity, this is not a period of hand-wringing in the life of the Department. Our research volume is rising. Our applications are up; and there is a growing sense that we have survived the worst of the financial and organizational hangover from the "swinging sixties." That quiet optimism noted some pages back is in the air. The issue for the future is how to maintain and expand upon it.

LANGLEY C. KEYES
With continued guidance from the School Council, the Laboratory of Architecture and Planning (L.A.P.) continued to provide a variety of support services to research projects and programs carried out by faculty and students of both departments. The L.A.P. also expanded its program of continuing education.

Michael L. Joroff, a researcher and consultant in public management and planning, and a lecturer in the Department of Urban Studies and Planning (D.U.S.P.) for the past seven years, joined the L.A.P. as Associate Director in January. His full-time presence in the L.A.P. will allow it to play a much broader and more aggressive role in fostering research within the School.

To implement this expanded role, the Laboratory will initiate research proposals and help to link researchers within the School with researchers in other universities and with practitioners who can contribute to our efforts. The L.A.P. will establish an L.A.P. Associates Program whereby accomplished practitioners will be brought into the Laboratory as research associates to help initiate and carry out research about matters of high interest.

The L.A.P.'s mission in the School will continue to be to: further the state of the art of practice and teaching in the fields of architecture and planning; link the School with the world of practice; and encourage research about areas of emerging concern to society and the professions.

RESEARCH PROJECTS AND PROGRAMS

Newly funded and ongoing research projects in the Laboratory of Architecture and Planning include:

MIT Solar Demonstration Building, directed by Research Associate Timothy Johnson. This project resulted in the construction of M.I.T. Solar House 5. The building was completed in April 1978. Eight-hundred feet of experimental building was created at the west end of Briggs field, along Vassar Street. The building demonstrates passive solar heat using new building materials developed at M.I.T. and by several industrial concerns. With the careful use of passive solar energy design elements, the building is expected to supply 85 percent of its own heat. The building is now being used by the Department of Architecture as academic space.

The opening of this very innovative Solar House was greeted with critical acclaim by the architectural and scientific community. Since its opening, it has been visited by hundreds of professional and government officials from this country and abroad. It has received wide coverage in the national press, on local television, and in professional journals. More than 1,000 letters of inquiry have been received.

The Solar Energy Project is also directed by Timothy Johnson. It is sponsored by a grant from the National Science Foundation. The project focused on developing variable building skins which control the amount of thermal radiation entering and leaving a building. These...
skins also offer the user control over the visual environment through varying proportion of transparent to opaque wall area.

The Architectural Education Study, directed by Dean William Porter and Professor Julian Beinart, and funded by the Mellon Foundation, is laying groundwork for developing new directions in studio-based architectural education. The major topics are: the teaching and learning of architecture in schools; the development of effectiveness in practice; and an overview of the evolving profession. Case studies have been prepared dealing with professional development and changing professional roles and competences. These are intended to provide bases for judging current teaching practice and information for planning new approaches.

The Environmental Impact Assessment Project, directed by Professor Lawrence Susskind and funded by the Rockefeller Foundation, is an investigation of the ways in which public agencies can better predict and assess environmental impacts of proposed policies, programs, or public investments. Five cross-cutting themes provide a framework for accumulating research findings and recommendations: 1) generating alternatives; 2) evaluating impacts on the natural environment; 3) social impact assessment; 4) presenting technical information for public consideration; and 5) decision making.

The Energy Impacts Project, directed by Professor Michael O'Hare, and funded by the Department of Energy. The project is working to develop: 1) a facility siting process that reveals social costs and compensates people for them; 2) an information process that "packages" information which facilitates various types of decision making; and 3) six case studies of previous New England energy facility siting efforts.

The Maryland Project, directed by Professor Michael O'Hare, and funded by the State of Maryland. Enforced disclosure of a residence's projected heating costs, as determined by a government-performed or approved test, promises on theoretical grounds to be a more effective way to encourage energy conservation than conventional programs such as building code stringency. This project will evaluate the analytical and technical questions associated with the feasibility of such a plan preparatory to developing an implementable scheme. The economics, legal issues, politics, and engineering alternatives for testing and information dissemination are to be reviewed.

Neighborhood Evolution and Decay is directed by Senior Research Scientist and D. U. S. P. Lecturer David Birch. Funded by the Department of Housing and Urban Development, it is a study of the process of neighborhood changes as the basis for developing a conceptual model of neighborhood dynamics, which can be used to estimate where and how decline, abandonment, and rejuvenation take place.

Simulation Model for Inter-Area Migration is also directed by Dr. Birch and funded by the Department of Housing. It is a detailed analysis of the migration of people from one urban or rural area to another and of the reasons for their choice of location. This analysis will form the basis for developing a simulation model of inter-area migration. The two above projects are funded by the Department of Housing and Urban Development.

Relating Transportation to Neighborhood Change, is directed by Dr. Birch and funded by the Department of Transportation. The project is to assess the effects of changes in transportation technology and energy costs on neighborhood change.

Firm Behavior as a Determinant to Economic Change, is directed by Dr. Birch and funded by the Department of Commerce. The project aims to describe and explain aggregate economic change in terms of the behavior of individual firms at the intra- and inter-regional level.
The ACCESS Project and Special Projects are directed by Dr. Birch and funded by a wide array of public and private agencies. They provide studies through an innovative data system (available nationwide) for analyzing large social science data files. The system now contains data for 4.5 million firms, 1.5 million members of the work force, 2 million individuals, 55,000 households, and 30,000 consumers as well as extensive measures of counties and our 315 migration areas over time. Individual clients request special studies.

New England Employment Study is directed by Dr. Birch and funded by the New England Regional Commission. This project provides up-to-date employment data for the Commission. NERCOM staff is being trained to use Dr. Birch's ACCESS data system for their own research.

Urban Patterns of Change is directed by Professor Anne Vernez-Moudon and funded by the National Endowment for the Arts. The project describes the structure and related physical elements of Victorian San Francisco and their monitored changes over the past 100 years. The project describes the physical structure and related elements of Victorian San Francisco, and the changes in land subdivisions and built and open space patterns which have taken place over this period of time.

CONTINUING EDUCATION

Our Continuing Education Programs completed their first full year of operation, involving some 200 people in various courses and programs. There were three major program efforts: January seminars, summer course, and fall and spring extension courses.

The summer, fall, and spring programs are run jointly with the Office of Special Programs at the Harvard Graduate School of Design (GSD). This collaboration is one of the most active public areas of joint venture between the two schools. We share with Harvard a brochure, but run our courses at M.I.T. facilities. The January Seminars are an M.I.T. -only program.

Overall, we have attempted to use continuing education both as a way of providing a service to alumni and practitioners, and to develop the School. Regular faculty, graduate students, and local professionals have taught the course, and interacted in many ways with the School.

Based on M.I.T.'s Independent Activities Period, the January seminars program opens the School's I.A.P. short course to practitioners. Costs are low (under $100) and the courses are not given for credit. Forty people attended this program in 1978.

In the summer of 1977, M.I.T. offered seven of the 18 courses given in the joint program with the Harvard GSD. The following six courses were given: Non-traditional Techniques for Local Economic Development, Melvin King and Sandra Kanter; Planning Process, Thomas Nutt-Powell; Changing Neighborhoods, Tunney Lee and Robert Yin; Creative Citizen Participation, Philip Herr; Improving Professional Practice, William Ronco; and Systems Building, Eric Dluhosch. The 1977 participants mostly came from outside New England; they represented a diverse mix of architects and planners from all over the nation.

In the fall of 1977, we began to collaborate in the Harvard GSD's extension programs, offering 6 of the 10 courses. The four courses which were given included: Japanese Gardens, Julie Moir; Realities of Historic Preservation, Robert Neiley; Drawing the Built Environment, Barbara Steen; and Organizing Professionals' Work, Andrew Hahn, Peter Linkow, and William Ronco.
In the spring of 1978, we offered eight of the 16 courses. One course was given: Working Drawing Techniques, D. L. Chandler. In the summer of 1978 we will be offering 15 courses: Realities of Historic Preservation, Robert Neiley; Japanese Gardens, Julie Moir; Effective Professional Practice, William Ronco; Systems Building, Eric Dluhosch; Impact Assessment, Philip Herr; Residential Settings for Children and Young Adults, Florence Ladd; Uses of TV in Planning and Architecture, Thomas Piper; Changing Neighborhoods, Tunney Lee and Robert Yin; Planning Process, Thomas and Bonnie Nutt-Powell; Lightweight Structures, Jean-Francois Gabriel; and Holography as Art, Harriet Casdin-Silver.

WILLIAM L. PORTER
School of Engineering

If we were to characterize the activities of the School of Engineering for the 1977-78 academic year by a single headline, it would have to be "Continued Growth in Engineering." This past year saw continued growth in both undergraduate and graduate enrollment and also in research volume. Specifically, undergraduate enrollment in engineering increased from 1,801 in 1976-77 to 2,016, a 12 percent increase. Thus, in the five-year period since 1973-74, undergraduate engineering enrollment has increased by almost 60 percent, encompassing now some 61 percent of the Institute's undergraduates who have selected majors. Five years ago, only 43 percent of the Institute's undergraduates were engineering majors. Further, 66 percent of the second-year students who had designated a major in 1977-78 designated one in engineering last year.

During the past year, seven of the School's eight departments experienced undergraduate enrollment increases exceeding 10 percent. One department -- Materials Science and Engineering -- experienced an enrollment increase of almost 50 percent. Numerically, the Departments of Electrical Engineering and Computer Science, Chemical Engineering, and Mechanical Engineering experienced the largest increases. Electrical Engineering and Computer Science's enrollment increased by almost 100 to a total of 926; Chemical Engineering's by almost 50 to 297; and Mechanical Engineering's by just over 30 to 349. Since 1973-74, enrollment in Chemical Engineering has increased by 178 percent and in Mechanical Engineering by 93 percent. One department in the School -- Civil Engineering -- experienced a small decrease in undergraduate enrollment. However, its enrollment was still at its second highest point in the past decade.

In last year's report, Dean Alfred H. Keil noted that increases in undergraduate enrollment appeared certain for the next two years and projected the School's enrollment at about 2,200 in 1979-80. Based upon the Course designations of the Class of 1981, we now expect to reach that level one year early with engineering enrollment between 2,160 and 2,175 next fall. Assuming no major downturn in research and development spending, durable goods output, and relative professional salaries, opportunities for graduating engineers will remain high, and enrollment -- if there are no changes in Institute admissions policy -- will probably reach the 2,250 to 2,300 range in 1979-80 and remain at that level for several years.

At the graduate level, enrollment in the School's programs increased to 1,795, up some 15 percent over the past five years. Six departments experienced enrollment increases in the past year, and two -- the Departments of Ocean and Nuclear Engineering -- experienced downturns of approximately 10 percent each. In each instance, the enrollment decline resulted from anticipated changes in the makeup of the Department's graduate student population. In Ocean Engineering, there has been a decrease in enrollment in Course XIII-A, the special naval architecture and marine engineering program offered for US Navy officers; and in Nuclear Engineering, the first of the two master's classes of the special program sponsored by the Atomic Energy Organization of Iran graduated before the beginning of the year. As of this writing, the second class is in the process of completing its programs; all of the students should complete their degrees by the end of the 1978 summer session. A further small decline in the Nuclear Engineering graduate enrollment can be expected next fall.
Enrollment of women undergraduate students in engineering has grown by 198 percent -- from 83 to 247 -- in the last five years; they now represent 12 percent of the School's undergraduate student body. However, even with this considerable growth, women students, with about 40 percent of their number enrolled in engineering, are underrepresented when compared to the total undergraduate population, 60 percent of whom enroll in engineering. At the graduate level, the increase in women's enrollment is even more dramatic, up 252 percent over the past five years. During the past year, 116 women were engaged in graduate study in engineering, 49 at the doctoral level.

Minority student enrollment in the School has grown at about the same rate as the total student body, up about 60 percent at the undergraduate level and 30 percent at the graduate level during the past five years. The numbers, however, particularly at the graduate level, are disappointingly small. The pattern at the graduate level for black students, in particular, reflects national trends to go to work after completion of the bachelor's degree rather than to continue the educational process through graduate study. This is a serious problem which M.I.T. as an institution must address and which is also being addressed nationally through the National Academy of Engineering's Committee on Minorities. The solution may well lie in a combination of improved communication as to the benefits of graduate study, more attractive packages of financial support for graduate study, and increased peer and counseling support during the program.

The enrollment increases discussed in the preceding paragraphs have led to departmental teaching loads that are unprecedented in the School's history. During the 1977-78 academic year, credit units totaling 280, 319 were awarded in the School, 24 percent over the comparable figure for 1973-74. This increased teaching load was supported by a budget essentially identical in purchasing power to that of the 1973-74 academic year. Recognizing the pressures on the faculty and staff created by these loads, substantial increases in the School's academic budget have been approved for the 1978-79 academic year.

In addition, the Institute has initiated within its Leadership Campaign a special development fund directed toward "Strengthening M.I.T.'s Commitment to Engineering Education and Practice." This fund is designed primarily to support the increased teaching loads resulting from our present and anticipated enrollment increases. In using this fund, the School will substantially increase its population of assistant professors, resulting in a more realistic distribution of faculty among the three ranks. The School has been greatly concerned that over the past decade the number of assistant professors declined by 46 percent from 111 in a faculty of 324 to 60 in a faculty of 333. This special development fund will also support systematic curriculum development, particularly in the undergraduate core curriculum subjects and broader introductory graduate subjects; provide resources for the School to explore; experiment with and implement the use of modern technology (e.g., computers and television) in the delivery of its educational programs; provide seed funds for planning and formulating larger research projects requiring cooperative efforts by groups of faculty and for related pilot projects; and provide resources for the purchase of new research equipment necessary to support the work of new assistant professors as well as present faculty moving into new fields of importance to the School.

During the past year, research directly administered within the School of Engineering continued to increase at about the eight percent rate experienced in fiscal 1977, exceeding $26 million at year end. This represents a growth of approximately 60 percent since fiscal 1974, a rate somewhat higher than the Institute taken as a whole. In addition, a significant portion of the School's research volume -- perhaps as much as an additional $20 million -- is administered by interdepartmental laboratories such as the Energy Laboratory, the Research Laboratory of Electronics, and the Center for Materials Science and Engineering. Research contracts in these laboratories also have been increasing rapidly.
The reports of the School's departments and centers address their respective research activities and accomplishments. Much of this work is directed toward expanding the engineering science base which serves as the foundation for engineering practice. As observed in last year's report, the School has in recent years turned increasing attention to the development of technology and its use in the engineering process. This process continues as both faculty and students move to conduct more of their research in technology application areas and to study broader, applied problems particularly as they incorporate synthesis and design. Further, an increasing amount of the School's research activities, in addition to those of its Center for Policy Alternatives, relate to policy issues. For example, the US Department of Energy has asked faculty associated with the Center for Transportation Studies to work with the Energy Laboratory to develop transportation energy contingency plans for use in the event of a major oil shortage. An objective of this research is to be able to respond to national emergencies similar to the oil embargo of 1973. We can anticipate an increasing number of projects such as this which are concerned with the technological, legal, regulatory, and societal aspects of a particular problem.

One further aspect of our research activities deserves mention. The School's faculty continues to find itself hard pressed to maintain the sponsored research volume necessary to support its own research as well as that of the students. The faculty note that the day of the short five- to ten-page proposal is gone, replaced by the 50- to 75-page proposal; that sole-source procurement opportunities rarely exist, that they experience longer delays between the submission of the proposal and notice of award or rejection and, if an award is made, still further delays before the funds are received; and that the average expenditure per contract per year in current dollars has not changed significantly in the last decade, while inflation has significantly decreased the dollar's purchasing power during this period. Taken all together, faculty are spending perhaps as much as five times the amount of time they spent a decade ago in activities directly related to obtaining research support. Many, for example, report spending a significant portion of their work week on these activities now. It is unclear that this level of activity can be sustained for any length of time; it is clear, however, that it cannot be increased.

Before turning to the reports of the School's departments and centers it is appropriate to comment upon a number of School-wide educational activities. These include the work of the Office of the Associate Dean for Educational Programs and the Committee on Engineering Education.

**Engineering Internship Program**

This academic year marked the first year of operation of the School of Engineering's new Engineering Internship Program. The first class of 32 sophomore engineering students started their summer work assignments at 12 participating companies in June 1978.

This School-wide educational program, which aims to combine the best that M.I.T. and industry have to offer, resulted from a recommendation of the 1975 School of Engineering Self-Appraisal Study and is modeled after the continuing, and very vibrant, Course VI-A in the Department of Electrical Engineering and Computer Science. Course VI-A had its beginnings in 1907 when Professor Dugald C. Jackson was Head of the Department of Electrical Engineering. After observing several of the then new six-year engineering programs, which had alternating periods in school and at industrial plants, Jackson and others proposed such a program at M.I.T. in cooperation with the Lynn Works of the General Electric Company. In remarks at a meeting of the American Institute of Electrical Engineers a year later, Professor Jackson commented: "It seems to me that the engineering schools must in some manner improve their process if they are to make the men (sic.) who will go far in the engineering industries of the future, and if they are to try an experiment there is
nothing which looks more likely to bring good results than this plan which is an analogue of the plan that has worked advantageously for the medical schools and the law schools."

Implementation of the Program was delayed until 1917, by which time the course's structure had become a five-year program leading to the joint award of the Bachelor of Science and Master of Science. The Program has continued as a strong academic entity in basically that form until today. Currently, interest among Electrical Engineering and Computer Science students in the VI-A program is strong and the Program continues to enjoy a high level of industrial acceptance.

Students in the School of Engineering participate in the Engineering Internship Program by registering in the appropriate departmental degree program. Programs have been established in the Departments of Aeronautics and Astronautics, Civil Engineering, Electrical Engineering and Computer Science (in addition to Course VI-A), Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, and Ocean Engineering. Students normally enter the Program in the summer following their sophomore year and typically spend three summers and one graduate term in residence at a participating company or government agency, receiving academic credit while earning a salary to help defray their educational expenses. (In this first year, student salaries for sophomores ranged from $845 to $1,083 per month.)

Emphasis is placed on involving students in rewarding work assignments and in real-world problems that extend the learning experience to areas not available in an academic setting. Students will typically do a combined S.B.-S.M. thesis on a topic related to their work in industry during their graduate term in residence. Students are selected by the participating companies through a series of competitive interviews held each spring on the M.I.T. campus.

The Program is under the supervision of Professor Joseph M. Sussman, Associate Dean for Educational Programs in the School of Engineering; John R. Martuccelli is the Program's Director. Mr. Martuccelli is responsible for the operating aspects of the program and contractual relations with participating companies. The program's academic activities are guided by a faculty steering committee which was formed in October 1977. This committee, chaired by the Associate Dean for Educational Programs, is comprised of a coordinator from each department in the School. In addition, a faculty representative has been selected for each participating company. This faculty member is charged with providing effective liaison between the company, students and M.I.T. The Associate Dean for Educational Programs, the Program Director, and the appropriate faculty representatives plan to visit each participating company this summer.

The 32 participating students were selected from an applicant pool of 65 by the participating companies on the basis of 221 student-company interviews held during March. Most of the participating departments had in excess of 20 percent of their sophomore class apply to the Program. Also, most of the departments had more than 10 percent of their sophomores accepted to and now participating in the Engineering Internship Program.


Efforts to enroll additional companies for participation beginning in the summer of 1979 will begin shortly, following an evaluation of Department and current company requirements for next summer.
School-wide Engineering Electives

This year marked the establishment of the first set of School-wide elective subjects in the School of Engineering. These subjects will be offered beginning in September 1978 as a two-year experiment authorized by the Committee on Educational Policy. The experiment is primarily concerned with subjects that typically are not central to the core of any departmental program, but rather are important elective subjects of interest to students throughout the School of Engineering. The goal of the program is to provide an intellectual and administrative mechanism for the development and evolution of such subjects, while not disturbing the traditional departmental curriculum development process.

This program grew out of a proposal by the Committee on Engineering Education, which delegated implementation of the program to the Office of the Associate Dean for Educational Programs. An ad hoc faculty committee, composed of representatives of each of the departments in the School of Engineering, and chaired by the Associate Dean for Educational Programs, was formed in October 1977. This committee is charged with selecting subjects for School-wide elective status and with monitoring the program throughout the experiment.

Five subjects were selected with evaluation of the concept in mind: Computer Models of Physical and Engineering Systems I; Management in Engineering; Introduction to Technology and Law; Dynamics of Physical and Social Systems; and Entrepreneurship. These subjects are representative of the broad range of interdepartmental interests in the School of Engineering. Several of these subjects were originally created through School of Engineering curriculum development funding provided in recent years.

The ad hoc faculty committee is currently focused on planning for the evaluation of the School-wide elective concept with an eye to being able to recommend whether School-wide electives should become a permanent part of M.I.T.'s curriculum at the end of the two-year experimental implementation in May 1980.

Proposal for Dual Undergraduate Majors

Several years ago, the office of the Associate Dean for Educational Programs in cooperation with the Committee on Engineering Education began to explore the concept of dual undergraduate majors at M.I.T. A dual major is defined as a Bachelor's degree program in which the degree is recommended by two departments and the student meets the spirit of the degree requirements in each of these two departments. The specific need addressed is that of designing educational programs in engineering at the undergraduate level which provide the student with more career options and a more broadly based educational program than currently exists. Several important instances of this are the education of engineers with competence in several engineering disciplines, the education of engineering managers, and the education of engineers with a special interest in the societal impacts of science and technology.

The study and development of dual major programs was the basis of a major proposal to the Comprehensive Assistance to Undergraduate Science Education (CAUSE) program of the National Science Foundation. The CAUSE program was initiated in fiscal 1976 as a major national effort to assist colleges and universities in improving the quality of their undergraduate science programs. Its primary objectives are to strengthen the resources for undergraduate science education components of the nation's two- and four-year colleges and universities, improve the quality of science instruction at the undergraduate level, and enhance the capability of institutions for self-assessment, management, and evaluation of their science programs.

The School's proposal has been accepted, providing resources beginning in September 1978 to examine these ideas and related educational concepts at M.I.T. The project will be directed
by the Associate Dean for Educational Programs of the School of Engineering. The management and evaluation unit for the program is the School's Committee on Engineering Education. In addition, faculty working groups will be established to work on particular dual major programs.

Special Programs for Pre-College Minority Students

In 1975, in collaboration with the Engineer's Council for Professional Development, the M.I.T. School of Engineering designed a summer program to enhance the participation of minorities in the engineering professions. This is a two-week residential program that has been held each summer since then for 40 minority high school students each year from the eastern United States who have demonstrated interest and the ability to engage in engineering studies. The program is designed to increase minority students' awareness of professional opportunities in engineering and to introduce these students to the college experience.

The program format is an intensive one in which the students are engaged in academic activities in which they develop some new skills in mathematics and physics and in which they experience firsthand the nature of academic work at the college level. The program includes a major design experience that extends throughout the duration of the program. Through this design experience, these students are exposed to the thought processes of engineers as they develop a design to meet specifications set by a client within the constraints of limited resources and time. In effect, this design experience is a microcosm of the practice of engineering. The students also are exposed to the current and future directions of the various engineering disciplines through seminars conducted by faculty in the eight departments of the School of Engineering. Through the mechanism of field trips, students meet with engineers working in local industrial firms and have the opportunity to learn firsthand the nature of the lifestyle of the practicing professional. These industrial firms have been particularly helpful in bringing together minority students with practicing minority engineers.

In the summer of 1978 the program will include for the first time a seminar on the social impacts of the engineering profession. In this seminar, students will be exposed to major engineering problems from virtually all of the engineering disciplines and will have an opportunity to explore the social implications of these engineering enterprises.

The MITE program has had a positive impact on the enrollment of minority engineering students at M.I.T. Of the 40 students who participate in the program each year, approximately two-thirds have completed the junior year of high school and thus are able to apply for admission to M.I.T. during the following academic year. A total of 11 of the 80 students who participated in the program during the past two years are now registered at M.I.T.

Support for the program has been derived from a variety of sources. In the summers of 1976 and 1977 the program was supported from funds generated within M.I.T., with a small fraction coming from the Engineer's Council for Professional Development. For the summer of 1978 a large fraction (approximately one-third of the cost of the program) is supported by funds provided by the US Air Force.

Student Support

Efforts continued during the year to develop support for both undergraduate and graduate students. The General Motors Scholarship program, begun in 1975-76, continued with the award of five new scholarships. Recipients of these new awards are students in the Departments of Electrical Engineering and Computer Science, and Mechanical Engineering. This
School of Engineering

program provides full tuition and fees in addition to summer employment for engineering students beginning at the end of their second year.

In addition, the School, together with the Student Financial Aid Office, was successful in developing a new scholarship program with Kodak. The first class of three Kodak scholars was selected this spring. This scholarship program provides each scholar with an award equal to 75 percent of their tuition.

In March, the School of Engineering received $100,000 from the Ford Motor Company Fund under a $1.6 million program to aid talented and promising students. The grant will establish a $100,000 restricted endowment fund, the income to be used for a yearly Henry Ford II Scholar Award of $5,000. The award will be made at the end of a student's third year of undergraduate study to the student with the highest record of academic performance. The first Ford Scholar will be named in the spring of 1979.

Honeywell Inc. and Monsanto Company sponsored achievement awards for undergraduate students during the past year. M.I.T. was chosen as one of 12 schools nationwide to receive the Honeywell Award for Outstanding Achievement in Engineering, consisting of a plaque and a $300 check to an engineering student selected by M.I.T., and a permanent plaque and $300 to the School of Engineering. Jordin T. Kare, a senior in the Department of Electrical Engineering and Computer Science, received this award.

The Monsanto Achievement Award is made on the basis of the best academic record after two and one-half years of study at M.I.T. and is awarded to minority undergraduate students in engineering who are US citizens or permanent residents. In providing support for this award, Monsanto Company has two objectives: to promote academic excellence among minority engineering students at M.I.T. by encouraging competition for this award, and to promote Monsanto's name among M.I.T. students. This award consists of a $500 cash prize and an engraved plaque and was awarded to Heinz Stubblefield, a third-year student in Ocean Engineering.

Technology and Policy Degree Program

At this year's Commencement Exercises, the first Master of Science degrees in Technology and Policy were awarded to four students. This two-year degree program, which typically enrolls 20 students in each class, was begun in 1976 with support from the Alfred P. Sloan Foundation. The program is designed to develop proficiency in policy analysis and implementation for technological problems. The program requires each student to develop an advanced competence in a specific technological area of the student's choice, skills in policy analysis, and an understanding of the context of policy issues, and to engage in a thesis project providing an integrating experience between the technology studied and the policy issue. Students are expected to take or demonstrate competence in a concentration of three advanced subjects in a chosen field of technology, an introductory and an advanced subject in systems analysis, two intermediate level subjects in economics, and two subjects in law and political processes. In addition, students in the program gain practical experience through the project proseminar and a thesis.

Committee on Engineering Education (C.E.E.)

In the fall of 1975, Dr. Alfred H. Keil, then Dean of Engineering, created the Committee on Engineering Education as an outgrowth of the then just completed School-wide "Self-Appraisal" project. At that time, both financial pressures and the perception of possible new needs and opportunities in the education of Engineering students suggested a re-examination of the goals, the organization, and the teaching styles of the School of Engineering.
The Committee's charge is broad. It advises the Dean and the Engineering Council on educational and academic policy important to the School as a whole; it also defines issues and formulates programs whose breadth puts them outside the scope of any single department. At the same time, the Committee has no statutory standing or authority and derives its effectiveness from the support which its specific proposals receive both from the Dean and Engineering Council and from the School faculty and students.

Awareness by the Committee of this position has played a part in the selection of tasks undertaken over the last several years. Its first reports to the Dean and the faculty issued in fall 1976 attempted to redefine broadly the goals of engineering education to provide a framework for its proposals (and other proposals on the structure of the School). The Committee then undertook a number of studies and proposals of relatively limited scope and short-term payoff while it continued examination of a few major long-term issues. Individual members of the Committee have had responsibility for following certain specific activities: Professor Hermann A. Haus has had responsibilities for the Committee's study of Tutored Video Instruction and for its interactions with Mount Holyoke College on a program to introduce women from liberal arts schools to engineering education and practice; Professor Norman P. Jones, interactions with the Center for Advanced Engineering Study and the School's activities concerning the continuing education of engineers; Professor Fred Moavenzadeh, liaison with the Institute's Committee on Educational Policy; Professor Henry M. Paynter, communication with the School's faculty through a committee newsletter; Professor Bernhardt J. Wuensch, the cooperative School of Engineering-Department of Humanities program for teaching technical communication; and Professor Leon Trilling, the Committee's chairman, responsibility for the seminar "What is Engineering?" and liaison with the School of Humanities and Social Science.

During the summer of 1977, the Committee on Engineering Education proposed a program to improve the skills of engineering students in oral and written communication. The resulting program, developed in conjunction with Professor Robert R. Rathbone of the Department of Humanities and the staff of the Writing Program, operated successfully during the 1977-78 year. Nine engineering subjects in the program enrolled a total of 350 students who performed experimental or design projects. The projects generated requirements for communication -- from proposals to final reports -- in a straightforward way that approximated real-world conditions, facilitated communication instruction, and enhanced the students' motivation to communication. The educational premise of this program, and the Committee's concern, is that communication skills are essential in the professional engineer's career. From this premise the program derives its goal: to bring students' competence in communicating their ideas up to the level of their competence in engineering.

The program, as developed, guides students in preparing the specific written and oral reports that are assigned in their engineering subjects. Communication instruction thus becomes an integral tool by which students fulfill engineering requirements. At the same time, the humanities instructor becomes a member of the teaching staff of the engineering subject. Compared with other methods of teaching communication at the college level, this program has advantages of psychology, realism, and economy. Communication is taught where students' motivation to learn is strongest -- in the professional curriculum -- and skills are developed and exercised in reports resembling those required in an engineer's professional career.

This program also provided an opportunity for engineering teaching assistants and faculty members to develop a capability to evaluate technical writing. The program will be continued during the 1978-79 academic year during which this part of it will be emphasized.

Beginning in the first term of the year, the Committee on Engineering Education assumed responsibility for the undergraduate seminar "What is Engineering?". This seminar had been
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started by Professors Mildred S. Dresselhaus and Sheila E. Widnall and was originally aimed particularly at an audience of minority and women students for the purpose of acquainting them with the engineering profession. The seminar's actual enrollment increasingly came to mirror the average composition of the student body and the Committee is designing it as a general introduction to engineering. In its present form, half the lectures are given by faculty of the School and describe some major activity of their department or discipline. The other half is devoted to the presentation in some depth of the initiation, execution, and technical, political, economic, social, and ecological consequences of several major engineering projects. This year the seminar discussed the Aswan Dam, the design and marketing of the SX70 Polaroid camera, and the nature and some consequences of data processing. Next year the seminar will discuss the disposal of nuclear waste, telecommunications, and air transport from the Boeing 707 to the SST.

This format for the seminar is seen as a pattern which is capable of extension and refinement -- as a broad School-wide subject, as a vehicle for cooperative teaching with the new college, and in other ways. For example, several of the "project" sections were videotaped, and both Wellesley and Mount Holyoke colleagues have expressed an interest in showing some of the tapes during their winter term activities.

Current issues facing the Committee include:

- the interface between the School and the School of Humanities and Social Science -- how, for example, can the undergraduate Humanities, Arts, and Social Science Requirement be made more meaningful to a larger number of our students and how can the social context of our professional activities be included in the core of our programs

- physics teaching as it affects the School

- use of computers in engineering education -- how can the style of undergraduate teaching be improved if faculty members take advantage of new opportunities

- women in engineering -- how can women from liberal arts colleges be introduced to graduate engineering education and practice. The modalities of a four-year dual B.A. and engineering degree for students from Mount Holyoke College and of a five-year joint B.S. and M.S. degree for Wellesley students, taking advantage of cross-registration, are being explored.

During the forthcoming year, the Committee plans to devote significant time to some longer-range thinking and planning on a set of interrelated issues which are all variations on the theme of the evolving role of the engineer, and particularly of the M.I.T. educated engineer. These include:

- graduate education -- the issue of cooperative education with industry and government agencies including the relations of traditional graduate education to new patterns of continuing education; relationship of department programs with programs focused on "Centers" and the issues of the educational role to be played by the Centers

- research policy -- are more flexible arrangements required to meet the career needs of some junior faculty, and to retain for M.I.T. a leading role in some high technology fields that are so capital-intensive or complex as to be out of reach of the traditional mode of graduate instruction

- introduction of the ethical, social, political, and economic contexts into the core of professional engineering education.
SCHOOL APPOINTMENTS AND FACULTY AWARDS

During the past year, a number of major appointments were made within the School. These included the following: Professor Joseph M. Sussman joined the Office of the Dean of Engineering in September as Associate Dean of Engineering for Educational Programs. Professor Sussman succeeded Professor Ernest G. Cravalho (Matsushita Professor of Mechanical Engineering in Medicine) who was appointed Associate Director for Medical Engineering and Medical Physics in the Division of Health Sciences and Technology.

Professor James C. Wei, a distinguished chemical engineer noted for his major accomplishments in both academia and industry, joined the faculty as Head of the Department of Chemical Engineering and Warren K. Lewis Professor of Chemical Engineering. Professor Wei was a member of the first US chemistry delegation to visit the People's Republic of China this past May. There he gave invited lectures at seven universities and research institutes.

Completing his term as Head of the Department of Aeronautics and Astronautics, Professor Rene H. Miller, Slater Professor of Flight Transportation, will return to teaching and research after a sabbatical leave in England. Professor Miller served the Department with distinction as its Head for 10 years. Professor Jack L. Kerrebrock, Richard Cockburn Maclaurin Professor of Aeronautics and Astronautics and a distinguished member of the aeronautics and astronautics community, will assume the leadership of the Department on July 1, 1978.

Professor Wilbur B. Davenport, Jr. resigned from his position as Head of the Department of Electrical Engineering and Computer Science to return to teaching and research in the Department. Professor Davenport served the Department effectively from February 1974, when he assumed this major responsibility. Today the Department is stronger -- intellectually and administratively -- because of Professor Davenport's exemplary leadership. Also returning to full-time teaching and research are Professors Fernando J. Corbato and Paul L. Penfield, who served very effectively as Associate Department Heads during Professor Davenport's term. Professor Corbato has also been named to the Cecil H. Green professorship. He will use the chair's resources during his term as Green Professor to enable him to concentrate on computer operating systems, time-sharing systems, and knowledge-based application systems. Professor Penfield will participate in a new research project concerning automated techniques for converting algorithms into integrated circuit devices -- a project which is expected to have important applications to communications and other fields. Professor Gerald L. Wilson will succeed Professor Davenport as Department Head, effective September 1, 1978. He is Director of the School's Electric Power Systems Engineering Laboratory, and an engineer widely recognized for his teaching and research in the simulation, design, and operation of electric power systems. Professor Joel Moses, a leading computer scientist and engineer best known for his work in the field of symbolic manipulation, will be the Associate Department Head for Computer Science and Engineering.

Professor Richard B. Adler, widely recognized for his textbooks in semiconductor electronics, electromagnetic theory, and circuit theory, will be Associate Department Head for Electrical Science and Engineering.

After serving as the first Director of the Center for Transportation Studies, which was established in 1973, Professor Paul L. Roberts will return to teaching and research in the Department of Civil Engineering. Professor Roberts served most effectively as the Center's first Director and the measure of success that the Center has experienced and the accomplishments it has made are results of his leadership. Assuming the leadership role for the Center, effective July 1, 1978, will be Professor Daniel Roos, a noted expert on urban transportation and member of the faculty of the Department of Civil Engineering.
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Professor John G. Kassakian (Department of Electrical Engineering and Computer Science) concluded his two-year term as the first holder of the Carl Richard Soderberg Professorship in Power Engineering. That chair was established in 1975 to honor one of M.I.T.'s most illustrious teachers and engineers who also gained international recognition for his pioneering work in power engineering and particularly in the design and development of turbine engines. On July 1, 1978, Professor Michael P. Cleary will become the second holder of this career development chair. Dr. Cleary's primary field is fracture mechanics and plasticity theory, including the mechanics of porous and geological materials. He will use the resources of the Soderberg Professorship to pursue his interests in the mining and processing of coal and oil shale and other problems related to the recovery of tertiary oil.

Chosen for Esther and Harold E. Edgerton Professorships in the School were Associate Professor Gerald J. Sussman (Department of Electrical Engineering and Computer Science), Assistant Professor Christos Georgakis (Department of Chemical Engineering), and Assistant Professor Manuel Martinez-Sanchez (Department of Aeronautics and Astronautics). These professorships, established in 1973 by the M.I.T. Corporation to honor Professor and Mrs. Harold E. Edgerton, are "to provide new horizons in research and career development for younger faculty and students" and are designated for a two-year period.

Appointed Henry L. Doherty Professors in Ocean Utilization for a two-year period are Professor Alician V. Quinlan (Department of Mechanical Engineering) who will receive support for her project "Ecodynamic Analysis of Algal Blooms Fouling Nahant Beaches" and Professor Francis Noblesse (Department of Ocean Engineering), for his project on "Implementation of a New Method for Evaluating the Wave Resistance of a Ship." The Doherty Professorships are awarded through the M.I.T. Sea Grant Program.

As in past years, many of the School's faculty were recognized for their outstanding accomplishments.

Elected to the National Academy of Engineering were Professors Robert L. Coble (Department of Materials Science and Engineering), Jack L. Kerrebrock (Department of Aeronautics and Astronautics), Walter E. Morrow, Jr. (Department of Electrical Engineering and Computer Science and Director of M.I.T. Lincoln Laboratory), and James C. Wei (Department of Chemical Engineering). The addition of these four faculty members brings the total M.I.T. faculty membership in the Academy to 51 (of which 33 currently hold active faculty appointments) and represents 5.9 percent of the total Academy membership. Some 191 of M.I.T.'s alumni are members of the Academy.

Professor Robert M. Fano (Department of Electrical Engineering and Computer Science) was elected to membership in the National Academy of Sciences.

Professor Morris Cohen (Department of Materials Science and Engineering) received the National Medal of Science from President Carter. Professor Cohen was honored for his research in metallurgy and materials science -- "for original research and advancement of knowledge of the physical and mechanical metallurgy of iron and steel, and especially for his work on the martensitic transformation in the hardening of steel."

Professor Robert C. Mann (Department of Mechanical Engineering) received the American Society of Mechanical Engineers Medal for eminently distinguished engineering achievement. In addition, he is the first recipient of the ASME Bioengineers' Division H. R. Listner Biomedical Engineering Award.

Professor Nigel H. M. Wilson (Department of Civil Engineering) received the Visiting Professor of Planning in Civil Engineering Award from Stanford University, California, and a Jasper and Marion Whiting Foundation Travel Award.
Professor Nam P. Suh (Department of Mechanical Engineering) received the ASME Pi Tau Sigma Gustus Larson Award for outstanding achievement in engineering education.

Professor Thomas B. Sheridan (Department of Mechanical Engineering) received the Paul M. Fitts Award from the Human Factors Society for outstanding contributions to human factors education.

Professors Giuliana C. Tesoro (Department of Mechanical Engineering) and Mildred S. Dresselhaus (Department of Electrical Engineering and Computer Science) received Achievement Awards from the Society of Women Engineers.

Professor Clark K. Colton (Department of Chemical Engineering) received the 1977 Allan P. Colburn Award of the American Institute of Chemical Engineers for excellence in publications by a young member.

Associate Professor Nils R. Sandell, Jr. (Department of Electrical Engineering and Computer Science) was the recipient of the 14th Donald P. Eckman Award by the American Automatic Control Council.

Professor Kent F. Hansen (Department of Nuclear Engineering) received the American Nuclear Society Arthur Holly Compton Award.

Professor Wesley L. Harris, Jr. received the 1977 Award for excellence in engineering from the National Consortium for Black Professional Development.

This past year also saw several retirements from the School's faculty. These included Professor J. Harvey Evans who retired after 31 years of service in the Department of Ocean Engineering and Professor Irving Kaplan who retired after 20 years of service in the Department of Nuclear Engineering. Professor Kaplan will continue next year to teach his interdisciplinary subject on the history of nuclear engineering, which is a case study of the interactions of technology and society.

Also retiring this past year was Dean Alfred A. H. Keil, who joined M.I.T.'s faculty in 1968 as Professor and Head of the Department of Naval Architecture and Marine Engineering. Dr. Keil played a major role in expanding that Department's horizons to encompass the field we now know as Ocean Engineering. The Department's name was changed in 1971 to recognize this enlarged perspective. That same year Dr. Keil was named Dean of the School of Engineering succeeding Dr. Paul E. Gray. In August 1977, after six years of distinguished service as Dean, Dr. Keil resigned this position to return to the faculty. In recognition of his professional stature, his contributions to the development of engineering education, his dedication as a counselor of students and faculty, and his untiring, selfless, and devoted efforts to further engineering education at M.I.T., he was appointed Ford Professor of Engineering. Professor Keil will continue to serve the Institute following his retirement as an advisor to the Sea Grant Program and to the Institute's activities to develop a technical education program for the Iranian government. He also will continue to serve as a catalyst in a number of major research activities.

Subsequent to Dr. Keil's resignation, I was asked to assume the full responsibilities of the Office of the Dean of Engineering while a search for his successor was conducted. I am most appreciative of the cooperation and support that I received during this interim period from the School's faculty and staff. Also, I am happy to note that Dr. Robert C. Seamans, Jr. has been named Dean of Engineering, effective July 1, 1978. Dr. Seamans is a noted engineer who will bring a unique set of experiences to this position.

JAMES D. BRUCE
The continued increase in undergraduate enrollment, up 30 percent from last year, coupled with the worldwide growth in air transportation and space-related activities, has prompted the Department to initiate a five-year development plan. An improvement in facilities with particular emphasis on those available to undergraduates and a modest increase in junior teaching staff are planned. The Department's basic computational facilities are also being upgraded. The Undergraduate Projects Laboratory is receiving more modern equipment including a high-speed digitally controlled cyclic testing machine and an autoclave for composite structures research. The Department will also offer additional fellowships for graduate students wishing to work in new areas of importance to the future of the Department, such as computational fluid mechanics and advanced composite structures. It is expected that each of the five Divisions of Instruction will eventually participate in this program.

A modest (five percent) increase in graduate school enrollment reflects the low nationwide enrollment in aerospace studies in all schools during the past 10 years, which bottomed out at approximately one-third that of the peak years. However, despite this reduction in the available pool, the Department has seen only a small fluctuation in graduate school enrollment throughout the period.

Total research volume in the Department has continued its upward trend, with a 1978 volume of $4 million as compared to $3.6 million for 1977. The Department continues to generate a substantial amount of research administered by the special laboratories such as the Transportation Center, the Energy Laboratory, and the Research Laboratory of Electronics, and the true volume generated by the Department faculty in 1978 is close to $5 million.

Increased enrollment and research continue to present a burden to faculty. The Department seriously feels the need for new young faculty members who can share the burden of research and teaching and would be available to follow new thrusts in research as these may develop. For this reason, and as part of the five-year plan, the Department will attempt to add young assistant professors on a short-term basis to serve in areas which show promise for future development, recognizing that with an 80 percent tenure ratio the possibility of long-term appointments will be remote for the next several years.

In line with the Department's continued thrust into promising new areas of research, two new laboratories have been established -- the Technology Laboratory for Advanced Composites and the Space Systems Laboratory. The total number of Undergraduate Research Opportunities Program students in the Department this year was 36. Fourteen are involved in research in these two new laboratories.

The Department made the following awards to the student body. The Henry Webb Salisbury Award was presented to Frank Kun Chung, Guido Haymann-Haber, and Paul A. Lagace. The James Means Memorial Prize was awarded to Fort F. Felker III, Karyn T. Knoll, and Robert W. Parks. The Luis de Florez Award was presented to Kenneth D. Cameron, Brian N. Nield, Preston L. Vorlicek, Kevin P. Dopart, and Robert E. Sullivan.

The very active student chapter of the American Institute of Aeronautics and Astronautics in the Department contributed greatly to departmental and student activities and encouraged student participation in the Northeast Regional Conference. Four out of six of the prizes at the Conference were awarded to participants from the Department -- Marian Tomusiak, Carolyn Major, David Steffy, and Celeste Satter with Karyn Knoll.
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The departmental teaching and research activities may best be detailed by the following brief description of activities in the five Divisions of Instruction together with the 14 research laboratories associated with these divisions.

Instrumentation, Guidance and Control

This Division, which enrolls the largest group of graduate students of any of the divisions, for the first time in many years increased the size of its faculty with the addition of Professor William S. Widnall. Dr. Widnall brings an excellent background in applied optimal estimation and control, disciplines central to the Department's interest in the foreseeable future, and perfectly matched to the interests of many of the graduate students in this Division. It is hoped that with the addition of Professor Widnall, and consequent lightening of the heavy thesis supervision load in the Department, new research programs in the mainstream areas of estimation, control, and navigation will be generated. Such programs would provide research opportunities on campus in addition to the excellent ones provided by the Draper Laboratory, which continues to support close to half the graduates in this Division.

Major on-campus research activities of the Division were concentrated in the Man-Vehicle Laboratory and in the Laser Laboratory. In the Man-Vehicle Laboratory, research continued on habituation to novel vestibular environments and significant progress has been made toward the goals of investigating causes and means of prevention of space motion sickness. Of particular interest is the program scheduled for the first Spacelab flight involving a sled system for use in linear acceleration testing as part of this study, and investigating the activity of the vestibular system in weightlessness. One of the investigators in this program, Byron Lichtenberg, has been selected as one of the two candidate payloads specialists for this program. In a similar field, a semiautomated clinical vestibular testing device has been completed and nystagmus analysis on normals and patients will begin over the summer to provide data for evaluating the system as a means of clinical diagnosis for wider distribution. Work leading to the determination of compensatory visual neural changes with eye movements, using the fish as an experimental animal, has made a great deal of progress during the last year. Another program is focused on visual vestibular experiments to develop models of pilot orientation for use in specifying and using motion cues in flight trainers.

The Laboratory is continuing its study on the etiology of ski accidents in order to provide information as to: the actual use of bindings by skiers, the influence of some environmental variables upon the release characteristics, and trends of injuries in order to determine improvements and changes in the types of equipment being used. Also of interest is a study on special pedagogic strategies in arithmetic leading to a new technique for teaching arithmetic to students with learning problems, which is making a significant contribution to the teaching of mathematics to all levels. This program is now funded by the US Department of Education.

In the Laser Laboratory the performance of the passive ring resonator laser gyroscope has been substantially improved. Experiments are also being conducted to investigate the use of optical fibers for the measurement of inertial rotation. The modification of atomic energy levels in the presence of intense optical radiation has been measured with high resolution and the results have provided conclusive experimental evidence as to the true behavior of atoms in strong fields.

Structures, Materials and Aeroelasticity

This Division has benefited greatly from the five-year plan of the Department as a result of commitments to purchase an autoclave, new vibration measuring equipment, and a
A programmable testing machine. A major program in research on composite structures in the Technology Laboratory for Advanced Composites has as objectives the ability to predict damage under cyclic load after the different types of damage have been identified, the determination of the damping characteristics of composite materials, and the use of composite materials to damp out structural vibration as well as to provide the strength carrying capability. New methods of fabrication and new methods of using filamentary composites in structural forms are also being investigated.

In the Aeroelastics and Structures Research Laboratory numerous extensions of various finite-element formulations are currently under investigation. The equilibrium finite-element model is being applied to formulation of elastic-plastic analysis, nonlinear contact problems are being studied, the hybrid finite-element model is being applied to the analysis of creep problems in the finite strain range, the study of the viscous damping behavior of laminated composite materials using complex modular representation has been started, and the hybrid model for thin laminated composite plates is being extended to an approximate formulation that includes local stress concentration effects of free edges. Also, two finite element computer codes have been developed to study elastic-plastic transient response to impact loads with particular reference to engine rotor failures. This theory has been checked against the experimental data and good agreement has been noted. Studies have been extended to include certain metal panel structures housing power plant equipment which may be subjected to impact loads, and to the study of crashworthiness of railroad tank cars. Computer codes developed under these programs have been disseminated to many users under M.I.T. copyright licensing agreements.

In another area, work on rotary wing aircraft and wind turbines has continued. In a study of the vertical gust response and its alleviation for hingeless helicopter rotor blades, feedback control systems were used to reduce undesirable responses. The aerodynamics and dynamics of horizontal axis wind turbines including their drive system and support structure are being investigated in order to provide a comprehensive theory for the design of large wind turbines. A brief design manual which would provide engineering data in simplified form, useful to the full spectrum of wind turbine designers, is also being prepared. Work has continued on the study of wind effects on buildings and structures, including the dispersal of pollutants, both in the wind tunnel and on site.

Energy Conversion and Propulsion

This Division, the second largest in the Department in graduate student interest, shows a continued growth in research activities related to gas turbines. Rocket propulsion and space propulsion have passed through a period of low interest, but are expected to grow appreciably in the near future.

The work carried out in this Division is best characterized as research on dynamic energy conversion covering a wide range of disciplines and devices. Fluid mechanics, solid mechanics, plasma physics, heat transfer, and numerical computation of transonic flows are important disciplines with applications to gas turbines both aircraft and stationary, MHD power generators, high powered lasers, and fusion reactors.

Research programs on cooled turbines and on compressors for aircraft engines continue to expand, with substantial research on film cooling and transient effects in high work turbines. Three-dimensional flow in transonic compressors is being studied analytically, computationally and experimentally and a new program of research on instability and distorted flow in compressors has been launched. Three-dimensional work on compressors has led to broad initiatives in computational fluid dynamics for the coming year.
Studies in MHD are directed to critical problems of the overall system. The electrochemical corrosion of electrodes was explained and new electrode materials were successfully screened. An executive computer program for the design of complex MHD and other advanced power plants has been developed and used in the study of emissions from such power plants.

Mechanics and Physics of Fluids

Activities of this Division are characterized by a high degree of interdepartmental cooperation, with the faculty participating very actively across school and department lines. Cooperative and teaching programs exist with the Departments of Mathematics, Meteorology, Mechanical Engineering, and Ocean Engineering.

Research highlights of this Division include major advances in the understanding of the structure of boundary layer turbulence. This work has been extended to a study of wind generation of water waves, which has demonstrated that the growth of small-scale capillary waves can feed energy directly to large-scale motions.

Work on vortex flows is continuing, with stability calculations and with direct measurements of the circulation of the vortex sheets that roll up to form a ring.

Research is also continuing on gas surface interaction in an attempt to determine the evolution of size distribution and location of water droplets which grow by vapor condensation as the result of the release of a set of nucleation centers.

Numerical fluid mechanics research has been applied to configurations with sharp internal and external corners in lateral cross sections, in order to determine the flow field behavior under near detached shock conditions. Ultimate applications are to wave riders, engine inlet geometry, and to general evaluation capabilities.

Solution of the nonlinear transonic potential equation have been obtained by linearizing the system of governing equations with respect to a dimensional thickness parameter. Parametric differentiation and integral equation methods have been combined in a novel procedure to obtain solutions to steady transonic flow of airfoils. Preliminary research concerned with gases in high rotation with potential application to isotope separation was initiated this year.

In the area of acoustics, studies of the unsteady aerodynamics related to noise from blade vortex interaction at high speed on helicopter rotors have been conducted and the effects of free stream turbulence on low frequency and high frequency broad-band noise generated by model rotors were experimentally investigated.

Investigations have been conducted leading toward improvement of the wind tunnel magnetic balance system using superconducting coil configurations. In conjunction with this facility, both experimental and theoretical analyses have been made of boundary layer separation and adverse pressure gradients on spinning bodies. Research has continued on the wakes of hypersonic vehicles and an experimental study of the aerodynamics of waveriders is in progress. Recent experiments mapping the wake of wire-supported models show that the effects of support wires are very large, giving added impetus to the further development of the magnetic balance.

An unusual biomedical engineering development involves the use of inflated pressure cells for applying pneumatic pressure to assist individuals who have a lateral deviation of the spine. This work is a cooperative effort with the Children's Hospital under National Institutes of Health sponsorship.
A new subject in Satellite Engineering was offered this spring by four faculty members plus outside lecturers from Lincoln Laboratory and with advice and guidance from Communications Satellite Corporation (COMSAT) personnel. A high degree of interest in this subject reflects the importance of this growing area of space technology.

With the establishment of the Space Systems Laboratory, a more active program of sponsored research has been initiated, with particular emphasis on materials processing and manufacturing in space and the assembly of large-space structures. Experiments have been conducted in the M.I.T. pool under simulated zero g conditions to determine the effects of water drag on such simulation. It has been found that with properly controlled experiments this is not a serious limitation, and preliminary studies of productivity in space have indicated that such productivity is potentially much higher than has previously been expected. A systems study of logistic costs of satellite solar power systems including optimization of space transportation systems and the tradeoff between the use of terrestrial and lunar material in such application is being conducted.

The other primary area of interest in this Division concerns air transportation systems, where the teaching program has attracted worldwide interest and included a highly successful two-week summer course. Research has continued on computer display of flight information, on the development and evaluation of analytical and simulation models for airport capacity and delay analysis, on evaluation of air traffic control models and simulations, on the scheduling of runway usage, and on terminal area computer simulation. Research also has been conducted on the operator (pilot) workload and on computer display of flight information. Research on network analysis and decomposition methods is continuing. An effort is being made to determine optimum scheduling techniques for ultra short haul systems including tradeoff between load factor, frequency of service, and number of terminals served.

Policy-oriented analytical models are being developed to determine the impact of changing aircraft technology on the demand for air transportation. In a parallel study the effect of fare and travel time on such demand is being investigated. Regional aviation forecasting models are being developed for the Massachusetts Aeronautics Commission and a review conducted of the State airport system plan and forecasts.

Miscellaneous Department Activities

Professors Eugene Covert and Harold Wachman chaired the Undergraduate and Graduate Committees respectively. Professor Winston Markey chaired the Doctoral Committee and the Interdepartmental Doctoral Program in Instrumentation, and has introduced guidelines which will provide better coordination among the students, their committees, and the graduate office. Professor H. Philip Whitaker continues to advise the Engineer's degree while serving as chairman of the Freshman Orientation Committee. Professor Markey organized a series of Department seminars which were taken for credit by 20 students.

Professor Covert continues to chair the Committee on Curricula and Professor James Mar the Athletic Board.

Professor Leon Trilling served as Chairman of the Committee on Engineering Education and as Chairman of the Institute Committee on the Humanities, Arts, and Social Sciences Requirement. Professor Charles Oman was appointed faculty advisor to M.I.T. students interested in developing careers as professional astronauts.
Professor Oman also was appointed to the Hermann von Helmholtz Chair in Health Sciences and Technology, and Professor Manuel Martinez-Sanchez to the Esther and Harold E. Edgerton Chair.

Professor Jack Kerrebrock was elected to the National Academy of Engineering.

The Department welcomed to its faculty Professor William S. Widnall in the Division of Instrumentation, Guidance and Control, and Professor Edward M. Greitzer to the Division of Propulsion and Energy Conversion.

A highlight of the year was the establishment of the Charles Stark Draper Chair for developing new young faculty members in the area so ably pioneered by Professor Draper.

The Department looks forward to welcoming Dr. Dean Chapman as Jerome Clarke Hunsaker Professor during fall 1978. Dr. Chapman is a world-renowned expert on computational fluid mechanics.

As usual, members of the faculty were particularly active professionally and on various government advisory boards. Professor Sheila Widnall presented the Midwest Mechanics seminars on fluids and was appointed by the President to the Board of Governors of the US Air Force Academy. Professor Covert was appointed Vice Chairman of the US Air Force Scientific Advisory Board and chaired the National Academy of Engineering committee on the Main Shuttle Engine. Dr. John McCarthy chaired the Air Force Division Advisory Group on Aeronautical Systems. Next year he will take a three-year leave of absence to act as Director of the NASA Lewis Center. Professor Wesley Harris chaired the National Research Council/M.I.T. Planning Committee on Retention of Minority Undergraduate Students in Engineering. Professor Lawrence Young is the President-elect of the Biomedical Engineering Society. Professor Shaoul Ezekiel was guest lecturer in Moscow at the invitation of the Soviet Academy. He also received the Graduate Student Committee award for outstanding graduate teaching.

Finally, after close to 10 years of service as Department Head, Professor Rene Miller relinquished this challenging and interesting assignment to return to full-time teaching and research, and Professor Kerrebrock was appointed as the new Department Head.

RENE H. MILLER

Department of Chemical Engineering

During the past year, departmental activities increased to higher levels. High enrollment and increased research volume placed heavy demands on the faculty. Professor James Wei, formerly the Allan P. Colburn Professor of Chemical Engineering at the University of Delaware, was appointed Warren K. Lewis Professor of Chemical Engineering and Head of the Department. In the fall term before Professor Wei relocated to the Cambridge campus, Professor Clark K. Colton served as Deputy Head. Faculty committees continued to evaluate our academic programs to ensure the maintenance of proper priorities to achieve departmental goals. A new chair in Chemical Engineering was established in honor of Joseph R. Mares, Class of 1924, to be known as the Joseph R. Mares Professorship for Faculty Development.
The Undergraduate Program

Total enrollment in the undergraduate program increased again this year to a total of 312, and the combination of lecture presentations and multiple sections for recitations initiated last year for core subjects was extended to accommodate the large classes. In spite of the increased demands on the faculty, student-faculty interactions continued to be effective. The following table shows the trends in Chemical Engineering enrollment.

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<tbody>
<tr>
<td>Sophomore</td>
<td>31</td>
<td>47</td>
<td>79</td>
<td>103</td>
<td>107</td>
</tr>
<tr>
<td>Junior</td>
<td>37</td>
<td>39</td>
<td>60</td>
<td>97</td>
<td>106</td>
</tr>
<tr>
<td>Senior</td>
<td>39</td>
<td>38</td>
<td>45</td>
<td>51*</td>
<td>99</td>
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<tr>
<td>TOTAL</td>
<td>107</td>
<td>124</td>
<td>184</td>
<td>251</td>
<td>312</td>
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*Does not include students in the five-year program who transferred to the graduate school.

A faculty committee headed by Professor Richard G. Donnelly critically reviewed the specified requirements for the Bachelor of Science in Chemical Engineering degree; upon the committee's recommendation, the Department faculty voted to increase the current requirements, particularly in chemistry and in the area of design and chemical engineering operations.

The Graduate Program

Graduate enrollment increased again this year to a total of 185 full-time students. The enrollment in the doctoral program increased significantly to a total of 70. Offers from industry for graduates continued to be very attractive. The following table shows the trend in graduate enrollment for recent years.

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<tr>
<td>Total Graduate Students</td>
<td>148</td>
<td>149</td>
<td>163</td>
<td>181</td>
<td>185</td>
</tr>
<tr>
<td>Doctoral Candidates</td>
<td>47</td>
<td>49</td>
<td>46</td>
<td>49</td>
<td>70</td>
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</table>

Thirty-six graduate students attended the Practice School Stations during the past year. Activity at the new Albany (New York) Station started in the fall term, and with the cooperation of the General Electric Company, operation has begun in two GE plants: one at Waterford, New York, (Silicone Products Department) and the other at Selkirk, New York, (Plastics Department). The work at this station has contributed very successfully to the program by
School of Engineering

providing in-plant experience to complement the research and development work of the station at the Oak Ridge National Laboratory.

During the spring term, Professor J. Th. G. Overbeek of the University of Utrecht and Visiting Professor of Chemical Engineering at M.I.T. offered the new subject 10.621 Electrochemistry. Other new subjects being developed are 10.48J Gas-Solid Reactions to be offered jointly with the Department of Materials Science and Engineering and 10.57J Thermomechanical Processing of Polymers to be offered jointly with the Department of Mechanical Engineering.

Professor Michael P. Manning organized the Visiting Faculty Lecture Series for the year. Professors visiting M.I.T. in this series were David Ollis of Princeton University; Octave Levenspiel of the Oregon State University; Sanford Sternstein of Rensselaer Polytechnic Institute; Lanny D. Schmidt of the University of Minnesota; Howard Brenner of the University of Rochester; Alfred Anderson of the University of California at Santa Barbara; James Carberry of the University of Notre Dame; Peter Harriott of Cornell University; and L. Gary Leal of the California Institute of Technology. Professors Overbeek, William M. Deen, and Frederick A. Putnam also presented seminars. Dr. Phillip Leider of the Westvaco Corp. Research Center also participated in the seminar series.

THE FACULTY

Professor Wei was the Sherman Fairchild Distinguished Scholar at the California Institute of Technology during the fall term. He also served as Editor of the McGraw-Hill Book Company series in Chemical Engineering and on the boards of Chemical Engineering Communications, Chemical Technology, Industrial and Engineering Chemistry Reviews, and the Journal of Bioengineering. He was Vice Chairman of the Environmental Pollutant Movement and Transportation Committee and member of the Science Advisory Board of the Environmental Protection Agency. He was a member of the first US chemistry delegation to visit the People’s Republic of China chaired by Dr. Glenn Seaborg. He continued to serve as chairman of the Awards Committee of the American Institute of Chemical Engineers (AIChE) and was a member of the Steering Committee of the Dynamic Objectives Committee of the AIChE. He was elected to membership in the National Academy of Engineering. He gave invited seminars at the University of California at Santa Barbara, Stanford University, the California Institute of Technology, the Polytechnic Institute of New York, General Motors Science Laboratory, the University of Illinois at Urbana, the University of Southern California, the University of California at Los Angeles, the University of Arizona, Grace-Davidson Company, and seven universities and research institutes in the People’s Republic of China. He is a member of the Visiting Committee of the Chemical Engineering Department, University of Houston.

Professor Janus M. Beer was superintendent of research of the International Flame Research Foundation, chaired meetings of the Program Executive, and attended meetings of the International Board of Directors. He was a member of the Advisory Committee of the Italian National Research Council's Combustion Research Institute. He gave invited seminars and lectures at the Exxon Research and Development Company, Pennsylvania State University, the California Institute of Technology, and several for the M.I.T. Energy Laboratory.

Professor Clark K. Colton received the 1977 Allan P. Colburn Award of the AIChE for excellence in publications by a young member. He was elected to the Board of Directors of the Food, Pharmaceutical and Bioengineering Division of the AIChE. He served as a consultant to the Artificial Kidney-Chronic Uremia Program of the National Institutes of Health and to the
Department of Chemical Engineering

Dialysis Devices Subcommittee of the Food and Drug Administration. He was a member of the editorial board of the Journal of Membrane Science and was appointed Associate Editor of the new Journal of the American Society for Artificial Organs. He gave invited seminars at the University of Delaware, the University of Florida, the University of California at San Diego, and the University of Houston.

Professor Lawrence B. Evans served as Executive Officer of the not-for-profit CACHE (Computer Aids for Chemical Engineering Education) Corporation whose headquarters are located at M.I.T. He was an invited lecturer at the Pittsburgh Energy Research Center of the US Department of Energy and at the National Institute of Occupational Safety and Health in Cincinnati, Ohio.

Professor Emeritus Hoyt C. Hottel gave an invited lecture in the New England Aquarium lecture series. He was a member of the National Research Council Committee on the Chemistry of Coal Utilization and of the National Academy of Sciences Report Review Committee.

Professor John P. Longwell served as consultant to several government agencies including the Department of Energy and the Office of Science and Technology on various aspects of production and use of synthetic fuels and petroleum in the coming era of limited supply. He was chairman of NASA's Ad Hoc Committee on Alternate Aircraft Fuels. He also was Program Director of M.I.T.'s Energy Laboratory.

Professor Edward W. Merrill gave an invited lecture at the Institute for Materials Science of the University of Connecticut on polymers as biomaterials. He received the Outstanding Teachers Award from the Graduate Student Committee of the Department.

Professor Robert C. Reid received the American Society for Engineering Education Lectureship Award in Chemical Engineering and delivered lectures at the Chemical Engineering Faculty Summer School of the Society and at Cornell University, the University of Pennsylvania, the University of California at Berkeley and Louisiana State University. He served on the National Science Foundation (NSF) Advisory Panel for Engineering Chemistry and Energetics, the National Bureau of Standards Evaluation Panel in Physical Chemistry, the National Academy of Sciences Committee on Liquefied Natural Gas Importation, and the Visiting Committee of the Chemical Engineering Department, Princeton University. He was a member of the Brookhaven National Laboratory Advisory Panel for the Energy Division and has been elected chairman for 1978-79. He was Visiting Professor of Chemical Engineering at the University of California at Berkeley during the spring term.

Professor Paul F. Rempp of the University of Strasbourg (France) was Visiting Professor of Chemical Engineering at M.I.T. in the fall term.

Professor Adel F. Sarofim served on the Committee on Health and Ecological Effects of Increased Coal Utilization set up by the Department of Health, Education and Welfare on the implications to health effects of increased coal utilization. He was invited to present the keynote lecture on radiation at the Sixth International Heat Transfer Conference.

Professor Charles N. Satterfield served on the Ad Hoc Panel on DirectCombustion of Coal of the Commission on Sociotechnical Systems of the National Research Council. He was the invited plenary lecturer on oxidation catalysis at the NSF Workshop on Research Needs and Instrumental Requirements in Catalysis.

Professor Kenneth A. Smith delivered invited seminars at Purdue University, the Worcester Polytechnic Institute, and the University of Pennsylvania. He was a member of the editorial board for the AIChE Journal and was Associate Director of the Arteriosclerosis Center at M.I.T.
Professor J. Edward Vivian continued to serve as Executive Officer of the Department and Director of the School of Chemical Engineering Practice. He was an advisor to the Spanish Institute of Technology Postgraduate (ITP) Foundation of the National Institute of Industry in Madrid on their newly established graduate practice school program for chemical engineers.

Professor Robert E. Cohen received the young-faculty Dreyfus Teacher Scholar Grant from the Camille and Henry Dreyfus Foundation. He participated in the M.I.T.-Cairo University program; during several trips to Egypt he presented a five-day lecture course on polymer engineering and science, and visited a number of Egyptian plastics firms. He gave an invited lecture to the Akron Polymer Lecture Group. Professor Cohen also was appointed co-chairman of the arrangements committee for the 50th anniversary meeting of the Society of Rheology.

Professor William Deen was appointed the Hermann von Helmholtz Assistant Professor of Health Sciences and Technology and received the Outstanding Faculty Award from the Graduate Student Committee of the Department.

Professor Richard Donnelly was elected a director of the National Catalysis Society for a four-year term and vice chairman of the Seventh North American Meeting of the Society. He was promoted to Associate Professor of Chemical Engineering.

Professor Christos Georgakis was appointed to the Esther and Harold E. Edgerton Assistant Professorship.

Professor Frederick A. Putnam, DuPont Assistant Professor of Chemical Engineering, received the Victor K. La-Mer Award given annually by the American Chemical Society, Division of Colloid and Surface Chemistry, for the outstanding Ph.D. thesis in the field of colloid and surface science.

Professor Selim M. Senkin was appointed Assistant Professor of Chemical Engineering and Director of the practice school station at the Oak Ridge National Laboratory.

Professor Costas Vayenas from Yale University was appointed Assistant Professor of Chemical Engineering in the Department.

**RESEARCH**

The research volume of the Department was approximately $1.8 million compared to $1.6 million in 1976-77, and $1.4 million in 1975-76. When interdisciplinary research activity for which Department faculty are responsible is included, the volume is approximately $4.1 million compared to $2.4 million in 1976-77. The Department's research extends over a wide range of activity with energy and fuel projects, reactor performance studies, polymer studies, and biochemical and biomedical research accounting for the major portion.

Professor Robert C. Armstrong supervised studies of the effect on vortex formation of small amounts of high molecular weight polymers and the conformational changes in transient elongational flows of isolated flexible macromolecules. Related studies included the rheological properties of filled elastomers and bulk molding compounds.

Professor Bee continued to supervise the design and construction of two pilot plant research facilities: the Combustion Research Facility for the study of turbulent diffusion flames and the Fluidized Combustor for the study of coal combustion.
Professors Beer and Sarofim continued experiments on the fate of nitrogen compounds during coal combustion. The contributions of the oxidation of volatiles and char to the formation of nitrogen oxides and the char-nitric oxide reaction to the partial destruction of the nitrogen oxides formed have been identified. They also carried out theoretical and experimental studies on the emission of nitric oxide from fluidized coal combustion with special reference to the reduction of nitric oxide by reaction with carbon and ammonia.

An interdisciplinary group including Professors Beer, Georgakis, Longwell, Sarofim, and Glenn C. Williams from the Department developed for the Department of Energy a model of fluidized-bed coal combustors which was capable of predicting combustion efficiencies and concentrations of major pollutants in fair agreement with the limited data from pilot plant units.

Professor Lloyd A. Clomburg continued work on modeling large-scale industrial glass furnaces where the mixing is accomplished entirely by convection. The numerical analysis based on modeling the convection has been successfully utilized by industry.

Professors Robert Cohen and Armstrong completed preliminary measurements of the viscoelastic and viscometric properties of commercial polystyrene with the objective of predicting stress differences in steady shear flow.

Professor Colton continued research in the field of enzyme engineering. In collaboration with Professor D. I. C. Wang of the Department of Nutrition and Food Science he investigated the cell-free enzymatic synthesis of the polypeptide antibiotic gramicidin S and in collaboration with Professor George M. Whitesides of the Department of Chemistry he initiated theoretical and experimental kinetic studies with the co-immobilized enzyme system of acetate kinase and adenylate kinase. He carried out research in collaboration with the Joslin Research Laboratory at Harvard Medical School, oriented toward the development of artificial pancreas devices for the treatment of diabetes.

Professors Colton and Smith in collaboration with Professor R. S. Lees of the Arteriosclerosis Center and Professor M. B. Stemerman of Beth Israel Hospital continued research related to the factors which may cause arteriosclerosis. Particular attention is being given to obtaining a quantitative understanding of the transport of low-density lipoproteins and other proteins in the arterial wall. Early results indicate good agreement between theory and experiment.

Professor Deen conducted biomedical research aimed at quantifying electrostatic and electrokinetic influences on the permeation of macromolecules through glomerular capillary walls in the kidney in normal and diseased states. Related biomedical projects included experimental studies of diffusion in well-characterized microporous membranes and the modeling of transport phenomena relating to kidney function.

Professor Donnelly supervised research in the area of heterogeneous catalysis focused on the identification of chemisorbed species and the techniques for their identification. He also supervised fundamental studies in surface and colloid chemistry directed to a better understanding of the stabilization, flocculation, and coalescence factors of dispersed systems of industrial importance, such as occur in environmental problems and oil slicks at sea.

Professor Evans and Dr. Paul Gallier supervised Project ASPEN (Advanced Systems for Process Engineering). The objective of the project is to develop a computer-based process simulator, capable of modeling fossil fuel conversion processes and capable of making preliminary cost estimates and economic analyses. The project has a professional staff of nine including a number of engineers on loan from industry. Active participation in the design of the system has been obtained from an advisory committee of nearly 60 industrial and university experts in process simulation. In a related study in collaboration with
Drs. Joseph Boston and Herbert Britt, an improved technique for the modeling and simulation of acid gas treatment processes was studied.

Professors Evans and Karen C. Cohen and Professor Myron Tribus of the Center for Advanced Engineering Study (C.A.E.S.) collaborated in the direction of Project PROCEED (Program for Continuing Engineering Education). The goal of this project is to develop and evaluate a new approach to providing information and skills needed by engineers to solve problems on-the-job, particularly in adopting cost-effective methods of fuel saving in industry. A consortium of universities, industries, and professional societies is being organized to assist in the work of the project. Dr. C. Michael Mohr also participated on this project.

Professor Evans in collaboration with Professor D. I. C. Wang supervised research investigating the transient behavior of mixed cultures of yeast, grown on mixed substrates, which produced a number of complex interactions not previously reported. Professors Evans and Jack B. Howard supervised research on the analysis and design of wall supported catalytic reactors which are of particular interest in carrying out highly exothermic reactions.

Professor Ronald A. Hites continued various studies in the area of environmental organic chemistry with a view to providing background information on the identities, abundances, and fates of deleterious organic compounds found in waste waters. Such information is needed for the formulation of appropriate regulatory controls.

Professors Howard and Hites studied the role of aromatics, such as those found in coal, on the formation of soot and burnout in flames with a view to developing a better understanding of the soot-forming process in the combustion of coal. In a related study they investigated the effect of sulfur and nitrogen in coal on the formation of carcinogenic polycyclic aromatic hydrocarbons formed along with soot.

Professors Howard and Sarofim used a laser beam technique to study the kinetics of soot burnout with a view to developing efficient soot control processes. In related research they obtained data for the design of char gasifiers using a laminar flow reactor to obtain rate of reaction data of char with carbon dioxide, steam, and oxygen at temperatures from 1250 K to 2050 K. They also investigated the vaporization and recondensation of the mineral matter in coal under simulated combustion conditions with particular emphasis on the formation of sub-micron particulates.

Professor Howard carried out research on the pyrolysis and hydropyrolysis of coal to assess the important variables in coal gasification processes and in coal conversion processes based primarily on pyrolysis. In collaboration with Professor Longwell, an assessment was undertaken of the technical and economic feasibility of pyrolyzing coal in the presence of sulfur-accepting solids to produce clean gaseous and liquid fuels suitable for use in gas turbines for generating peak load electricity.

The National Institute of Environmental Health Sciences provided a five-year grant for research on the formation, composition, and toxicology of combustion-formed particulates to be administered by the newly formed Center for Environmental Health Sciences. Department faculty involved include Professors Longwell, Sarofim, Howard, Beer, and Hites.

Professor Manning continued research on kinetics and catalysis directed toward development of improved microcatalytic chromatographic reactor techniques.

Professor Merrill, in collaboration with Dr. Edwin Salzman of the Harvard Medical School, supervised research leading to two new methods of binding the anticoagulant, heparin, to polymer surfaces to produce superior compatible biomaterials. In a related study Professor
Merrill directed research leading to a novel method using carbon-14 labeled heparin for monitoring the heparin binding reaction. The method has proved to be the most accurate assay for heparin bound in very thin layers or in mono-layers yet developed.

Professor Merrill and Professor C. S. P. Sung of the Department of Materials Science and Engineering continued their studies on segmented polyurethane for biomedical uses, in particular films cast from solvent solution which they have shown have radically different biomedical behavior toward blood platelets depending on the surface contacted, whether at the air surface, at the mold surface, or in contact with internal segments. Such materials require special handling when they are to be used in contact with blood for significant periods of time.

Professor Merrill and Professor John G. Trump of the Department of Electrical Engineering and Computer Science studied the importance of radiative degradation relative to thermal degradation in depolymerizing common thermoplastic polymers in applications involving high energy radiation.

Professor Merrill, in collaboration with Professor Trump and Professor Anthony J. Sinskey of the Department of Nutrition and Food Science and Dr. Kenneth A. Wright of the Department of Electrical Engineering and Computer Science, continued research on the electron bombardment of water and sludge with particular emphasis on the effects on polychlorinated biphenyls (PCB) and related trace organic materials in water. Early results indicated nearly complete conversion of such compounds to water soluble products.

Professor Michael Modell conducted research on the unusual and relatively unexplored solvent and reactive properties of water at near critical conditions, as applied to the reforming of organics as a biomass-to-fuel and waste treatment process and to a coal conversion process to produce clean gaseous and liquid products. In related research, he invented a unique process for regenerating activated carbon and other adsorbents using near critical fluids as extracting agents, such as the use of carbon dioxide near its critical condition (31°C and 72 atm.) to reactivate the carbon adsorbent in waste water treatment.

Professor Putnam carried out research characterizing surfaces of platinum and molybdenum-sulfide catalysts with application to fundamental catalytic studies. He joined the Center for Materials Science and Engineering thrust area AT-III, an interdisciplinary group, in the study of platinum catalytic surfaces.

Professor Reid investigated the use of cobalt and/or nickel catalysts for the reduction of metabolic carbon dioxide with hydrogen for space craft environment control systems. Other phenomena studied by Professor Reid include the thermodynamics and kinetics of homogeneous nucleation, the heat capacity of liquids at high temperatures and supercritical extraction using carbon dioxide and other such materials near their critical condition as solvents.

Professors Sarofim and Longwell continued studies on methods for controlling the emission of nitrogen oxides from combustors burning fuels with a high nitrogen content by the use of high combustion temperatures to overcome kinetic constraints and fuel rich operation to overcome thermodynamic limitations. The method has shown promising results and involves an interesting competition between the reactions leading to the emissions of cyanides, amines, nitrogen oxides, and molecular nitrogen.

Professors Sarofim and Smith investigated the kinetics of secondary nucleation in crystallization processes involving the formation of two solid phases, as in entectic freezing, as well as single solid phase systems.
Professor Satterfield directed research investigating liquid-solid mass transfer phenomena encountered in trickle bed reactors and in the Fischer-Tropsch synthesis of hydrocarbons in slurry reactors.

Professors Satterfield and Modell continued their investigation of the catalytic hydrodenitrogenation and hydrodesulfurization reactions to determine the most practical methods to remove nitrogen and sulfur compounds from synthetic liquid fuels.

Professors Smith and Colton studied the effect of osmotic pressure and gel formation on the ultrafiltration of macromolecular solutions, such as aqueous solutions of albumin, using a novel interferometric method of diffusivity measurement developed as part of the project.

Professors Smith and Reid and Professor Preetinder S. Virk conducted studies pertinent to understanding the behavior of cryogenic hydrocarbon liquids, including the phenomenon of roll-over in large liquefied natural gas (LNG) storage tanks as a result of stratification due to variation in composition and density of the LNG, the phenomenon of flameless vapor explosions associated with superheating a cryogenic liquid, the phenomena associated with cryogenic liquid spills, and the possibility of electrostatic charge generation associated with LNG operations.

Professor Vayenas carried out research in catalytic oxidation reactions on metal surfaces in order to improve the theoretical understanding of these reactions and to obtain optimum product selectivity.

Professor Virk carried out research exploring the mechanism of hydrogen transfer to coal during liquefaction processes. The work involved applications of pericyclic reaction theory to ascertain the effectiveness of donor solvents.

Professor Wei supervised research on the catalytic hydrometallation process for the removal of metallic components from residual fuel oils using autoclave and continuous high pressure fixed-bed reactor techniques. He also continued in the mathematical modeling of coal gasification reactors, both for simulation of existing plant data and for predicting performance in new design and operations. The simulation has been very successful in moving bed reactors, such as the Lurgi dry ash and slagging reactors; it is being extended to entrained bed reactors, such as the Texaco and Bi-Gas reactors.

Professor Williams directed research on the high temperature absorption of sulfur dioxide by limestones and dolomites for application in the removal of sulfur dioxide in the fluidized coal combustion. In collaboration with Professor Georgakis, he studied the removal of sulfur compounds from low Btu fuel gases for combined cycle power generation by sulfidation and regeneration of solid absorbents.

JAMES WEI

Department of Civil Engineering

Operation of the Department of Civil Engineering during the past year was characterized by the largest research volume, largest student enrollment, and smallest number of faculty members in the past decade. The load on the faculty implicit in these facts was further amplified by the usually large number of faculty members engaged in 1) major administrative
responsibilities of an interdisciplinary, extra-departmental nature at M.I.T.; and 2) major studies of important national issues for President Carter's administration. Although imposing a heavy burden on the Department's operation, these extramural activities provide new evidence of the stature and leadership position of our faculty.

In addition to reduced faculty size and increased faculty responsibilities, the Department was confronted with an additional five faculty terminations to become effective at the end of the academic year. As a result, the Department conducted a search of unprecedented size and scope for new faculty members. This search resulted in the appointment of five new assistant professors and two visiting associate professors for next year. Several positions remain unfilled and will be the object of a continuing search process.

The Undergraduate Program

Undergraduate enrollment experienced a slight decline for the first time in recent years, down to 166 students from the last year's high of 176 students. This is consistent with our belief that the steady growth in undergraduate enrollment over the past decade has peaked and will level off over the next year or two.

The structure of the undergraduate program remained essentially unchanged during the past year. However, a proposed change of fundamental importance was made by the Constructed Facilities Division. As proposed, this change would consolidate three existing primary options into a single primary based on subjects in materials, structures, and soil mechanics. The intent is to unify and strengthen the mechanics base of students in the Division. Discussion of the proposal revealed a number of fundamental concerns about the current undergraduate program which will be the subject of intensive study during the next year. It seems clear that major changes in the program are likely to occur.

Our undergraduate core subject in economics, which the Department has offered for several years, was dropped from the curriculum in order that an appropriate subject involving the Department of Economics could be developed. An interdepartmental committee proposed that a joint subject be offered consisting of an existing nine-unit subject, 14.001 Economic Principles I, augmented by a three-unit segment to be taught by a faculty member from the Department of Civil Engineering. The resulting new joint subject will be offered for the first time during the next academic year.

The increased emphasis on undergraduate laboratory and field work noted in last year's report has been facilitated by increased Department support for laboratory teaching and equipment. This is a reversal of budgetary constraints on this mode of teaching in prior years and is seen as an important mechanism for attracting and maintaining undergraduate enrollment in the Department. Of special note in this regard is the successful reactivation by Professor Francois M. M. Morel of the sanitary engineering laboratory, in the basement of Building 1, for teaching an undergraduate laboratory subject in the chemical and biological aspects of aquatic systems. The two undergraduate laboratory subjects offered by the Water Resources and Environmental Engineering Division have also been able to make good use of the Charles River as a focus of their expanded activity. Professor James M. Becker's structures laboratory continues to be an innovative center of experimental work for undergraduates in the Constructed Facilities Division.

The Graduate Program

Last year's graduate enrollment which had been deliberately allowed to drop somewhat to a level of 202 students was allowed to increase during the past year to a total of 220 students,
School of Engineering

the second highest level in recent years. This large enrollment was made possible in spite of reduced faculty size and availability by relying more heavily than usual on part-time lecturers and visiting faculty.

A source of some concern for the future was the decline in US graduate applications experienced during the past year. Formal applications declined by 18.9 percent from the previous year (196 in 1976-77, 159 in 1977-78). An informal check with other leading schools indicates no increases and many similar decreases in spite of large graduating classes. The significance of these informal observations is not yet clear.

The most active development of new graduate subjects took place in the Constructed Facilities Division where five new subjects were offered: 1.441 and 1.442 Modeling of Construction Processes; 1.587 Safety of Structures and Foundations Under Dynamic Loads; 1.154 Assessment of System Behavior; and 1.573 Advanced Structural Analysis III. Within the Water Resources and Environmental Engineering Division two new subjects were introduced: 1.721 Groundwater Resources Evaluation and Modeling; and 1.75 Numerical Modeling and Sampling of Pollutant Transport.

The Transportation Systems Division continued attempts to strengthen its offerings in the areas of transportation management, and transportation policy and institutional analysis. Regarding the former, Professor Henry Marcus of the Department of Ocean Engineering was granted a joint appointment and presented a new subject, 1.285J/13.681J Issues in Transportation Management.

RESEARCH

The Department's research activities have been enlarged in recent years by the development of analytical skills for quantifying the behavior of systems and application of probabilistic methods to assess risk levels. This has led to several new research activities for our Constructed Facilities Division. The first, which is supported by the US Department of Transportation, is to assess quantitatively the impact on owner cost of alternative allocations of risk in the construction of mass transit projects. The second, sponsored by the Bureau of Mines, is to develop procedures for assessing risk in open pit mines. Exploration sampling strategies, probabilistic description of rock properties and faulting, stability of fractured rock structures, and probabilistic methods will be combined to produce safety estimates.

The Venezuelan Technical Institute of Petroleum (INTEVEP) is supporting the initiation of a research and development program on offshore structures in seismically active regions. This project provides us with a unique opportunity to establish a major integrated research effort in the rapidly evolving field of offshore construction. Elements of the program that represent new areas for us are: marine geotechnical exploration, probabilistic storm modeling and structural degradation design and construction of offshore oil production facilities. The marine exploration phase will allow us to participate in some pioneering experiments involving instrumentation developed at M.I.T.

The Department of Energy (DOE) is sponsoring work on the development of analysis capabilities for evaluating the behavior of coal gasification facilities. Our long-term objective is to have an involvement with the total spectrum of energy facilities. This project provides us with an excellent connection within DOE for the coal area.

In addition to the projects noted above, significant activity occurred in the more "traditional" areas such as earthquake engineering, soil behavior, design code formulation, analysis
methods, underground construction, and management information systems. We are expecting to receive funding for research related to dam safety which will allow us to maintain our leading position in geotechnical risk and also provide support for the establishment of activity in the economic consequences of failures.

In our Water Resources and Environmental Engineering Division, we have seen an increased level of research activities both in scope and dollar amount. In September 1977, a total of 40 research projects were active. Twenty-nine of these were supported by 14 different external sponsors: eight by Federal agencies and six by industrial organizations. M.I.T. research and endowed chairs and foundation grants supported 11 projects. Of the eight Federal agencies, the National Science Foundation (NSF) supported a total of nine projects, while the National Oceanic and Atmospheric Administration (NOAA) had seven projects. Other government agencies included the Department of Energy (two projects), National Weather Service (two projects), Office of Naval Research (ONR), State Department Agency for International Development (AID), and Environmental Protection Agency (EPA).

The participation of the Division in international water resources programs continued through a new State Department-AID project involving M.I.T., the University of Cairo, and Egyptian ministries dealing with irrigation and water resources of Egypt. Several faculty members participated together with five research assistants. The opportunity for graduate students to spend significant periods of time in Egypt while working on their research is a valuable educational feature of such projects.

A major portion of the research performed by faculty members in the Transportation Systems Division was conducted through the Center for Transportation Studies and is summarized in the Center's report.

**FACULTY**

A large number of our faculty was engaged in major studies of national significance during the past year. Among these, the following faculty members served the Office of Science and Technology of the President of the United States: Professors Erik H. Vanmarcke (Independent Dam Safety Review Panel); Frank E. Perkins (Independent Dam Safety Review Panel, Chairman); Robert V. Whitman (Working Group on Earthquake Hazards Reduction); Gregory B. Baecher (Committee on Nuclear Waste Storage); and Fred Moavenzadeh (Policy on Third World Science and Technology).

Serving the National Academy of Science were: Professors Richard L. de Neufville (Expert Mission to Korea); Peter S. Eagleson (Review Panel on Remote Sensing in Earth Sciences); Marvin L. Manheim (Bay Area Rapid Transit Impact Study Advisory Committee); and Paul O. Roberts (Committee on Transportation).

Serving the Nuclear Regulatory Commission was Professor C. Allin Cornell on the Seismic Safety Project. Serving the US Department of Labor was Professor Raymond E. Levitt on the Technical Advisory Committee on Construction Manpower Demand System. Faculty members were also involved in professional societies, local government, and other agencies too numerous to list.

The following faculty members were on sabbatical leave during the year: during the fall term, Professor Donald R. F. Harleman was a Guest Scholar at the International Institute for Applied Systems Analysis in Vienna, Austria. Professor William A. Little was at the Fluor Corporation, San Diego, California for the fall term. Professor Nigel H. M. Wilson was a Visiting Associate
Professor at Stanford University, California for the academic year. During the fall term, Professor Erik H. Vanmarcke worked on preparation of textbooks.

Professor Charles L. Ladd served as President of the Boston Society of Civil Engineers.

Professor Nigel H. M. Wilson won the Visiting Professor of Planning in Civil Engineering Award from Stanford University. He also received a Jasper and Marion Whiting Foundation Travel Award.

Faculty Changes

The following faculty members resigned from the Department during the past academic year: Professors Charles L. Miller, William A. Litle, Stamatia Frondistou-Yannas, William W. Seifert, Bryan Pearce, and Jose Roesset. Each of them has served the Department well and will be missed by their students and colleagues.

The following individuals have been appointed to the faculty of the Department for the coming year: Dr. Hilary (Max) Irvine from the University of New Zealand; Dr. Harry Hemond, a Weizmann Postdoctoral Fellow; Dr. Michael Meyer; Dr. Elisabeth Pate from Stanford University; and Dr. Yosef Sheffi.

The Department will also have Drs. Robin Arthur and Alain L. Kornhauser as Visiting Associate Professors for the coming year. Dr. Arthur comes to us from University College in London, England; Dr. Kornhauser is a member of the faculty and Director of the Transportation Program at Princeton University.

FRANK E. PERKINS

Department of Electrical Engineering and Computer Science

The Department of Electrical Engineering and Computer Science continues to concentrate in undergraduate education, graduate education, and research, with great student interest in all of these.

A new set of two subjects for the Electrical Engineering side of the common core is now under development, and will be taught for the first time in 1978-79. Professors Stephen D. Senturia and William M. Siebert are in charge of these developments.

There are two new research activities which represent the first efforts in a deliberate thrust into integrated-circuit research. Professor Henry I. Smith, who is a specialist in X-ray and electron-beam lithography, is setting up an X-ray replication facility adjacent to the Department's microelectronics laboratory. This facility will be useful to researchers at M.I.T. in several fields, and will be compatible with more extensive facilities at Lincoln Laboratory. Second, a new research project devoted to automation of design of custom LSI circuits is getting under way, under the direction of Professor Jonathan Allen.

Next year the Department will be led by a new team of Department Head and Associate Heads, since Professor Wilbur B. Davenport has resigned as Head and the two Associate Heads, Professor Fernando J. Corbato and Paul Penfield, Jr., have submitted their resignations concurrently. These three have served in this capacity for four and one half years.
Undergraduate Program

It appears that enrollment in the Department is still increasing. We anticipate that the 1978-79 undergraduate enrollment should be about 900 students as compared with a current figure of about 870. Since we are in a somewhat better position to support graduate teaching assistants, we anticipate that some of the pressure on the faculty may be relieved. We do not, however, expect to be able to return to the small-size tutorial mode in our large core subjects.

A new pair of subjects has been introduced into the Common Core Curriculum to replace Introductory Network Theory (6.011) and Signals and Systems (6.015). The new subjects are more physically based than the subjects they replace and have an added component of electronic circuits. Furthermore, we have added a laboratory to both subjects to provide an alternative to problem sets as a learning tool. These changes are part of the recommendations of the Common Core Curriculum Committee chaired by Professor Penfield. The recommendations were presented to the Department this spring. They include major revisions of the common core subjects as noted above; ensuring that all our students are knowledgeable in at least two programming languages; and continuing to search for a departmental computation facility which would increase the utilization of computers as a natural component of every student's professional activity.

The Ernst A. Guillemin Prize for the outstanding undergraduate thesis in Electrical Engineering was awarded to Roy S. Bondurant of Dewitt, New York. The Computer Systems Prize for the outstanding undergraduate thesis in Computer Science was awarded to James W. Leth of Loveland, California, and Loren M. Kohnfelder of Fullerton, California. The Institute of Electrical and Electronics Engineers (IEEE) Fortescue Fellowship was awarded to Michael E. Mauel of South Bend, Indiana. The Honeywell Award for Outstanding Achievement in Engineering went to Jordin M. Kare of Narberth, Pennsylvania.

Graduate Program

Applications for graduate study for 1977-78 exceeded 1,000 for the third straight year. The Department reduced the size of the graduate population from 505 for September 1976 to 476 for September 1977. This resulted from a reduction in the number of teaching assistantships due to budget limitations. Easing of budget limitations for 1978-79 encouraged the Department to plan on a graduate population of about 500 for the fall term 1978.

During 1977-78 the Department awarded 123 Master's Degrees, 44 Electrical Engineer's Degrees and 42 Doctorates.

Graduate students Sheldon A. Borkin, Charles H. Cox III, Roger D. Duffey, and John Carter were given Supervised Investors Services, Inc. Awards for outstanding teaching performance by graduate students in the Department of Electrical Engineering and Computer Science. The Carlton E. Tucker Award for Excellence in Teaching, which carries the same citation, was won by Thomas Holton. Professors James H. McClellan and James R. Melcher were presented Teaching Awards by the Graduate Student Council for outstanding teaching on the graduate level. Professor McClellan received the award last year also.

Cooperative Program (VI-A)

The Department's VI-A Program topped the previous year's enrollment with 78 new students, a 6.8 percent increase, so again we have the largest class in the Program's 61-year history.
During the academic year, 12.6 percent of the Department's total undergraduate and graduate population was enrolled in the Program (182 students). S.B. degrees were awarded to 22 VI-A students, while 21 others completed the entire Five-Year Program receiving their combined S.B. and S.M. degrees simultaneously.

This spring we were happy to have added Motorola, Inc. to the list of participating companies. Motorola has initially taken two students at their Communications Division in Schaumburg, Illinois and it is hoped that their Semiconductor Division in Phoenix, Arizona will be added to the Program in the next year.

RESEARCH

Most research is performed in departmental or interdepartmental laboratories. Just a few results are noted briefly here. More complete information appears in portions of this report dealing with the following laboratories: the Electric Power Systems Engineering Laboratory (E.P.S.E.L.), the Research Laboratory of Electronics (R.L.E.), the Laboratory for Computer Science (L.C.S.), the Artificial Intelligence Laboratory, the Energy Laboratory, the Electronics Systems Laboratory (E.S.L.), the Operations Research Center, and the Center for Materials Science and Engineering (C.M.S.E.).

Application of High Voltages

An intense electron beam from a high voltage accelerator has been used successfully as the deactivating agent in the treatment of municipal wastewater sludge. In these pilot plant studies, under the direction of Professor Emeritus John G. Trump at the High Voltage Research Laboratory, a prototype system erected at one of Boston's wastewater treatment plants demonstrated continuous on-line treatment providing bacterial and viral disinfection. The success of this National Science Foundation supported program has led a number of communities to consider incorporating the high energy electron process into their municipal systems. High voltage insulation techniques useful in atomic particle acceleration also have been applied to electric power transmission in another program at HVRL. In this work, compressed gas dielectrics are used to allow more compact, higher gradient power apparatus. These sealed systems, immune from atmospheric pollution, nonetheless are sensitive to minute quantities of residual particle contamination. To improve the reliability of these systems, three major areas of investigation were undertaken; new insulating gases were developed which employ mixtures of several components to inhibit discharge inception, solid insulator flashover was related to static charge accumulation, and control of particle contamination by electrostatic pumping was modeled and demonstrated.

Semantics of Distributed Computer Systems

For many computer applications, a natural realization is a distributed system of computers communicating over a network. Furthermore, the rapidly dropping cost of computer hardware and the increasing power and flexibility of mini and microcomputers indicate that such a realization will soon be economically feasible. However, there are many technical problems that must be solved to facilitate programming such systems. Professor Barbara Liskov, in conjunction with Dr. David Clark and Professors Irene Greif and Liba Svobodova, is studying these problems by investigating the design of a programming language and system to support construction of distributed applications.
Short Pulses from Semiconductor Lasers

The broad bandwidth available from lasers has not found application in communications. Laser systems that have successfully utilized the available bandwidth such as modelocked lasers producing picosecond pulses are physically large and not easily incorporated in a communication system. In an effort to develop a compact laser system with potential application to a high rate optical communication system, Professors Hermann A. Haus and Erich P. Ippen, visiting from the Bell Laboratories for one year, and their graduate students have successfully modelocked a semiconductor laser in an external resonator. The total system is 6 cm long and produces CW pulses each 20 ps long and at a repetition rate of 3 GHz. Such pulse trains can be modulated and multiplexed and demultiplexed using principles that are well known. The new system is the first step in the development of high rate optical communication systems.

Microchannel Spatial Light Modulator

Professor Cardinal Warde and his students have developed a prototype optical signal processing device called the Microchannel Spatial Light Modulator. The device characteristics are being tailored for applications which include adaptive phase compensation for atmospheric optical communication receivers, real-time optical computing, laser beam steering and incoherent to coherent light conversion. In addition, a closed-loop, all-optical feedback system that drives this device so it performs real-time phase compensation has been proposed, and theoretical calculations have been done to estimate the overall system performance. Laboratory realization of high-speed spatial phase compensation is the immediate goal of the program.

FACULTY

Faculty promotions include Thomas F. Weiss, Shaoul Ezekiel, and H. Kent Bowen to Professor; and Madhu S. Gupta, John G. Kassakian, and James H. McClellan to Associate Professor.

Professor Kenneth N. Stevens was appointed Clarence Joseph LeBel Professor of Electrical Engineering in recognition of his outstanding contributions to the field of hearing. Also, Gerald J. Sussman became the Esther and Harold E. Edgerton Associate Professor of Electrical Engineering.

Joining our faculty this year are Harold Abelson, formerly a staff member of the M.I.T. Artificial Intelligence Laboratory since 1970, and now Assistant Professor in the Division for Study and Research in Education (D.S.R.E.) and in our Department; Randall Davis, appointed Assistant Professor of Computer Science and Engineering, who received his Ph.D. in 1976 from Stanford University; Irene G. Grief, appointed Professor of Computer Science and Engineering who received her Ph.D. at M.I.T. in 1975 and who comes from an assistant professorship in the Department of Computer Science at University of Washington; Walter E. Morrow to Professor, who will also continue to serve as Director of M.I.T. Lincoln Laboratory; Michael M. Salour to Assistant Professor of Electrical Engineering, who received his Ph.D. in Physics from Harvard University; and Henry I. Smith to Adjunct Professor of Electrical Engineering, who will continue as Assistant Group Leader in Group 87 at Lincoln Laboratory.
Other academic appointments were Nathaniel I. Durlach to Senior Research Scientist, and Michael E. Kim, who was awarded an IBM Postdoctoral fellowship.

Professors Jonathan Allen and Frederic R. Morgenthaler have been elected Fellows of the Institute of Electrical and Electronics Engineers; Professor Allen was cited for contributions to the design of computer architecture for signal processing and to the synthesis of speech from text, while Professor Morgenthaler was cited for contributions to the theory and applications of microwave magnetics. Nathaniel Durlach, Senior Research Scientist, and Professor Weiss were among the 14 newly elected Fellows of the Acoustical Society of America. Professor Morrow has been elected to membership in the National Academy of Engineering for contributions to ionospheric, tropospheric, and orbital scatter communication and to military communication satellite technology. Professor Robert M. Fano, Ford Professor of Engineering, has been elected to membership in the National Academy of Sciences. Professor Mildred S. Dresselhaus is the 1977 achievement award recipient given by the Society of Women Engineers. Nils R. Sandell, Jr., Associate Professor of Systems Science and Engineering, has been awarded the 14th Donald P. Eckman Award by the American Automatic Control Council.

Professor Davenport has been appointed to a new Carnegie Commission to study the future course of public television in the United States; and Professor Jack Ruina has been appointed by the Federal Office of Science and Technology as a senior consultant concerned with matters of national security and technology transfer.

The Department was happy to welcome the following Visiting Faculty during the academic year. Professor Yu-Chi Ho was appointed Visiting Professor of Electrical Engineering and Computer Science; as Gordon McKay Professor of Engineering and Applied Mathematics at Harvard University, he worked in the field of control and communications systems research. Visiting Professor Erich P. Ippen comes from Bell Telephone Laboratories where he is a member of the technical staff, and worked in experimental optics with Professor H. A. Haus and associates. Professor James L. Massey is Visiting Professor of Electrical Engineering, from the University of Notre Dame where he is the Freimann Professor of Electrical Engineering and worked in communication networks.

Department faculty who were away this year included Professors Davis, Gerald P. Dinneen, Murray Eden, Robert G. Gallager, Ronald Parker, Michael M. Salour, Jerome H. Saltzer, and John McReynolds Wozencraft. Professor Davis spent the first year of his appointment as Assistant Professor on leave so that he could continue and complete the research he had performed for his Ph.D. at Stanford University. Professor Dinneen has been granted a leave of absence to accept the position as Assistant Secretary of Defense under President Carter. Professor Eden extended his leave of absence to continue as chief of the Biomedical Engineering and Instrumentation Branch of the National Institutes of Health's Division of Research Services in Washington, DC. Professor Gallager received a 1977-78 Guggenheim Fellowship which enabled him to conduct theoretical studies in data communications networks at L'Ecole National de Telecommunication, Paris, France. Professor Parker was on leave from academic duties and pursued his research on controlled thermonuclear fusion at the M.I.T. Francis Bitter National Magnet Laboratory. Professor Salour spent his first year on the faculty on leave and at the Optics Section of the Physics Department at Imperial College London. Professor Saltzer was on sabbatical from academic duties as a Temporary Visiting Scientist with the IBM Data Processing Group in White Plains, where he worked on communicating computer systems. And Professor Wozencraft continued his leave to head the establishment of a Master's degree program at the Naval Postgraduate School at Monterey, California.
Department of Materials Science and Engineering

Professor Barry A. Blesser has resigned to direct a consulting firm; and Professor Ira Goldstein has resigned to accept a pair of positions at the Xerox Palo Alto Research Center and at Stanford University.

WILBUR B. DAVENPORT, JR.

Department of Materials Science and Engineering

Undergraduate Program

The success of the freshman course in solid-state chemistry, 3.091, continued unabatedly under the able direction of Professor August Witt. In the fall of 1977 344 students registered and a further 82 students took the course in the spring of 1978. Many members of the faculty continued to participate in this activity by teaching recitation sections on a regular basis.

The number of undergraduate students electing to major in Materials Science and Engineering continues to increase. During the year under review, we had 35 sophomores, 28 juniors, and 13 seniors, making a total of 76 students registered in the Department. From the pre-registration figures, we confidently expect that we will have 40 sophomores, 35 juniors, and 28 seniors, making a total of 103 undergraduate students in the Department in the coming year. This will be the first time since the immediate post-war years that the total number of undergraduates in the Department has exceeded 100. In large measure, the increase in the number of undergraduates who find an attractive and relevant program in the Department has been due to the success of the Engineering Internship Program (still called by almost everybody the Coop program) which is Course IIIB.

The phenomenal success of this Program is due almost entirely to the enthusiasm and administrative skill which Professor Thomas King has brought to the task of placing and supervising the students involved. During the academic year there were 34 students in the Internship Program; five of them graduated in June. Of the 29 remaining students, 24 were placed in suitable jobs by the efforts of Professor King and the faculty and staff of the Department. The remaining four students were placed by the new Engineering Internship Program administered by the Dean's office. The collaboration between the departmental and the School-wide Engineering Internship Program has been good. The existence of people in the Dean's office who are able to help with this Program has been appreciated by us. We foresee a further growth in the departmental Engineering Internship Program in the next year or two and we will certainly need additional help in the near future.

During the year a number of the subjects we offered attracted many students from other parts of the Institute, and consequently we were running classes with between 40 and 50 students in them. This is more than we like to teach at one time, but with our limited resources it is not possible to divide these classes into smaller groups. The pressure was felt particularly in the laboratory, 3.081, taught by Professor Robert Ogilvie. This is proving to be an exceptionally attractive laboratory subject for many students. During the last year more than 40 students registered in the subject and we anticipate an even larger enrollment next year. We attempted to cope with this increase in numbers by duplicating experiments and by running small groups of students through the laboratories at different times of the day. We have
allocated a substantial proportion of the equipment money available to us to re-equip and update this laboratory; next year we will have television teaching aids in the laboratory to help with the large number of students.

Graduate Program

The number of graduate students is determined by the financial resources available to us through research grants and contracts, and the manner in which the faculty and others decide to spend this money. During 1977-78, we have averaged 156 graduate students in the Department. At the present time, this number has dropped to 151 because of students graduating. We confidently expect the number to increase again to 160 or more in September.

As of February 1978, 19 of the graduate students were women, two were black, and four were Asian American. The proportion of women both in the undergraduate and graduate programs continues to increase. Perhaps this reflects the record of achievement of women in the Department in past years. Since 1970-71, nine women have received doctorates in the Department, a much larger number than in any other department within the School of Engineering. At the present time, we have 15 teaching assistants and 11 students on fellowships. The remarkable number of 106 of our students are supported by research assistantships, proportionately more than in any other department.

Faculty

Professor Kenneth C. Russell was promoted to full professor. Professor John W. Cahn spent a second year on leave at the National Bureau of Standards.

Professor Robert W. Balluffi, Francis Norwood Bard Professor of Metallurgy at Cornell University, was appointed Professor of Physical Metallurgy. Professor Balluffi, one of the most distinguished experimentalists working in metallurgy today, will join the faculty of the Department in August 1978.

Last year, as in previous years, the members of the faculty received many honors and awards. These will be set out in detail elsewhere. Two honors merit special mention. Professor Robert L. Coble was elected to the National Academy of Engineering. Professor Morris Cohen received the National Medal of Science from President Carter.

Research

The rapid expansion in our research efforts devoted to the role of materials in energy applications continued throughout 1977-78. In the academic year 1977-78, the Department administered research grants and contracts to a total value of more than $13 million. The expenditure on research was at a rated $4.8 million per annum. This means that on the average, each member of the Department of Materials Science and Engineering spends approximately $140,000 per annum on research and provides very nearly half of the salary budget for the academic year from these funds. As I noted in my report last year, this puts a very heavy burden on the faculty who have to write proposals, attend workshops and review meetings, and prepare for visits by the sponsors, in addition to doing research and teaching. The fiscal management of these many and often complicated budgets is a task which is not a part of the departmental administrative responsibilities in some other departments.
As I indicated in my report last year, the change to an emphasis on research related to energy has resulted in some change in the style of our research operation. Much of it is now carried out by interdisciplinary groups of professors and students. Many of the groups are brought together by the Energy Laboratory, the Bitter National Magnet Laboratory, or one of the other mission-oriented laboratories within M.I.T. The association with industrial laboratories in these various cooperative efforts has continued to increase. To carry out our part of the research on time and to provide continuity and professional guidance to our students, it has been necessary to increase the full-time research staff. We now have 40 postdoctoral research assistants of various types, including 15 Visiting Scientists.

In all classes of materials (ceramics, metals, polymers, electronic materials, and glasses) the emphasis is strongly on the processing of the materials. It is now recognized that processing is not only a way of producing components of the required size and shape, but it is also an essential means of determining and controlling the structure and hence the properties of the component. There is also an increasing awareness of the importance of productivity and the economic advantage to be gained by substituting one process for another. Thus, much of our research is concerned with materials engineering in its many aspects.

It is not possible here to describe all of the research projects under way. A new technique which already has many variants and appears to have a wide range of applications will serve as an illustration. The production of solid components by radically new powder techniques is currently the subject of intense interest at the research and the development stages. The production of extremely fine powder by various ingenious devices has opened up many new avenues to low-cost production of high-duty components. Some of these devices involve the use of lasers, the quenching of these powders very rapidly, the consolidation of the powders by hot isostatic pressing, or other techniques which involve superplastic flow of the solid material. In a few instances, these techniques are being used on a production basis to make components from traditional alloys. We are exploring many aspects of this set of problems. For example the ceramic processing group is studying the precise mechanisms by which super-fine powders can be consolidated into 100 percent dense, highly uniform ceramics for high temperature and other structural applications. The metallurgists are exploring parallel techniques applied to alloys which cannot be made in sufficiently ductile form by conventional methods. This is leading to some very exciting new materials, for dyes, for aluminum structural components, and for hard magnetic materials, to quote only a few examples. Professors Harvey Kent Bowen, Robert Coble, Morris Cohen, Nicholas Grant, Regis Pelloux, and John Vander Sande are all involved in various aspects of this work.

While the work on processing is attracting so much attention, we are not unmindful of the necessity to continue both the quantity and quality of our more basic scientific work. This work provides the scientific basis for understanding the mechanisms involved in the various processes and the structure-property relationships of the new materials we are developing. In this more basic science we have been aided greatly by the installation of a new type of scanning transmission electron microscope (VG HB5 STEM) which has been installed in the electron microscope facility of the Center for Materials Science and Engineering. Professor Vander Sande has been largely responsible for this development which provides unique and exciting opportunities to not only detect but also to identify and characterize extremely fine particles. We look forward to the establishment during the coming year of a related facility concerned with surface characterization. This will be supervised by Professor Ronald Latanision.

Throughout the year, as in previous years, the faculty of the Department have continued to give much thought to the question of balances between our efforts in undergraduate and graduate teaching and in research; balances which determine the character of a department. We are a department which is strongly oriented toward research. We put a great deal of effort into our undergraduate program and we are, of course, pleased to see that this activity is now prospering. The research environment adds much to the quality of the educational experiences of our students.
at all levels. We will continue to watch the balance between the numbers of postdoctoral research associates, graduate students, and faculty to ensure that we maintain the high sense of excitement about research and, at the same time, continue to provide the best possible education and training for our undergraduate and graduate students.

WALTER S. OWEN

Department of Mechanical Engineering

The mechanical engineering profession continues to offer rewarding careers solving many of the serious problems society faces, particularly in energy supply and conservation, health care and human rehabilitation, transportation, environmental engineering, and manufacturing. The broad disciplinary base in mechanics and materials, the fluid and thermal sciences, and system dynamics and control, combined with the design orientation of the field, provides a very flexible background not only to deal with today's problems but also those which will develop in the future as societal needs and priorities shift. With the curricular freedom afforded by the unspecified bachelor's and master's programs, mechanical engineering also provides excellent background for careers in medicine, law, public policy, and management.

Enrollment in the Department increased again this year (11 percent undergraduate and 24.5 percent graduate) reflecting the increasing demand for mechanical engineers, the growing importance of the field, and the high quality of the faculty and academic programs. The increase in total undergraduate enrollment occurred in spite of a 25 percent drop in the entering sophomore class size to 99. Undergraduates now number 349 or nearly twice the population in 1973-74. Projections for next year indicate a sophomore class of 120 to 160 students and a total undergraduate body of around 425, which is at the upper limit the Department can accommodate with existing space and equipment. While the growing popularity of mechanical engineering (now the second largest Course at the Institute) is gratifying, the large growth in students combined with a reduction in the number of faculty has placed an intolerable work load on the Department and threatens its continuing position as the nation's leading department of mechanical engineering.

Demand for the Department's graduates was also very keen. High starting salaries for S.B. and S.M. graduates, together with vigorous industrial recruiting, deterred some highly qualified students from continuing toward the Ph.D. At the same time the demand for Ph.D.s both from industry and academia increased strongly. Companies in search of mechanical engineers made numerous visits to the Department to explore ways in which they could attract graduates through support of fellowships, summer employment, unrestricted grants to the Department, or by affiliation with the Industrial Liaison Program. Doctoral candidates interested in teaching received multiple offers as most mechanical engineering departments in the country attempted to add junior faculty.

Total research volume and volume administered through the Department are projected to increase from $5.66 to $7 million and $3.36 to $4.4 million, respectively. The total volume includes research performed by mechanical engineering faculty through the inter-departmental centers and laboratories. The major research activities of the faculty, although very broad, are concentrated primarily in four principal programmatic areas: Energy and Environment; Biomedical Engineering; Manufacturing, Materials and Materials Processing; and Human Services including Transportation. Cutting across these programmatic lines, about half of the faculty members are engaged in some energy-related research.
The Department organization in three disciplinary divisions -- Mechanics and Materials, Fluid and Thermal Sciences, and Systems and Design -- was continued. The Heads and Associate Heads of the three divisions were respectively: Professors Nam P. Suh and Stanley Backer (who is new this year); Professors Joseph L. Smith, Jr. and Ain A. Sonin; and Professors David N. Wormley, (also new this year), and Henry M. Paynter. The Steering Committee, consisting of the Department Head and the above six faculty members, sets the Department policy and advises the Department Head on matters of personnel, program development, and internal resource allocation.

Additional progress was made toward implementing the recommendations of the Departmental Planning Committee Report of 1976 (summarized in the 1975-76 Annual Report). The ad hoc Graduate Curriculum Review Committee completed its work and presented a draft report which was accepted enthusiastically by the faculty; highlights of their findings are included here under the "Graduate Program."

The Planning Committee's recommendation to refurbish the Sloan Laboratories in Building 31 to create a new Fossil Fuel Research Facility has been substantially implemented. These laboratories have been placed under the supervision of the Dean of Engineering. They currently encompass research in combustion, automotive engine efficiency and emissions, gas turbines, smoldering combustion, and MHD with participation of the Energy Laboratory and faculty from the Departments of Mechanical and Chemical Engineering and Aeronautics and Astronautics.

Plans for an Engineering Design Center in refurbished space on the fourth floor of Building 3 are being developed and should be completed during the coming academic year. The Department's design activity received a significant boost this year through arrangements to acquire a complete modern computer-aided design facility by September 1, 1978. This facility will make possible the introduction of computer-graphics concepts at the freshman level and of hands-on use at the upperclass and graduate levels.

Construction also progressed on the new Biomechanics and Human Rehabilitation Laboratory under the leadership of Professor Robert W. Mann and his colleagues. Plans are now being finalized for completion of the Laboratory.

The new Laboratory for Manufacturing and Productivity, with the incorporation of the previously successful M.I.T./Industry Polymer Processing Program, has now reached an annual research volume exceeding $1 million. The Laboratory is directed by Professor Suh, and faculty from several departments in the School of Engineering and the Sloan School of Management as well as staff from the Center for Policy Alternatives are involved.

In accord with the Planning Committee recommendation for the establishment of a pilot S.B.-S.M. Cooperative Program with Industry, the Department joined in the new School of Engineering Internship Program, placing 11 sophomores in seven participating companies.

All of the above activities are outlined in greater detail in the "Graduate Program" and "Research" sections of this report.

UNDERGRADUATE PROGRAM

Undergraduate enrollment grew by 11 percent this year following a record 30 percent increase in 1976-77. The increase this year occurred in spite of a 25 percent reduction in the size of the entering sophomore class from 125 to 99. The total of 349 undergraduates is the largest
School of Engineering

class since the 1950s, is nearly twice the population in 1972-73, and exceeds the graduate population for only the second time (the first in 1976-77) in 30 years. More than 100 sophomores are already preregistered for 1978-79 and projections indicate an entering class of 120 to 160. This increase will produce a projected population of 425, three and a half times the enrollment in 1971-72 and almost twice the graduate population.

This continued increase places intense pressures on the faculty and facilities of the Department which have not expanded to meet the demands of increased enrollment. An infusion of new equipment, more and refurbished space, and -- of most importance -- additional junior faculty are essential to the continuing quality of the undergraduate program.

The reasons for the dramatic growth of undergraduate enrollment are complex but are believed to include such factors as: outstanding job opportunities for graduates in such expanding fields as energy, manufacturing, and mechanical design; the great flexibility of the profession; the breadth and flexibility of the undergraduate program as preparation for careers in medicine, law, public policy and technology assessment, and management; and the quality of the faculty and the program. The popularity of mechanical engineering nationally shows similar trends to those at M.I.T.

About 14 percent of the Class of 1978 had taken advantage of the undesignated degree program (Course II-A) to pursue interdisciplinary programs meeting their particular career objectives. Of the 37 undergraduates registered in II-A, about half are combining chemistry, biology, and mechanical engineering as preparation for biomedical engineering and/or medical school. Graduates of this type of program have been extremely successful in gaining entrance to leading medical schools. Other programs frequently chosen by II-A students relate to energy and environmental policy, law, and management.

Women and minority students continue to choose mechanical engineering approximately in proportion to their relative populations at M.I.T.

The Engineering Internship Program

The Department's undergraduate cooperative program, Course II-B, was combined this year with the new School of Engineering Internship Program. Acceptance into the program is based on selection of student applicants at the end of their sophomore year by participating companies. The program provides for two planned summer work experiences, for which academic credit is given, during the undergraduate years. Students may terminate at the end of their fourth year with an S.B. or if admitted to graduate school may continue the internship and write a single combined bachelor's and master's thesis, possibly on a problem provided by the cooperating company. The graduate program involves an additional seven months' work experience and requires a total of five calendar years from freshman matriculation to completion of the S.B. and S.M.

A total of 21 mechanical engineering sophomores from the class total of 99 applied, and 11 were placed with seven different participating companies. Professor Igor Paul directs the Internship Program within the Department and serves on the Engineering School Internship Steering Committee.

Undergraduate Office

The Undergraduate Office, now in its fifth year, continued its invaluable service to undergraduates under the guidance of the Undergraduate Officer, Professor Peter Griffith, and his assistant, Peggy Garlick. The Office is a clearing house for all undergraduate activities.
Department of Mechanical Engineering

combining functions previously scattered throughout the Department: faculty teaching assignments (both graduate and undergraduate); communication between the Department and the Registrar's Office, the Schedules Office, and the Committee on Academic Performance; listing of job opportunities; coordination of UROP projects and undergraduate thesis topics; and support of the student-operated Pi Tau Sigma course and instructor evaluations.

**Undergraduate Enrollment Committee**

The Undergraduate Enrollment Committee, which is responsible for presenting the Department and its programs to prospective students, was continued with Departmental Instructor Jeffrey L. Stein responsible. Major activities included participation in the Freshmen Academic Midway in September, the Department's contribution to M.I.T.'s Open House, and conceiving and organizing FITME DAY (Freshmen Introduction to Mechanical Engineering). The first annual FITME DAY, which included a tour of the Department and informal discussion with its faculty, was well received by over 70 freshmen who attended. During Open House, visitors crowded enthusiastically into many of the Department's laboratories which gave interesting and informative demonstrations.

**Undergraduate Committee**

The Undergraduate Committee, chaired by Professor James A. Fay, and composed of seven faculty and 11 representative student members, provides a very effective policy forum for all issues affecting undergraduate life at M.I.T. When appropriate, it recommends action by the department administration, the faculty or its committees, or student groups. During its three meetings this year the main agenda items were: possible reasons for the recent large increases in enrollment, producing overcrowding of classes and laboratories, and a shortage of thesis supervisors; the restructuring of subject 2.30 Mechanical Behavior of Solids; and a proposal to provide evening open hours of the student shop.

As a result of the Committee's recommendations, the following actions were taken: 1) Pi Tau Sigma (the Mechanical Engineering Student Honorary Society) will conduct a survey of undergraduates to determine why they selected mechanical engineering as their major field of study and report its findings next year. 2) The offering of more restricted electives in both terms will be considered even at the expense of increasing section sizes of the core subjects. 3) The undergraduate thesis, which was considered worthwhile, will remain as a departmental requirement, but the Department will encourage a broader selection of faculty to propose suitable topics and serve as advisors. The thesis topic list will be published as early in the fall term as possible, so students can locate their advisors at an early date. 4) Various new approaches to revising and revitalizing 2.30 Mechanical Behavior of Solids are being considered, with particular attention given to improving the overcrowded and antiquated laboratory. 5) The Department, on a trial basis at the end of the spring term, kept the student shop open one evening a week to facilitate completion of projects and theses.

**Undergraduate Laboratory**

The Undergraduate Laboratory includes four basic core subjects: 2.86 Manufacturing Processes Laboratory, 2.671 Measurement and Instrumentation, 2.30 Mechanical Behavior of Solids, and 2.672 Projects Laboratory, plus one restricted elective 2.14 Control System Principles. All of these subjects involve extensive facilities, including machine tools, mechanical testing machines, electromechanical devices, and electronic and mechanical instrumentation. Because of the budget stringencies of recent years, much existing equipment is now outdated and subject to an increasing frequency of failures which frustrate students and in some cases present safety hazards.
A limited amount of new laboratory equipment was acquired this year using M.I.T. funds and unrestricted industrial grants. Funds for a new controls laboratory to include microprocessor-based hybrid student work stations were requested from the National Science Foundation through the Instructional Scientific Equipment Grant Program.

Under the direction of Professor Adam C. Bell and with the support of Technical Instructor Edward Fischer the two laboratories 2.671 and 2.672 have been very successfully integrated into a common location in the basement of Building 3. This integration has optimized utilization of space, instrumentation, and supervisory personnel while enhancing the quality of the undergraduate laboratory experience.

The quality of teaching in the laboratories remains excellent and student interest in these subjects continues to increase.

New experiments were developed by Professors Griffith and Avram Bar-Cohen in 2.672 and by Professor Bell in 2.671.

Subjects of Instruction

Professor Wormley restructured the laboratory for 2.14 Control System Principles to include the use of small analog computing stations and "black boxes" which the students use in system identification experiments. It is hoped that this laboratory can be extended next year to include digital control and microprocessor applications to mechanical engineering.

Professor Shawn Buckley in collaboration with colleagues from the School of Engineering together with Professor Jay Forrester and his colleagues from the Sloan School of Management have developed a new subject 2.193J Dynamics of Physical and Social Systems. The objective of this subject is to introduce the conceptual and technical foundations of systems dynamics -- both physical and social -- without prior knowledge of calculus. This subject will become an Engineering School-wide elective next year.

Professor Alician V. Quinlan, following two years of development, codified the Department's undergraduate offerings in environmental ecology into a two-term sequence 2.131J and 2.132J Environmental Ecology I, II which provides an introduction to modeling, dynamics, and control of environmental ecosystems.

Professor Peter Huber has developed a new advanced undergraduate subject, 2.21 Applications in Fluid Mechanics, which will be offered for the first time in spring 1979. The subject is expected to become a restricted elective and will deal with such areas as compressible flow, turbulence, and boundary layers with applications to lifting surfaces, internal flows in conduits, and fluid machinery.

Professor Robert O. Ritchie, as Series Professor for the undergraduate subject sequence in mechanics, processing, and materials, is leading an evaluation of the content of these subjects. As a result of the review to date, an experimental section of 2.01 Mechanics of Solids will be conducted this fall by Professor Frank A. McClintock. The objective of the experiment is to determine how modern finite-element approaches to structural analysis should be introduced into the foundations of this subject.

The Design Contest, now a classic component of 2.70 Introduction to Design, created unusual excitement among both faculty and students as sophomores competed with their personally designed and fabricated vehicles in the "King of the Mountain" contest. Professor Woodie C. Flowers is in charge of this subject. Student enthusiasm for design throughout the undergraduate program remained high.
Student Organizations

The Student Chapter of the American Society of Mechanical Engineers (ASME) was led this past year by its officers, Valynn Knight, President; Emilie McCabe, Vice President; Sue Burzyk, Treasurer; Warren Manning, Secretary; and Professor David C. Gossard, Faculty Advisor. The Chapter organized a series of speakers for its regular meetings to discuss various aspects of the engineering profession, and the Chapter's activities were expanded to include organizing and sponsoring a series of plant visits during the January Independent Activities Period. In addition, President Knight and Vice President McCabe attended the national ASME winter annual meeting in San Francisco. Their attendance was made possible through a gift from the Procter and Gamble Company.

Pi Tau Sigma, the mechanical engineering honorary society, continued its tradition of service to the Department, the most valuable of which is the student evaluations of subjects of instruction and instructors. This spring, the students made plans to survey undergraduates to determine the reasons for the rapidly growing popularity of the Department. The biweekly student-faculty Friday afternoon parties, which provide a friendly forum for discussion and relaxation, were most successfully continued this past year. Officers of Pi Tau Sigma were William Baum, President; Elizabeth A. Kendall, Vice President; Linda A. Dornbrook, Treasurer; and Richard L. Steidle, Secretary. Professor Ernest Cravalho continued to serve as Faculty Advisor.

BlackME, the organization of black students in mechanical engineering, provides academic help and facilitates communications among black students and between them and the faculty. The organization, formally constituted two years ago, proved singularly successful at first in improving both the morale and academic performance of the Department's black students. During the spring of 1977, morale deteriorated due in part to frustration among some seniors who were unable to secure financial support for graduate study, and as a result of communications breakdown between some black students and faculty.

This year, with Professor Borivoje B. Mikic as Faculty Advisor and A. David Stuart as President, BlackME and the Department successfully restored a sense of enthusiasm to the organization. BlackME hosted two student/faculty dinners which resulted in friendly but very frank and helpful interchanges of views and conceptions; is completing a file of study materials for all the required mechanical engineering subjects which will be available to all students; and sponsored an open house this spring to interest black freshmen in the Department. Professor and Mrs. Mikic also sponsored an informal dinner party for the members and their faculty advisors. These activities, together with increased interest in the tutoring program on the part of this year's sophomores (the group for whom the program is most beneficial) have revitalized BlackME and greatly improved the morale of our black students. This year two BlackME representatives (Mr. Stuart and Connie Nathan) were named to the Undergraduate Committee.

Notable Student Awards

Susan L. Kayton was one of the women selected for an Association of M.I.T. Alumnae Senior Academic Award for 1978 for her "innovative capability and can-do spirit." The Department received a large number of outstanding entries for the Luis de Florez Awards. Prizes were awarded on the basis of "outstanding ingenuity and creative judgment." The first prize of $1,000 was won by J. Randolph Andrews for an innovative folding bicycle, second prize of $500 by Eric L. Mears for his Grip Slip Over-Running Clutch, and the $300 third prize by Brian S. Armstrong for his Bed/Desk System. Finally a $200 fourth prize was awarded to Richard L. Steidle for his Perspective-Drawing Drafting Protractor.
School of Engineering

GRADUATE PROGRAM

Graduate enrollment increased this year to 274 students, an increase of 24.5 percent in spite of the fact that the number of new applications received (343), applicants admitted (196) and percent of admitted students registered (45 percent) did not change significantly from fall 1976. This is the first substantial increase in graduate enrollment in over four years and is apparently due to more graduate students continuing their education owing to an increase in available financial support. Evidence of this observation lies in the facts that research assistantships increased by five percent to 138, teaching assistantships from three to 10, National Institutes of Health Predoctoral Fellowships from one to five, and foreign fellowships from 24 to 36. It is expected that next year's enrollment will receive a boost from an increase in industry-sponsored students.

In 1977-78 the Department awarded 72 S.M. degrees, one combined S.B./S.M. degree, seven Mechanical Engineer and 20 doctoral degrees.

Ad Hoc Graduate Curriculum Review Committee

Following a recommendation of the Departmental Planning Committee, the Department Head appointed an ad hoc Graduate Curriculum Review Committee to evaluate the existing graduate curriculum and make recommendations for changes in content and administrative procedures in light of the evolving and future requirements of graduate education in mechanical engineering. The Committee included a core group of faculty members, one from each of the Department's three disciplinary Divisions, together with an outer group of nine. An intense review was conducted within each Division, coordinated by Committee members, but carried out primarily by small faculty groups and reviewed by the divisional faculty as a whole. Special emphasis was placed on identifying core graduate subjects which cover, in graduate-level depth, the basic disciplines upon which the mechanical engineering profession is based. Typically, these are the first subjects taken by incoming graduate students, and usually make up a large fraction of the subjects most graduate students take in their first two years. These subjects also provide basic background for the doctoral qualifying examinations.

The Committee's recommendations, released in a draft report and approved by vote of the faculty in spring 1978, have resulted in the following actions:

A series of graduate core subjects has been identified consisting of existing, revised, and new basic subjects in the underlying mechanical engineering disciplines and their integration through the design process.

Two new core subjects were designated; a new design subject 2.731 Advanced Engineering Design (which was developed and successfully given in spring 1978) and a new subject in manufacturing-oriented disciplines, 2.865 Manufacturing Processes and Surface Properties. Several core subjects and advanced follow-on subjects have been revised and restructured (see the section on New Subjects of Instruction).

The foreign language requirement for the doctorate was considered to make "little contribution to the quality of a typical Ph.D.'s research or to his/her professional relationships, nor did it effectively serve a cultural purpose," and was, therefore, abolished by vote of the faculty. In addition, recognizing that many of the graduate students write poorly, in October 1977, the faculty adopted the Committee's comprehensive recommendation requiring all incoming graduate students to demonstrate satisfactory English writing ability or
Department of Mechanical Engineering

successfully complete remedial training. This controversial recommendation was approved by a substantial majority of the faculty. The process for its implementation has been worked out with the assistance and support of the Department of Humanities and will be in effect for graduate students entering this fall.

The Committee's recommendation that a small Graduate Academic Committee be established to review the curriculum has been implemented through the formation of an Academic Policy Committee which will have responsibility for both undergraduate and graduate policy matters including approval of new subjects, review of curricula and subject content and relevance, and admissions policies and procedures. This group will supercede the Undergraduate Executive Committee which will be disbanded. Professor Joseph L. Smith, Jr. has been appointed as the first chairman of the new committee.

New Subjects of Instruction

A new core subject 2.731 Advanced Engineering Design was developed and successfully offered by Professor Bell in the spring term. This subject emphasizes the creative process of design from identification of need to the details necessary for physical realization, drawing heavily on the broad range of disciplines typically required in the synthesis of a complex device or system. A novel feature of this course is the use of a new "axiomatic" approach originated this year by Professor Nam P. Suh for rational decision making in the design of products for efficient manufacturing and assembly.

Development of a new course, 2.865 Manufacturing Process and Surface Properties, to serve as a basic core subject in manufacturing-oriented disciplines was initiated. It will cover:
1) surfaces, friction and wear, lubrication; 2) metal forming, metal cutting, and unconventional manufacturing methods; and 3) manufacturing systems and automation.

Professor Michael P. Cleary introduced 2.074 Mechanics of Porous/Geological Materials to bring modern methods of continuum mechanics to bear on the design of machines, extraction schemes, and structures involving geo-materials. The subject includes an overview of available techniques, solutions, and remaining problems. Professor Cleary also revised 2.072 Mechanics of Continuous Media to achieve a comprehensive, compact presentation of the discipline, using such classical subjects as rubber elasticity, viscoelasticity, plasticity, and fluid dynamics to illustrate practical applications of the general unified formalism.

A new course 2.157 Computer-Aided Design was developed by Professor Gossard and will be offered for the first time in the fall of 1978. This relatively new area of study does not have a well-established position in most university curricula even though it is a rapidly growing field and an increasingly important engineering tool. Professor Gossard's objectives are 1) to provide students with hands-on experience in the use of interactive graphics systems, 2) to expose students to the use of the computer as an aid in design and engineering evaluation, and 3) to provide an understanding of the state of the art of computer-aided design system applications.

A new control course, 2.171 Analysis and Design of Actuation Devices and Computer Control Systems, was also introduced in the fall by Professor Richard S. Sidell. The subject deals with the modeling, analysis, and design of electromechanical, hydraulic, and pneumatic power-level actuators, the synthesis of continuous and discrete control algorithms, and the design/selection of analog and digital control hardware. Emphasis is placed on the similarities among various types of actuators and on their nonideal nonlinear properties. The use of minicomputers and microprocessors in the control of physical systems is also discussed. The concepts
presented were reinforced by laboratory experience with computer control systems and control hardware.

Previously titled "Biomechanics," 2.75 has been renamed "Physiology of Human Movement" to reflect a substantial revision to augment prior stress on the applied mechanics of the human muscular skeletal system with an extended treatment of neurophysiology, brain science, and movement control. Under the direction of Professor Mann the goal is to explicate the relevant anatomy and physiology via applied mechanics and the information and control sciences and to illustrate how, over the long term of evolution and the short term of ontological development, the subtle interaction of nervous system information and biomechanical response influence the development of the species and of the individual.

Two courses this year: 2.18 Man-Machine Systems under Professor Thomas B. Sheridan and 2.120 Introduction to Transportation Technology under Professor J. Karl Hedrick were videotaped and distributed as part of the Center for Advanced Engineering Study's Tutored Video Instruction Program.

Student Life

Graduate students in the Department remained active both as a group and as individuals. Participation in the M.I.T. intramurals program has been extremely high with as many as four Department teams playing one sport.

Jeffrey L. Stein, Departmental Instructor for 1977-78, will return to full-time doctoral study next year. Mr. Stein is working with Professors Flowers and Derek Rowell on the design and control of above-knee prostheses.

RESEARCH

Research Volume

The total volume of sponsored research and the volume administered through the Department are projected to increase by 30 percent and 23 percent to $7 million and $4.4 million, respectively, for academic year 1977-78. The research volume per faculty will be approximately $142,000, a truly remarkable figure in light of the substantial increases in teaching loads and in the burden of Federal paperwork of recent years. Trends toward shorter-term contracts and long delays in Federal decision making and in contracting procedures have also made university research increasingly difficult.

Because of the stringencies of the budget for instruction, the Department has been unable to increase the number of faculty. To cope with the research load, it has been necessary to add additional professional staff who can devote full time to research. This step has been taken reluctantly since the Department considers engineering education to be its primary mission and would prefer that available research funds be used to support graduate students and faculty.

The shortage of discretionary funds for entering new fields of research, for career development of junior faculty, for acquiring new research equipment, and for supporting basic disciplinary research not currently popular with funding agencies continues to be a serious problem. Some
relief was afforded this year by the award to the Department of seed funds for the Laboratory for Manufacturing and Productivity from the IBM Fund and the Sloan Basic Research Fund, and of equipment grants and salary support for new research in the area of fracture mechanics from the Sloan Basic Research Fund. In addition, some increases were made in grants to the Department by industrial firms and foundations. Such grants have proved extremely powerful in the past as seed funds leading to the development of large externally supported research programs, and these increases are particularly appreciated.

Scope and Trends

The Department's research activities are very broad, representing the wide spectrum of disciplinary skills and the range of interests from basic research to engineering development of the faculty. This breadth is one of the unique strengths of the Department and provides outstanding educational opportunities for graduate students.

Most of the research conducted by the faculty, staff, and students is concentrated in four major programmatic areas: Energy and Environment; Biomedical Engineering; Manufacturing, Materials and Materials Processing; and Human Services including Transportation. The distributions of research administered through the Department among these four areas as fractions of total departmental research are, respectively, 0.29, 0.26, 0.25, and 0.20. The research programs in all these areas have been growing in recent years. It is notable, however, that the fraction of research in manufacturing and processing has increased from 0.19 to 0.24 during the past four years, reflecting increased faculty commitment to the development of this field. The areas of energy, biomedical engineering, and transportation have been strengthened by an increasing involvement of the Department with the Energy Laboratory, the Harvard-M.I.T. Health Sciences program and the Center for Transportation Studies.

In addition to research oriented toward the above four applications areas, basic research is conducted in most of the fundamental disciplines which form the intellectual base of mechanical engineering. Funding for such work continues to be scarce and often basic investigations must be imbedded in applications-oriented programs. In some cases this is beneficial since it helps to maintain relevance of the basic work to end applications, but in others it seriously limits exploration of phenomena which may become extremely important in future applications. Examples of strong basic programs under way during the past year include: the fluid mechanics of one-dimensional flow in flexible, deformable tubes (Professor Ascher H. Shapiro); basic studies of ignition, combustion of gas/fuel mixtures, and smoldering (Professors John B. Heywood, James C. Keck, Tau-Yi Toong, and William C. Unkel); fatigue, creep, and fracture of metals, glassy polymers, and porous/geological materials (Professors Cleary, McClintock, Ritchie, and Ali S. Argon); tribology (Professors Suh and Ernest Rabinowicz); computational mechanics (Professor Klaus J. Bathe); and reverse osmosis and ultra-filtration (Professor Ronald F. Probstein).

New Programs and Notable Accomplishments

In the area of Biomedical Engineering, further development of programs in human mobility occurred. Plans for the physical renovation of space on the first floor of Building 3 were substantially completed and additional construction was carried out. The first phase of construction of a new Biomechanics and Human Rehabilitation Laboratory has also been completed, under the direction of Professors Mann, Flowers, and Rowell. Significant new research this year was completed on the kinematics and dynamics of human mobility; the development of man-interactive, microprocessor-controlled lower-limb prostheses; the in-vivo and in-vitro measurement of human hip pressure distributions; and in the development
of a device enabling blind persons to function as telephone operators. The new facility will include capability for man-interactive computer simulation of biological control of artificial upper and lower extremity prostheses, for quantitative studies of normal and pathological human mobility, and for the research and evaluation of auditory and cutaneous surrogates for vision loss and ataxic or amputated limbs.

Research on the use of ultrasonic and X-radiation in cancer therapy was continued with promising results. It has been shown that malignant tissue is more sensitive to temperature than normal tissue so that localized hyperthermia induced by ultrasound may be effective in inoperable tumor treatment. Professors Ernest G. Cravalho and Padmakar P. Lele are researching this field. Professors Paynter, Rowell, and Richard S. Sidell are investigating means for optimal delivery of X-radiation to cancerous tissue. Included in the latter program are the development of an interactive computer-graphics system for optimal radiation treatment planning and a programmable collimator for servocontrol of radiation beam profiles.

Professor Shapiro's research in the collapse of blood vessels is leading to clinical applications for the treatment of deep venous thrombosis and for external cardiac assist.

Professor Ioannis V. Yannas and his associates have successfully developed a technique for producing blood-compatible tubes for blood vessel replacement using non-crystalline collagen.

In Manufacturing, Materials and Materials Processing, the Laboratory for Manufacturing and Productivity, established in January 1977 under the leadership of Professor Suh, is enjoying outstanding success. New projects in the areas of manufacturing axiomatics, geothermal energy in manufacturing, sequential metal forming, and productivity in the footwear industry have already been funded. This Laboratory is intended to provide a new focus for research and education in manufacturing and productivity at M.I.T. The intent of the Laboratory is to view manufacturing from an overall, integrated point of view and to develop generic approaches and governing principles which will lead to productivity increases. In addition, the Laboratory is dedicated to improving the national talent pool in this critical area.

The area of Energy and Environment is the largest research area in the Department both in terms of research volume and faculty involvement. Approximately half of the faculty are engaged in some type of energy-related research.

In the Sloan Automotive Laboratory, Professors Heywood and Keck, together with Drs. Joe Rife and Senior Research Associate David P. Hoult are conducting research on the fuel efficiency and emissions of internal combustion engines under support of NASA, DOT, DOE, and the automotive industry. Research includes work on stratified charge, diesel and conventional engines, and on burners for aircraft gas turbines. In the latter work, it has been found that soot formation can be substantially eliminated while oxides of nitrogen are reduced by a factor of two, by proper design of the burner upstream geometry.

Coupling between the Department and the Energy Laboratory remains strong with cooperative programs in heat transfer and combustion. A major program in fluidized bed combustion, which is the most promising method of utilizing high-sulphur coal while meeting environmental constraints, is under way in cooperation with the Department of Chemical Engineering. Dr. Leon R. Glicksman is leading the Department's effort in fluidized beds.

An effort in resource recovery, concentrating on the extraction of oil from shale, has been funded by NSF and DOE under Professors Cleary and Carl R. Peterson.

The Department's program in noise control received a boost this year through EPA funding of a program on diesel engine noise. This project, under Professor Richard H. Lyon, involves the installation of a test facility which will enable detailed measurements of acoustic emissions to be made on an operating engine.
Building on past developments, the Cryogenic Engineering Laboratory in collaboration with the M.I.T. Electric Power Systems Engineering Laboratory, undertook the design and demonstration of a 10 MW cryogenic electric generator which will supply power to the Cambridge network. This research is under the direction of Professor Smith. Cryogenic generators offer the potential for very large capacity and/or lightweight machines for commercial and shipboard applications.

In the environmental area, Professor Quinlan in cooperation with Professor Jerome L. Connor (Civil Engineering) undertook a program to investigate the ecology of algal blooms fouling the bay at Nahant, Massachusetts. The objectives of the research are to evaluate the effectiveness of various measures to correct the algal stench and to determine if the material could profitably be harvested and processed for animal fodder. This work is in collaboration with the M.I.T. Sea Grant Program.

Professor Fay conducted research on scale effects in LNG hazard analysis and testing and on long distance transport of air pollutants.

In Transportation, the Vehicle Dynamics Laboratory continued to expand under the leadership of Professors Wormley and J. Karl Hedrick. The Laboratory continued its shift from advanced systems to the investigation of improved conventional transport systems, with increased emphasis on freight. Research was completed on the rocking dynamics of freight vehicles, and work related to highway truck stability and driver ride comfort was continued. New research on diesel engine control was initiated under industry support. A new program was funded by the Association of American Railroads to investigate the nonlinear behavior of rail vehicles.

Research on the lateral and longitudinal control of automated guideway transit vehicles was continued and an investigation of the advantages of operating automated transit vehicles both in functional platoons and as individual single-party vehicles was substantially completed. The ongoing research in guideway dynamics was continued with a study of the operation of two-way traffic on a single, elevated beam through use of cantilevered vehicles. This scheme may substantially reduce guideway construction cost which dominates the passenger-mile costs of advanced exclusive-guideway systems.

FACULTY AND STAFF

Size and Composition

The size of the faculty remained at 49 regular and one adjunct this year, about equal to the average count over the past five years, in spite of the doubling of undergraduate enrollment. Next year we hope to add two or three new faculty members. At present the faculty composition is: 28 professors, one adjunct professor, 11 associate, and 10 assistant professors.

The distribution of women and minorities in the faculty and staff is as follows. Of the 49 faculty members two are female, one is a black male, and four are oriental. Of the 32 lecturers who had appointments this year one is female, one is a black male, and two are oriental. Among the eight Research Associates two are female and two are oriental, and one of our five technical instructors is a woman. Finally, women comprise the majority of our five administrative staff members.
Notable Accomplishments and Awards

Professor Stephen H. Crandall was selected as National Academy of Sciences Exchange Lecturer to lecture in the USSR during May 1978. He also was elected Vice President, Basic Engineering Department of the American Society of Mechanical Engineers.

Professor Fay was elected a Fellow by the American Association for the Advancement of Science for "his notable engineering contributions, particularly in environmental engineering."

Professor mann received the American Society of Mechanical Engineers Medal from ASME at the Winter Annual Meeting for "eminently distinguished engineering achievement" and for "pioneering contributions to and development of the field of bioengineering and the successful synthesis of engineering and medicine to aid the physically handicapped." He was also the first recipient of the H. R. Listner Biomedical Engineering Award from the Bioengineering Division of the ASME. The citation was for outstanding contributions in the field of Biomedical Engineering.

Professor Paynter was elected a Fellow by the ASME for outstanding long-term contributions to the field of mechanical engineering. He was also designated a Sigma Xi National Lecturer.


Professor Quinlan was selected by the M.I.T. Sea Grant Policy Committee to receive one of two Henry L. Doherty (career development) Professorships in ocean utilization beginning July 1, 1978.

Professor Sheridan was presented the Paul M. Fitts Award by the Human Factors Society for "outstanding contributions to human factors education."

Professor Sonin was sent to West Germany by the US Nuclear Regulatory Commission to visit the institutions which are doing development work on nuclear power plant containment systems. He spent a week there in early November 1977, and reported back to the NRC on the state of the art of the German work.

Professor Suh received the Gustus L. Larson Memorial Award from ASME and Pi Tau Sigma for "outstanding achievement as one of the country's most distinguished and promising engineers and engineering educators of his generation in the field of mechanics and processing of materials, as evidenced by his originating the delamination theory of wear."

Adjunct Professor Giuliana C. Tesoro received an Achievement Award from the Society of Women Engineers for "significant contributions to the science and technology of polymers, fibers, and fabrics in textile and chemical engineering."

Professor Wormley received the Graduate Student Council Award for outstanding and dedicated teaching of a graduate course.

New Faculty

Dr. Michael E. Crawford was appointed Assistant Professor in the Fluid and Thermal Sciences Division, July 1, 1977, following postdoctoral research at Stanford. His disciplinary background is in heat transfer, thermodynamics, and turbulent fluid mechanics. He has joined the Cryogenics Engineering Laboratory where he is responsible for the heat transfer aspects of research on superconducting electric machines.
Dr. Günther Werner joined the Department July 1, 1977 as Associate Professor in the Mechanics and Materials Division. Dr. Werner obtained his professional education at the University of Aachen in Germany, has several years of experience in the manufacturing and quality control field, and is a recognized authority on grinding.

Visiting Faculty and Staff

Dr. Bar-Cohen, who was on sabbatical leave from the Department of Mechanical Engineering at Ben-Gurion University of the Negev in Israel, was Visiting Associate Professor for the academic year. He also held a full-time research staff appointment in the Energy Laboratory. Professor Bar-Cohen made contributions to the teaching program of the Systems and Design Division, and supervised undergraduate theses in the area of thermal design.

Dr. Harry Law, who is Associate Professor of Mechanics and Mechanical Engineering at Clemson University, was a Visiting Associate Professor for the spring term. Professor Law taught 2.032 Dynamics, presented occasional seminars in rail vehicle dynamics, and participated in the Vehicle Dynamics Laboratory where he collaborated with Professors Wormley and Hedrick.

Dr. Oleg A. Povarov, a native of the Soviet Union, was a Research Fellow under the IREX program (International Research and Exchange Board) for the academic year with Professor Warren Rohsenow as his host. Dr. Povarov participated in research on post-burnout heat transfer to mist flows and other projects in the Heat Transfer Laboratory.

Dr. Friedrich Prinz held an appointment from July to November as Visiting Assistant Professor. He worked with Professor Argon on the mechanism of recovery in work hardened materials.

Dr. Manoochehr Rashidi spent a sabbatical year as Visiting Engineer in the Fluid and Thermal Sciences Division. Professor Rashidi worked with Professors Heywood and Keck on combustion as it relates to engine efficiency and pollution.

Dr. Heinrich Zollinger, who for the past four years has been Rector of the Eidgenossische Technische Hochschule (ETH -- The Swiss Federal Institute of Technology), Zurich, Switzerland, spent the fall term as Visiting Professor. Dr. Zollinger is internationally known in the field of chemistry of fibers, textiles, and dyestuffs. Professor Zollinger lectured in a new Mechanical Engineering series of textile courses for industry and participated as consultant in Professor Tesoro's research programs in textile finishing.

Resignations

The resignations of Assistant Professor Douglas E. Kenyon (Thermal and Fluid Science Division) and Associate Professor Sidell (Systems and Design Division) were accepted with regret. Both left the Department for Industry.

Deaths

Professor Emeritus Earle Buckingham died June 3, 1978 at the age of 90. He attended the US Naval Academy for two years and then served as a mechanical engineer with a number of New England manufacturing firms. In 1925 he joined this Department as Associate Professor of Engineering Standards and Measurements, and in 1931 became Professor of Mechanical Engineering. He retired in 1953 but continued as a Lecturer in Mechanical Engineering for
several years. Professor Buckingham was the author of several books on gearing and manufacturing problems. One of his books, *The Analytical Mechanics of Gears*, remains a classic in its field and is used by many engineers as a design handbook for many types of gearing. In 1950 he received the Edward P. Connell Award from the American Gear Manufacturers Association. In recent years he resided in Springfield, Vermont, where he had established a consulting firm, Buckingham Associates, Inc.

Walter C. Eberhard, Assistant Professor Emeritus of Mechanical Engineering, died February 16, 1978 at the age of 85. He received an S.B. from the M.I.T. Department of Civil Engineering and worked several years in industry and government before joining the Graphics Division (later incorporated into this Department) in 1919 as a drawing instructor. He was promoted to Assistant Professor in 1944. He retired in 1957 and served for five years as an Emeritus Lecturer. Professor Eberhard was active until his death in conjunction with the Educational Testing Service in administering all of the college entrance examinations held at M.I.T.

Professor Emeritus James Holt, a member of our teaching staff for more than 40 years, died August 22, 1977 at the age of 80. Professor Holt received S.B. degrees in 1919 from Harvard University and M.I.T. He was appointed Instructor in Mechanical Engineering in 1920, became Assistant Professor in 1927, and Professor in 1947. He retired in 1962. Professor Holt was Executive Officer of the Department from 1946 until his retirement and also served briefly in 1954 and again in 1955 as Acting Head of the Department. A specialist in heat engineering, Professor Holt was a past president of the Massachusetts chapter of the American Society of Heating and Ventilating Engineers and a former chairman of the Boston Section of the American Society of Mechanical Engineers. He was also a past president of the Engineering Societies of New England and for many years a member of the American Institute of Consulting Engineers. He was also a member of Pi Tau Sigma and Sigma Xi.

HERBERT H. RICHARDSON

Department of Nuclear Engineering

This has been another strong year for research activity in the Department of Nuclear Engineering despite some shifting of the national effort toward other energy sources. In addition, although there have been some vocal anti-nuclear movements, student interest still remains strong. Nationally the number of orders for nuclear power plants is at a low level, yet most analyses still continue to predict that a substantial increase in nuclear power plants will be needed to meet our national goals. For this reason it seems very likely that as reserve electrical capacity diminishes during the next few years there will be an increase in the rate of ordering for new nuclear and coal plants. Despite this current lull in orders the demand for well-trained nuclear engineers remains high.

Although student interest remains strong, for the second year we have noted a decrease in applications (about 15 percent) so that the number is down some 30 percent from the high of three years ago. Nevertheless, the number of qualified applicants is still more than two times the number of openings of about 50 graduate students per year. Among this year's applicants we noted an increased fraction expressing interest in our fusion option.

This year the undergraduate program graduated its first full class. The senior class numbered 17 of whom 12 were awarded the S.B. degree. The other five opted for the five-year program
and will receive both an S.B. and S.M degree at the end of five years. This year's junior class had 11 students and the sophomore class, 21. Our original goal of about 80 undergraduates has not yet been achieved and it may be difficult to do so in the present controversy surrounding nuclear power. Nevertheless, we do appear to be able to maintain an undergraduate enrollment of about 50.

The graduate enrollment this year was 170 students which included 20 in the special Iranian program. Next year we expect to return to a total graduate enrollment of about 150 which is the level that has been maintained for several years, not including the students in the special Iranian program.

During the year the Department awarded a total of 95 advanced degrees including 20 doctorates, 18 Nuclear Engineers, and 57 Masters of Science. This represents about 10 percent of the advanced degrees in Nuclear Engineering awarded nationally.

This was the third and final year of the special Iranian program. There have not been any significant problems with the program this year. Of the 15 students enrolled in the second two-year program, four have completed their S.M. degree work by the end of June and 11 are expected to complete their S.M. degree work by the end of the summer term. The results of the program seem to be acceptable to the Atomic Energy Organization of Iran. In many cases the students from the first two-year program have experienced some difficulties in readjusting to Iran and some have indicated a lack of opportunities for them to utilize their education. This, together with the desire of several Iranian students to obtain a Ph.D., has resulted in many applications for continued enrollment as regular graduate students. Admission for regular graduate students in the Department has, of course, now been limited to the normal enrollment of about 150 graduate students.

As was noted in last year's report, support for graduate students remains a problem. The research support within the Department tapered off slightly from $1.7 million last year to about $1.5 million this year. This was due in part to the fact that some of the new research contracts were obtained through interdepartmental laboratories such as the Energy Laboratory and the Research Laboratory of Electronics. This latter type of research increased from about $750,000 to about $1 million, so overall the level of support remained about constant. As in previous years the majority of this support came from the Department of Energy although this year roughly $250,000 was obtained from non-governmental sources, mainly from the Electric Power Research Institute and private utilities. The Department continues to be fortunate to receive fellowship support from the General Electric Foundation, Northeast Utilities, and the proceeds from the Theos J. Thompson Memorial Fund.

The most significant change in the academic program during the last year was the development of the Nuclear Engineering Internship program. This new option offers undergraduates the opportunity to have actual on-the-job experience as part of their overall education. In the initial phase of this program three students have been placed with EG&G Idaho Laboratory. It is expected that we will be able to expand this program significantly next year. The program has two options, one leading to the S.B. in four years, the other to the S.M. in five years. An on-the-job problem will be used in lieu of a thesis. We feel this program offers a different dimension to a nuclear engineering education and will be of interest to a number of students. The development of this new program has been ably led by Professor John E. Meyer in conjunction with the Office of the Dean of Engineering.

The other parts of the academic program underwent only modest changes. The principal new features were the senior level undergraduate courses that were taught for the first time. The new undergraduate fusion laboratory course developed by Professor Louis Scaturro was quite successful. Professor David J. Rose offered a special seminar on the Energy for Developing Countries which attracted more than 20 interested students. Professor Kent F. Hansen
participated in the development of a new subject entitled Dynamics of Physical and Social Systems which has been accepted as a School-wide elective.

In the area of fusion, the courses remain the same in title; significant changes in content have been made to keep them abreast of this rapidly developing field. A fusion curriculum development committee consisting of Professors Rose, Scaturro, Thomas Dupree, Lawrence Lidsky, and Peter Politzer continues to be responsible for changes in fusion academic programs. The major changes in the reactor engineering programs carried out a year ago seem to have achieved their objective of giving the students a better understanding of the systems aspects of large nuclear power stations. The professors responsible for the overall development of the curriculum in reactor engineering are Professors Meyer, Michael Driscoll, Michael Golay, Mujid Kazimi, David Lanning, Neil Todreas, and Lothar Wolf.

During the summer of 1977, the Department offered four special summer programs. These Programs are an important way of establishing contacts between the Department and the various parts of the nuclear industry, as well as a means of providing added income. The 310 registrants in Nuclear Engineering programs in 1977 accounted for 18 percent of the registrants in all M.I.T. special summer programs. This enrollment is the second highest of all Institute summer offerings. The programs offered in 1977 were: 22.96s/95s/94s Nuclear Power Reactor Safety, directed by Professors Todreas and Norman Rasmussen; 22.85s Computerized Axial Tomography, directed by Professor Gordon Brownell; 22.83 Principles of Nuclear Medicine, directed by Professor Brownell, and Drs. Donald Hnatowich, Brian Murray, and Robert Zimmerman; and 22.80s Fundamentals of Controlled Fusion, directed by Professors Lidsky, Politzer, Rose, and James Woo. The Nuclear Power Reactor Safety course continues to have the largest enrollment of any course in the Institute’s Special Summer Programs.

RESEARCH

As noted above the research volume of the Department remained at the relatively high level of last year at about $2.5 million. Although this income is adequate to support a strong research program, we have noted some disturbing trends away from support for hard engineering, especially experimental work, and toward paper studies. Many of these paper studies are indeed valuable to sponsors in helping set government policy and so they represent important and valuable work. However, if the trend continues it will be harder and harder for students to obtain top-level experimental research experience which we judge to be vital in a well-rounded engineering program.

The research volume in the area of fusion technology is increasing. This includes a recent study grant to Professors Lidsky, Politzer, and Dr. Bruce Montgomery for a design study of a new stellarator concept called the Torsatron. This is an exciting concept which we hope may lead to the construction of such a machine here at M.I.T. Professor Kazimi continues to work with Professor Lidsky on fusion machine safety and risk analysis. Fortunately this increased research activity in the fusion area coincides with the increased student interest in fusion noted above. Professor Dupree continues his work in plasma theory concentrating on nonlinear phenomena. Professor Dieter Sigmar, although on leave at Oak Ridge National Laboratory, has maintained close ties with our program and will become an Adjunct Professor in the fall and continue to teach and do research part time. Professor Scaturro has been working with the Alcator project in the area of plasma diagnostics.

About one-third of the Department's research activity involves the various aspects of fusion. In addition to the projects noted above fusion technology continues to get considerable support
from other faculty especially in the areas of materials and heat transfer. Thus although fusion devices are considerably different from fission devices, many of the detailed engineering problems are similar and the expertise gained from fission reactor studies is very valuable in solving fusion problems.

In the area of reactor physics, Professors Hansen, Allan Henry, and William H. Reed continue their work for the Electric Power Research Institute on the development of major codes for the analysis of reactor transients. In the area of fission reactor engineering the research effort deals with a broad range of problems in both water and sodium-cooled reactors. Major projects in heat transfer, materials behavior, reliability, and structures are being studied by Professors Todreas, Golay, Driscoll, Meyer, Wolf, Rasmussen, and Kazimi. In addition, students from our Department have worked closely with Professors Kenneth Russell and Regis M. N. Pelloux of Materials Science and Engineering and Professors Peter Griffith and Warren Rohsenow of Mechanical Engineering. The close cooperation we have maintained with other departments in the School of Engineering has greatly increased the opportunities for our students and our ability to provide valuable research results to the nuclear industry.

This year Professors Rasmussen, Rose, and Elias Gyftopoulos undertook a major research problem for the Department of Energy on aspects of the nuclear proliferation problem. Dr. Marvin Miller of the Energy Laboratory was also a major participant in this project. Professors Lanning, Golay, Rose, and Rasmussen worked with Doctors William Hinkle and David Wood of the Energy Laboratory on a second contract on light water reactor technology for the DOE. In addition, the Department faculty participated in a number of small Energy Laboratory research contracts with various electric utility companies of the Northeast.

The Department faculty is heavily involved in Energy Laboratory research contracts totaling about $750,000. We believe these cooperative projects are very valuable and to the mutual benefit of both the Department and the Energy Laboratory.

Professors Sow-Hsin Chen and Sidney Yip have had another very productive year in their research using neutron scattering as a tool for understanding various aspects of molecular and solid-state physics. Professor Brownell continues his research in the applications of radiation to the diagnosis and treatment of disease. Professor Otto Harling continues as Director of the Nuclear Reactor Laboratory in addition to his research work in both fusion and fission materials problems.

Overall the Department has been able to obtain a high level of research support on a variety of challenging research problems. They have provided students with valuable educational experiences as well as financial support. This research has been at a level of about $137,000 per faculty member and paid approximately one-third of the faculty salaries. The slowdown in nuclear power plant orders has not as yet had a significant impact on our ability to raise research support, although the nature of the projects is shifting somewhat away from experimental research.

**FACULTY**

This year Professor Manson Benedict reached the mandatory retirement age for Institute Professors. For the five years since his normal retirement date, Professor Benedict has continued half time, teaching Economics of Nuclear Power, and Nuclear Chemical Engineering. Professor Benedict started the M.I.T. Nuclear Engineering Program as part of the Department of Chemical Engineering in the fall of 1952 and then established an independent Department of
School of Engineering

Nuclear Engineering in 1958. Certainly no single person has contributed more to the growth and success of the Department. His outstanding leadership has earned both him and the Department worldwide recognition. He will surely be missed.

Dr. William Reed joined the Department as a Visiting Professor for the 1977-78 academic year. During this time Dr. Reed carried out research in the general area of reactor physics and taught Numerical Methods of Reactor Physics. Professor Irving Kaplan, who has been with the Department since its inception, retired on July 1, 1978. Over the years Professor Kaplan's outstanding contributions have enriched the scholastic and personal lives of his students and colleagues. The breadth of Professor Kaplan's interests has resulted in his interaction with the Department of Humanities where he has taught courses in Greek and the History of Science. We are indeed fortunate that Professor Kaplan will continue on part time as a lecturer in the Department.

Professor Arden L. Bement, who was on leave from the Institute as Director of Material Science Defense Advanced Research Projects Agency of the Department of Defense, resigned from the Department to continue in this position at DARPA. Professor Bement had been with the Department since 1971 and during the past eight years has contributed significantly to the Department's growth and development in the nuclear materials area.

Professor Sigmar has been on leave for the past two years at Oak Ridge National Laboratory (ORNL), where he has had major responsibility for the ORNL TOKAMAK theory program. He plans to remain at ORNL, but will continue to contribute to the Department as an Adjunct Professor. Professor Owen Deutsch has left the Department to work at the Los Alamos Scientific Laboratory. Professor Golay was appointed an Associate Professor with tenure in July 1977. Professor Politzer was appointed Associate Professor in July 1978. Professor James Woo left the Department to accept a faculty position at Rensselaer Polytechnic Institute. Professor Hansen's appointment to the Nuclear Regulatory Commission was not approved by the US Senate and so he will not spend two years on leave as reported last year. Professor Todreas spent the last year on sabbatical in France working on heat transfer problems with Electricité de France.

Honors and Awards

Several of the Department faculty were recognized with honors. Professor Hansen received the American Nuclear Society Arthur Holly Compton Award in June 1978. Professor Yip received the Graduate Student Council Award for Outstanding Graduate Teaching. David Aldrich, a graduate student, won the 1978 American Nuclear Society Reactor Safety Division Best Student Paper Award. Professor Rasmussen received the Outstanding Teacher Award of the M.I.T. student chapter of the American Nuclear Society.

Activities Outside the Department

The Nuclear Engineering faculty members continue to be active outside the Department in both M.I.T. non-departmental activities and in a wide variety of activities outside the Institute for professional societies, government, and industry.

In June, Professor Lidsky was named Acting Director of the M.I.T. Plasma Fusion Center following the resignation of Dr. Albert Hill. Professor Lidsky continues to advise the Department of Energy on its fusion program. Professor Rose is currently very active as Chairman of the Advisory Committee to the World Council of Churches Division of Church and Society. In this capacity he is organizing an International Conference on Faith, Science, and the Future to be held at M.I.T. next year. He continues as a member of the Steering Committee.
of the National Academy of Sciences Committee on Nuclear and Alternative Energy Systems. In addition he serves on the Advisory Committee of the Comptroller General, US General Accounting Office and is a member of the Oak Ridge Advisory Committee for the Energy Division.

Professor Golay is currently Vice Chairman of the American Nuclear Society in the Environmental Sciences Division and is Chairman of the Northeast Section of the American Nuclear Society. He is also a member of the KISS Subcommittee of the American Society of Mechanical Engineers Heat Transfer Division. Professor Chen serves on the Argonne National Laboratory Review Committee for the Solid State Division and the Argonne Intense Neutron Source Project. Professor Kazimi serves as a member of the Board of Directors of the Northeast Section of the American Nuclear Society and a member of the American Institute of Chemical Engineers Nucleonics Heat Transfer Committee. Professor Gyftopoulos continues as Chairman of the National Energy Council of Greece and is also Chairman of the Institute's Committee on Junior Faculty Career Development Fund. Professor Meyer serves as a member of the Executive Committee of the Mathematics and Computation Division of the American Nuclear Society. Professor Hansen continues to serve on the Review Group for the Nuclear Regulatory Commission's Reactor Safety Research Division.

Professor Driscoll is serving as Chairman of the Reactor Physics Division of the American Nuclear Society as well as an advisor to the US Department of Energy and the Office of Science and Technology Policy. Professor Henry is a member of the Journals Advisory Board of the American Nuclear Society. Professor Reed serves as Chairman of the Mathematics and Computation Division of the American Nuclear Society. Professor Rasmussen completed a four-year term on the Defense Science Board. He was elected to the Board of Directors of the American Nuclear Society and serves on the Argonne National Laboratory Review Committees of the Components and Technology Division and the Reactor Safety Division. Professor Rasmussen also continues as Chairman of the Scientific Review Committee of the Idaho National Engineering Laboratory. He remains Chairman of the Institute's M.I.T. Reactor Safeguards Committee on which Professors Lanning, Harling, Driscoll also serve.

NORMAN C. RASMUSSEN

Department of Ocean Engineering

The world interest in the oceans as a source of energy, minerals, and food, and as a major medium for transport of the world's commodities, continues to increase. As a reflection of this, and as a mark of leadership, the Department's teaching and research programs deal with the broad aspects of ocean engineering, including naval architecture and marine engineering, ocean resource exploration and exploitation, and ocean environmental protection and enhancement.

Academic Highlights

The academic program of the Department continues to reflect the broad range of opportunities in ocean engineering. Our program includes those aspects of engineering in the sociotechnological area, as well as in the domains of analysis, synthesis, design, and experimental discovery.
The Department was visited this past year by the Engineers' Council for Professional Development to review our S.B. programs. While an official decision has not yet been rendered, we are confident that all our undergraduate degree programs will be accredited.

The graduate degree programs are also of high standing. While definitive comparisons are not available, we believe our programs are generally considered the broadest and of the highest quality of any in ocean engineering. We continue to receive favorable reports from those who hire or observe our recent graduates. Many representatives of academic institutions around the world write or visit to learn of our academic program. Also, many from industry visit with us or host us in their own environments. Such encounters serve as a valuable calibration, and lead us to be confident of our programs.

The availability of jobs for our graduates continues on the whole to be quite good. Opportunities in the offshore oil industry, for example, are, if anything, increasing each year. Naval architects, despite domestic shipbuilding difficulties, are getting good jobs, largely with defense-related design firms. Public sector jobs are also available for those with interests in resource management or environmental protection. In brief, times have been good for engineers at all degree levels graduating from the Department, and they have been so since at least 1971.

It is interesting to add that doctoral graduates are also in demand for academic jobs, a situation that was much less the case some five years ago.

The total enrollment of regular students in the Department now stands at 188, in many ways a significant drop from the figure of 200 obtained at this time last year. While last year's figure was an all-time high for the Department, we had hoped to exceed that number. Instead, we have experienced a decrease. The decrease is totally within the graduate enrollment, while undergraduate enrollment has in fact increased. The decrease in graduate enrollment is related, in part, to a smaller than expected enrollment of US Navy students in the Department's XIII-A program; in part to a change in Department policy which denies regular student status to those entering the Department with deficiencies to be removed in basic engineering subjects; and in part to a plateauing in apparent student interest in ocean engineering.

As described last year, the School of Engineering established the Engineering Internship Program to facilitate work/study education throughout the School. The new program conforms closely to our Cooperative program (Course XIII-C) and we have combined ours with the School-wide effort effective with next year's class. We expect the new arrangement to provide our students with more work opportunities, and thereby to increase enrollment in XIII-C.

**RESEARCH**

The Department's research program continues to be well-rounded and adequately funded. We are proud of the many advances we have made in recent years. Some examples are in: propeller-hull dynamic interactions; slender body ship resistance theory; dynamic plasticity applied to marine vessels; offshore platform dynamics; underwater welding technology; systems analysis of offshore oil; oil spill control; modeling of deep sea mining; and development of small robots for underwater work.

The foregoing list can be made quite long. We owe our research achievements, as well as our outstanding academic program, to the faculty and academic staff who toil long, creative hours.

The Department uses several research facilities located on campus, as well as the M.I.T. research ship, the R. V. Edgerton. Some highlights of the Department's facilities follow:
The Ship Model Towing Tank continues to be actively used for student laboratories, theses, sponsored research, commercial testing, and demonstrations. Student use of the Tank as part of formal classroom activities slightly increased in use over the previous year, indicating that the connection with the teaching program remains high.

There were essentially no sponsored projects which fully supported Tank use. A decade ago there was substantial income from sponsored research projects. This income has slowly waned due (apparently) to less sponsored research in ship resistance and related areas, and to smaller portions of the research funds being allocated to model testing aspects. Income from commercial tests in the Tank has remained moderate but steady over the past few years, enough that the Tank budget remains, on the average, in balance over this time period.

The Variable Pressure Water Tunnel (Propeller Tunnel) added a laser-doppler system for velocity measurement which by now has had over one year of extensive use for a variety of projects. The quality of the data obtained with this system is excellent; it has enabled acquisition of flow-field information heretofore impossible, for example, fluctuating flow in the field of a rotating propeller. The tunnel enjoys a continuing high level of academic and research activity.

The principal use of the Precision Wave Tank and Flume is in the study of oil on water, in connection with oil spill control research. While many vital research questions remain to be answered in this field, the Department senses a decrease of interest among Federal agencies in the support of research relevant to oil spill control. Plans are being developed to use this fine facility for other interfacial research projects, for example, in near surface turbulence driven by breaking gravity waves.

In comparison with the previous year, the use of the Marine Data Systems Laboratory is about the same. Connection with classroom activities has decreased somewhat, reflecting the change in scope and structure of the Ocean Engineering Laboratory from a summer field experience to an academic year one.

The major activity of the Laboratory this year has been the preparation for a March/April measurement program in the Arctic Ocean. A field team led by M.I.T. occupied a camp on ice to measure the lateral boundaries of the Arctic Ocean, the sub-bottom thicknesses of the Canada Abyssal Plain, refraction and coupling of sound waves into these sub-bottom layers, and ambient acoustic noise. For the first time a large array was deployed through the ice, and the engineering feasibility of such a system was demonstrated. Preliminary indications are that valuable data were obtained relevant to each objective.

In March of 1978, the Design Laboratory was fortunate to have the services of Professor Heinrich Soding of the Hannover University who assisted in the installation of his computer-aided lines fairing program. This program complements our effort that has, over the past several years, increasingly brought the capabilities of the Design Laboratory to the fore as a major contribution to design education, not only in ocean engineering, but also in engineering more generally. It is also pleasing to note that many computer-based design programs developed via the Laboratory are sought by and made available to practicing naval architects and ocean engineers for use in their professional activities.

This year the data analysis capabilities of the Laboratory were greatly expanded by addition of a digital spectral analyzer and associated equipment. These additions relate to our research in the dynamic response of offshore platforms. We elected to locate this new activity in the Design Laboratory principally for the ease in sharing related computer peripherals, and in monitoring and maintaining our overall investment in digital equipment. In this light, the Laboratory is increasingly seen as a major resource of the Department in computation; along with the Joint Computer Facility of Mechanical/Civil Engineering and the Information
School of Engineering Processing Center, it provides our students and faculty with a broad range of computer aids for both research and academic work.

FACULTY

The Department has had three active search committees this past year, with the intent of adding to our human resources in hydrodynamics, structures, and design. We were able to make two assistant professor appointments in hydrodynamics for this year, and two in structures, beginning next year. Finally, we have appointed one research associate in design and a second in systems analysis, also effective next year. The addition of these young people to our academic staff should provide ample opportunity for the Department to meet its obligations in teaching and research and, in particular, to broaden its programs in these key areas.

The new appointees are Assistant Professors Francis Noblesse and Robert J. VanHouten, in hydrodynamics, Assistant Professors Joao de Oliveira and Paul Xirouchakis, in structures, Dr. Michael Triantafyllou, in design, and Dr. Harilaos Psaraftis, in systems analysis. Also, Keatinge Keays was appointed a lecturer in the Department, a responsibility he shares with his duties as Administrative Officer.

We are pleased to report that Associate Professors Chryssostomos Chryssostomidis and Wesley L. Harris were awarded permanent academic tenure effective July 1, 1978. Dr. Ronald Yeung was promoted from Assistant to Associate Professor, also effective July 1, 1978.

Professor John Harvey Evans spent the spring term on sabbatical in the Boston area, completing a new book on ship structural design. Professors Patrick Leehey and Philip Mandel devoted the entire year to sabbatical leaves, the former in teaching and research in Austria and Norway, and the latter in design for the US Navy in Washington, DC.

Professor Judith T. Kildow extended her leave to encompass the 1977-78 academic year at the University of California at San Diego, and at Scripps Institute of Oceanography, respectively, where she has been teaching and conducting research in marine policy and ocean utilization.

We wish Professors Evans and Alfred A. H. Keil well as they officially retire from the Institute. Each has served the Department and M.I.T. in extraordinary ways, and we shall miss their daily creative energy, and their wise counsel and friendship.

The Department has been deeply benefited by its visitors this year. Professor Som D. Sharma of the University of Hamburg, Institut fur Schiffbau, is doing hydrodynamics research and is developing a new graduate subject on differential games as applied to collision avoidance. Professor Kiyohide Terai (Kawasaki Heavy Industries and Visiting Lecturer at University of Tokyo, Nagoya University, and Tohoku University) is conducting welding research with Professor Koichi Masubuchi.

Professor Ernest O. Tuck spent the fall term with us teaching portions of an advanced graduate subject in hydrodynamics and conducting research with Professor John Newman. Professor Tuck is the Chairman of the Department of Mathematics at the University of Adelaide.

Dr. Hironori Ozaki continued his appointment with us as a Research Associate this year. Dr. Kuoyu Itoga, also of Kawasaki Heavy Industries, joined the Department as a Research Associate and is assisting Dr. Ozaki and Professor Masubuchi in welding research.
Dr. Dan Schneerson (Chairman of the Department of Economics, University of Haifa, Israel) was appointed a Research Associate and will assist Professor Ernst Frankel in research on port economics for the Nigerian government.

Dr. Abraham Tal (Head of the Department of Computer Sciences and Applied Mathematics, Ministry of Defense, Israel) is participating in acoustics research with Professor Ira Dyer.

Other visitors include Dr. Hans H. Soding from West Germany, University of Hannover, Institute for Ship Design and Ship Theory, who spent a month with us installing a new computer program in the Design Laboratory under the guidance of Professor Chryssostomidis; and Dr. Valerie Postnov, Leningrad Shipbuilding Institute, Head of the Department of Strength of Ships, USSR, an exchange scholar under the IREX program. Dr. Postnov gave a series of three seminars during his brief stay at M.I.T.

Publications

Faculty in the Department have been active in book preparation. Four efforts were completed this year: Professor A. B. Baggeroer has contributed to a new text entitled, Applications of Digital Processing (Prentice Hall, 1978), with material on sonar signal processing. Professor Masubuchi published a book entitled Analysis of Design and Fabrication of Welded Structures. Professor Newman's book Marine Hydrodynamics was published in August 1977, by the M.I.T. Press. Finally, Lexington Press published Professor J. D. Nyhart's book, Ocean Thermal Energy Conversion in the summer of 1977.

Public Service

Professor Martin A. Abkowitz was appointed Member, Seakeeping Committee of the American Towing Tank Conference. Professor Alexander D. Carmichael was appointed to the Executive Committee, New England Section, of the Society of Naval Architects and Marine Engineers. He was also Chairman of the Subcommittee on International Cooperation on Marine Engineering Systems of SNAME. Professor John W. Devanney was appointed Member, Advisory Committee, National Ocean Pollution Program and National Academy of Sciences Ocean Resources Forum. Professor Dyer was a member of an evaluation team for the University of Miami, Department of Ocean Engineering. Professor Harris was Chairman, Planning Committee for "A Workshop on Retention of Minority Undergraduate Students in Engineering." October 30 through November 2, 1977. (Cosponsored by M.I.T. and the Committee on Minorities in Engineering, National Research Council.) He also serves as Associate Editor, the Journal of Compensatory Educational Support Programs.

Mr. Keays was Chairman of the 1978 Spring Meeting of SNAME. Professor Justin Kerwin acted as an advisor to the United States Yacht Racing Union Handicap Rule Committee. Professor Kildow was appointed Member, Task Force on Technical Goals and Objectives (Office of Environment Assessment, US Department of Commerce). Professor Henry Marcus was appointed Member, Energy Facility Siting Council of Massachusetts; Member, Committee on Innovation and Technology Transfer in the Marine Industry, National Academy of Sciences, Maritime Transportation Research Board. Professor Masubuchi was elected President, Japanese Associates of Greater Boston and Director, Japan Society of Boston. Professor Jerome H. Milgram was appointed Member, US General Accounting Office Panel for Evaluating US Coast Guard Response to 35 Oil Spills. Professor John N. Newman acted as an advisor to USYRU Handicap Rule Committee.

Professor Nyhart served as Co-chairman of the Panel on Institutional and Legal Requirements for OTEC Development and Demonstration, Society of International Law; as Panel Member,
Verification Guidelines for Offshore Structures; Member, US Public Advisory Committee on the Law of the Sea; and was appointed Member, North American Council of the International Peace Academy. Professor Yeung was appointed Panel Member, SNAME H-5 panel on Analytical Ship-Wave Relations; selected as Award Evaluation Committee Chairman, SNAME, New England Section; and named to the National Science Foundation, US-Japan Cooperative Science Program, exchange visitor on ship motion in shallow and restricted waters.

International Activities

Professor Baggeroer lectured at the University of Genoa and University of Florence, Italy. Professor Chryssostomidis was M.I.T. representative to BOSS '79. (This is an international conference on offshore structure behavior and design.) Professor Dyer was appointed Chairman, Science Advisory Committee Board, Israel Oceanographic and Liminological Research Institute. Professor Frankel presented a course on transportation planning at the University of Lagos, Nigeria; presented a course in port planning and management to 12 Nigerian Ports Authority executives; and held a series of seminars on port engineering and operations "Tocestrale Italy" before the Adriatic Regional Port Association. Professor Masubuchi was the Coordinator, M.I.T.-University of Tokyo Graduate Student Exchange Program. And finally, Professor Newman presented a seminar on "Wave Radiation by Slender Bodies" in Paris (Ecole Nationale Superieure de Techniques Advancées), and lectured at Delft Technical University (on same topic), at a Memorial Symposium for Professor R. Timman.

Honors and Awards

Professor Evans was elected Vice President, Society of Naval Architects and Marine Engineers in November 1977 (three-year term). Professor Harris won the 1977 Award for Excellence in Engineering, National Consortium for Black Professional Development. Professor Francis Noblesse was chosen Doherty Professor of Ocean Utilization.

HART NAUTICAL MUSEUM

In August 1977, Robert Weimer of Albuquerque, New Mexico wrote, "Last month I was able to make a very brief visit to the Hart Nautical Museum and, as a ship model builder, I was very impressed by the fine collection." This and similar unsolicited comments often brighten the life of the curator.

Although what most people think of as the Bicentennial Celebration ended on December 31, 1976, special events will continue into 1983, and the museum office still receives inquiries concerning the naval side of the Revolutionary War. To commemorate the 1778 Treaties of Commerce and Alliance between the United States and France, and the capture of H.M.S. Drake by the sloop-of-war Ranger commanded by John Paul Jones, a print depicting this engagement along with one of the Bon Homme Richard vs. the Serapis are displayed in the first floor corridor. On April 24, 1978, the date of the Ranger-Drake duel, they were featured in a special ceremony which included representatives of Boston historical groups, the French consulate, and the US Navy.

Among the gifts received by the museum during the past year is a copy of the important H. W. McCurdy Marine History of the Pacific Northwest, 1966-1976. This brings up-to-date and joins Mr. McCurdy's earlier work which covered the history of the region from 1896-1965.
a copy of which the museum received in 1967. These two volumes carry on the material in
the reprinted Lewis and Dryden's Marine History of the Pacific Northwest which accompanied
Mr. McCurdy's first volume. H. W. McCurdy II (Class of 1922) has been active in the
shipbuilding and dredging industries in the Puget Sound region.

Professor Emeritus and former museum curator, Evers Burtner, who for years was measurer
for Marblehead yacht clubs, gave the museum a copy of his useful booklet, The Golden Age of
Open Class Racing at Marblehead, 1906-1940.

Of particular interest in connection with Francis Russell Hart, for whom the museum is
named, was a gift from Richard W. Berry (Class of 1932, Course XIII-C) of The Great White
Fleet, a history of the ships of the United Fruit Company. Professor Theodore Wood, Jr.,
Department of Humanities, who has connections in the State of Maine, presented a copy of the
Stone Sloops of Chebeague, the story of an important, but long-vanished bit of New England's
shipping business. Four other books were received as gifts ranging from boat archeology to
modern submarines.

Because of the lack of storage space, the builder's plating model for the Mariner Class of
cargo ships, designed by the Bethlehem Steel Company in the early 1950s, was given to the
Quincy Historical Society.

Blueprints and miscellaneous papers were received on deposit in August 1977 from the owners
of the wooden diesel-electric tugboat Luna, now undergoing restoration at Lewis Wharf. She
and a sister-tug, the Venus, were of considerable interest in the early 1930s when our students
ran speed trials with them in Boston Harbor.

Several years ago the curator and his secretary chanced on a young man making copious notes
concerning a model of a three-masted schooner then on display in a corridor case. This
meeting led to an interchange of information about models and an acquaintanceship that has
survived. He is the Reverend Charles H. Hall, then of Machias, Maine, who learned to build
model ships from two old-timers there. Now in Pontiac, Michigan, he uses his models to
teach school children and others in Midland America about ships and the sea. In July 1977,
he presented the museum with a 1/144 scale model of a Maine-built schooner, a salt banker
of 1850, in return for assistance through the years.

The restored model of the fruit steamer Atlantida, damaged in an attempted theft in 1975, was
again put on display in the fall of 1977. The model of the Boston-Yarmouth steamer St. John,
damaged in another attempted theft in January 1978, has been repaired and returned in the
display area.

The number of researchers has increased slightly during the year. Their subjects have ranged
from the work of English and Dutch etchers through "ship outfitting," a history of marine
engineering, to what should be displayed in the marine section of Boston's new Museum of
Transportation.

Interest continues high in plans for the repair and restoration of Herreshoff, Lawley, Owen,
Paine, and Hand designed yachts, in plans for the building of models, and in photographs of
yachts and commercial and naval vessels.

Material furnished for publication included studies of sea serpents, photographs of ship models,
charts of Boston harbor, and 12 plans for the B. L. Makepeace 1978 calendar.

As his senior project, a student in the Department has taken the lines off an old half model in
the Peabody Museum of Salem and, under the curator's guidance, is working on detail plans.
During the 1977-78 year, the curator has given lectures for the Institute of Nautical Archaeology, the Quincy Historical Society, the Philadelphia Maritime Museum, the Massasoit Historical Association of Warren, Rhode Island, the Munson Institute of Mystic Seaport, the 3rd Annual Small Craft Curators Conference, the University of Maine at Portland, the Sea Education Association, and the Old South Association of Boston. He also continued his lectures on the history of ships during the 1978 I.A.P. when 43 students and staff attended one or more lectures, the best record yet. Some of this material was repeated for a Department freshman seminar and also a Tankard seminar on February 24, 1978.

Printed works included a chapter on "The Design and Construction of Steam Whalers" in Steam Whaling in the Western Arctic published by the Old Dartmouth Historical Society.

The curator continues to serve as maritime consultant to the National Trust for Historic Preservation, on the US Coast Guard SOLAS working group on subdivision of stability, and as an occasional consultant for National Geographic Magazine and Time-Life books.

IRA DYER

Center for Advanced Engineering Study (C.A.E.S.)

ADMINISTRATIVE OVERVIEW

The Center's three major areas of responsibility, Continuing Education, Research and Development, and Instructional Technology, are continuing to grow rapidly. The growth rates in each of these areas add new dimensions to the administrative structure of the Center.

The Advanced Study Program easily maintains its enrollment at the space limited value of approximately 50 Fellows per year. We are investigating the possibility of developing special programs responsive to the technological and educational needs of developing countries. The Self-Study Program continues its revenue growth rate from $320,000 in fiscal 1977 to almost $400,000 at the end of this fiscal year. The Self-Study Program serves approximately 12,000 students per year. Because of favorable revenue, we have developed two new sets of videotapes and are planning three more. John Fitch will leave for one year to work with the Association for Media-based Continuing Engineering Education at Georgia Institute of Technology. He will be replaced by Dick Noyes for the interim period.

The Tutored Video Instruction Program has taken on new dimensions; it has introduced T.V.I.-P.M., T.V.I. courses offered in the evening at M.I.T.; and T.V.I.-Short Courses, 10 lecture condensations of regular M.I.T. subjects developed to meet the current needs of industry. The T.V.I. program will also now be advertised to industry on a national basis instead of only locally as heretofore. The Program continues to grow. It is anticipated that T.V.I. will be economically stable at the end of the next fiscal year. The Conference Program has now provided support for three meetings: "Textiles in the 1980s," "Computer-Aided Manufacturing," and "The Maximum Entropy Formalism." We are planning four more meetings for fall 1978 with more to come. We have completed formal negotiations with the Royal Netherlands Industries Fair, and we are planning an additional four meetings in Europe with them. The Conference Program is almost assured to continue to be successful.
The Technical Curriculum Research and Development Program, sponsored by the Imperial Organization of Social Services of Iran, is entering the fourth year of a five-year contract. Curriculum development in electronics and mechanical engineering continues. Project PROCEED, sponsored by the National Science Foundation (NSF), is in its third year. PROCEED's unique modules, cases, and adaptive reference system have gained prominence with industry and government. There is approximately one year of funding remaining. We do not foresee any problem in identifying new sources of funding for the future. It is anticipated that ultimately Project PROCEED will grow to 27 persons and be separated from the Center. Possible alternatives are for Project PROCEED to become a wholly owned subsidiary of M.I.T. or to establish itself as a private, non-profit, independent corporation. Five universities and several industries have indicated a desire to join PROCEED.

The use of video and television as an important tool in teaching is being recognized by schools throughout the United States and Europe. I believe that M.I.T. is now at the forefront of experimentation with this technology. Video is now an integral part of the teaching process in many departments at M.I.T. It has been used as a catalyst in bringing whole communities to participate in local governmental decisions (the Department of Urban Studies and Planning); as a tool in remedial education (Office of Minority Education); to enhance the tutorial processes of departments (Electrical Engineering and Computer Science and Physics); as a new art form (Professor David Thorburn in the Department of Humanities); to interact with other educational institutions (Harvard University, Tufts University, University of Massachusetts). The list of video activities has grown substantially and now includes approximately 240 video projects in 30 departments. The recommendations of a 1976 campus-wide video policy committee, chaired by Professor Ithiel de Sola Pool, have now been surpassed.

The future growth and development of video at M.I.T. can probably be better served by making it a separate activity, reporting to the Provost. Negotiations are therefore currently under way to separate video from C.A.E.S. However, since the Center relies heavily on video for two of its programs (Self-Study and T.V.I.) and since the Center now provides about 60 percent of the income of video services, the Center expects to remain in close communication with the new independent video services. Within the Center the main impact of the removal of video services will be to free up valuable administrative time for the supervision of ongoing activities and the initiation of new ones.

In summary, we report that C.A.E.S. is serving an increasing number of students in an increasing variety of ways. Nationally and internationally, continuing education for scientists and engineers is receiving increased attention and C.A.E.S. expects to respond and lead in this field.

PERSONNEL CHANGES

As the Center's financial volume continues to grow, so does its staff. We have increased our personnel with nine new full-time positions and two half-time. In addition, five new people joined C.A.E.S. when Project PROCEED transferred from Chemical Engineering. Our full-time staff numbers 32 and we employ over 40 students, who assist in the various programs.

The Advanced Study Program has remained stable through the year in its staffing, but has increased its income volume over the previous year.

The T.V.I. Program added a full-time technical assistant last fall to coordinate the day-to-day operations and also allow the Director more time for marketing and developing the
Program. During the spring term, it became necessary with the increased number of courses to hire part-time secretarial services.

The Self-Study Program staff has grown. We are now developing new courses to add to our catalogue. Because of our continued growth in this area, we have added a sales assistant and have hired part-time assistance to update the computer programs. We have hired a half-time production coordinator to assist with taping lectures and editing. C.A.E.S. productions include a series of 20 lectures on Decision Analysis, an ILO Symposium, and a series of tapes on Computer Aided Manufacturing funded by NSF.

The new Conference Program hired a half-time coordinator for fiscal 1978. This position will become full-time next year, and a full-time secretary will be hired.

Instructional Technology continues to grow with the increased use of facilities from the M.I.T. campus. This area added a technician to its staff to help support the studio and editing facilities, and a production assistant to produce programming for the CABLE T.V. System. Our expenses continue to grow, as does the income.

In the Center's Research area the addition of Project PROCEED increased the Center's staff by five full-time personnel; the project director, two research associates, and two secretaries. The IOSS Program remains stable, with the addition of summer research staff hired from Wentworth Institute of Technology to assist in the development of curriculum for the Shiraz Technical Institute.

The Administration of C.A.E.S. has added half-time secretarial support to assist in the Director's Office. Jack Newcomb was promoted to Associate Director in February.

CONTINUING EDUCATION

Advanced Study Program

The Advanced Study Program continues under the direction of Paul E. Brown, with 72 students this past year, up 24 from last year, although more Fellows attended for only one term this past year. The number of "student years" was up 2.5. Twenty countries were represented. The Program was solvent and continued to win support from its alumni, who now total 499, and are often the source of new students. Our newest project, joint with the Center for Transportation Studies and the Department of Ocean Engineering, involved groups of Nigerian Fellows interested in port planning and development. They attended a special seminar offered for them, subjects the Center has developed for its Fellows, regular Institute subjects, and they worked on a project sponsored by their employer.

During the past year, the Advanced Study Program continued to provide experienced men and women from many countries with the opportunity to spend one or more academic terms at M.I.T. Several Fellows were half-time. Twenty-five Fellows completed the Program at the end of the fall term. Most of those who completed or started the Program at the middle of the academic year attended the Program for only one term.
Self-Study Program

The Self-Study Program continues to show the remarkable growth that began a little over two years ago when the entire approach to marketing and sales was revamped. John Fitch continues as Director of Technology-based Educational Development and Marketing.

Our best estimate is that we now reach between 10,000 and 12,000 students per year, primarily in industry. Since we no longer charge a per-student tuition, we base our estimate on the number of study guides sold and the relative frequency of orders that do and do not include these guides.

Toward the end of the year, we began the development of a 15- to 20-lecture subject on Microprocessors and have been negotiating contracts for the development of subjects on Corrosion, Introduction to Analog, and Digital Signal Processing. We also have begun discussions on still other topics such as Electrochemistry and Amorphous Semiconductors. We think it significant that although we have budgeted for the development of two subjects during the coming year, we may actually now have funds in hand for the development of four or five such subjects.

During the hiatus from subject development, the Self-Study Program took an alternate route to the task of increasing its library: namely, the acquisition of subjects from other universities. After a successful start with Colorado State University in having another institution produce materials to our technical quality specifications, we agreed this past year to distribute three additional subjects from this source; Probability Distributions and Decision Rules; Active Filters; and Quality Planning. In addition we entered into our first agreement with the University of Delaware for the distribution of a subject, which we specified and which they are now completing, on Integrated Optics.

Fiscal 1978 also saw us become the distributors for seven subjects from the faculty of Technology of the Open University of the United Kingdom. These subjects include four on Systems Engineering and one each on Materials, Mechanics, and Instrumentation. The films for these subjects were all produced by the British Broadcasting Corporation.

Tutored Video Instruction has now completed its third semester of operation. Since the program started in February 1977, it has been under the direction of Dr. John T. Lynch who now plans and markets the program full time.

T.V.I. is both a mode of instruction and a specific program at M.I.T. Using the T.V.I. mode, small groups of engineers in industry view videotapes of regular M.I.T. classes under the guidance of a company tutor. When the videotape is stopped, the tutor fosters active participation in discussions. As an educational technique, T.V.I. has been an unqualified success.

We have found that it is possible to produce inexpensive and educationally effective videotapes of classes without interfering with class instruction or taking faculty time. To produce and distribute T.V.I. tapes, the program employs Martha Leinroth, technical assistant, and 10 M.I.T. undergraduate students. With the growth of the program and the demand for high-quality videotapes, managing T.V.I. video operations has become a full-time job. We plan to increase the staff by one more person to handle the increased workload of brochure preparation and correspondence. We now cover these tasks with temporary help.

We have found that the most successful T.V.I. subjects are in areas of specialized applied technology where organizations and their engineers feel the subject content is critical to their development. We also have learned that the most critical marketing task is to provide technical details of subjects to engineers who are the potential users. We will continue to
interact with company education managers and engineering managers, but expect the demand for T.V.I. to come from engineers themselves. The implication of this in terms of program planning is the need to spend more time, effort, and money writing and distributing brochures.

Two variations of T.V.I. are being developed in response to needs of industry and industrial engineers. In the first variation, T.V.I. -P.M., engineers for a T.V.I. group study at M.I.T. in the evening. They enroll as Special Students and work with an M.I.T. graduate student tutor. In the second variation, T.V.I. -Short Course, an instructor delivers one lecture per week for 10 weeks covering the physical and mathematical models and selected application of the subject material which is offered that same semester in a regular M.I.T. subject. This last semester Professor Robert Kyhl delivered a short course, Microwave Circuits, in this format. Twenty engineers participated in this short course at Lincoln Laboratory. They found the content and the format of this course very effective.

Through Tutored Video Instruction we are learning to effectively and economically make M.I.T. educational resources available to engineers in industry.

Conference, Seminar, and Short Course Program

The Center inaugurated a new continuing education program this year. On September 26, 1977 we held our first meeting entitled, "Symposium on the Computer and Discrete Product Manufacturing." We have held two subsequent meetings. In January 1978 we held a seminar called "Substitutions Strategies in Textiles" and in May 1978 a meeting on the "Maximum Entropy Formalism." We are planning more meetings for the fall. The topics include: Computer-Aided Design; Energy Costs by the Year 2000; Solar Energy: Photovoltaics; and the Analysis of Filamentary Particles.

Approximately one year ago we began negotiations with the Royal Netherlands Industry Fair (Jaarbeurs) based in Utrecht, the Netherlands. These negotiations were formally completed in Holland in May 1978 and will provide for meetings to be held in Scandinavia, Luxembourg, Belgium, Holland, and the United Kingdom. We have already planned a number of these meetings to be held in the fall of 1978. They include meetings on: Photovoltaics; Energy Regeneration; Ultrasound, Ultraviolet, and Microwaves; Man and Machine; Computers in Design and Manufacturing; and Communicating Technical Information. We will continue to plan meetings with Jaarbeurs.

Our plans include supporting a number of meetings on and off campus in other parts of the country and in other parts of the world. The meetings which have already taken place have been the responsibility of the Director and Associate Director of the Center, with the support of consultants and some staff. We plan to hire a full-time director for this Program this summer. The director will handle most of the logistics and planning of these meetings in the future. This program is expected to grow quite rapidly both on and off campus.

Research and Development

Technical Curriculum Research and Development Project

Administered jointly by C.A.S. and the Department of Materials Science and Engineering, the Project is under the supervision of Professor Merton C. Flemings. It is directed by Dr. John W. McWane.
The Project is the result of a contract with the Imperial Organization for Social Services (IOSS) of Iran for the development of a new two-year technical college, the Shiraz Technical Institute (STI). STI is one of a series of vocational/technical schools being established by the IOSS to meet Iran's rapidly growing demand for technically trained professionals below the level of engineer.

From its inception, STI has been viewed as a "lighthouse" institution of technical education. To achieve this, we have set the following goals for the School to be: a national center of excellence and innovation in technical education; a source of new teachers and teaching materials for Iran's technical education system; and a source of technically trained professionals for Iranian industry.

Cooperating with M.I.T. in the development of STI are Wentworth Institute of Technology and Hugh Stubbins and Associates, Architects. Wentworth is responsible primarily for the operational aspects of the school, e.g., providing resident US advisors, purchase and shipment of books and equipment, and training of Iranian faculty and staff; while Hugh Stubbins and Associates is concerned with the design of the building and its furnishings.

The activities of the project fall into two broad categories.

Curriculum Materials Development. This is the principal activity of the project and is concerned with the development of innovative, state-of-the-art course materials in needed areas of engineering technology. Two projects are currently under way. The first is the development of a new introductory course in electronics that takes into account the dramatic advances in the field, particularly the variety of integrated circuits and transducers that are now available. The course is entitled Introduction to Electronics and Instrumentation and consists of eight three-week modules of instruction including text, laboratory directions, and problems. The module titles are: dc Current, Voltage, and Resistance; Basic Circuit Networks; Time Varying Signals; Operational Amplifiers; Power Supplies; ac Current, Voltage, and Impedance; Digital Circuits; and Electronic Measurement and Control. This course represents a major change and updating of the way in which electronics is introduced, and should be of great value to STI as well as to many US programs.

The second major project is the development of a new introductory course in mechanical engineering technology. This course, Introduction to Mechanical Systems, is designed to give students immediate, hands-on, practical experience with operating systems that are representative of a range of mechanical engineering concepts and techniques. It consists of four eight-week modules which include text, lab materials, and problems. The module titles are: Motorized Cart; Refrigerator/Heat Pump; Solar Energy Collector; Automated Hydraulic Press. Both courses will be taught for the first time at STI in the fall of 1978.

Curriculum Development. The second major activity of the Research and Development Project is the formulation of innovative, state-of-the-art programs in engineering technology. Following a study of manpower needs of the industrial community of Iran, and an analysis of student backgrounds and capabilities, curriculum objectives and a general course structure were established. The following engineering technology programs, each with options of specialty, were then identified: 1) Electrical Engineering Technology: Electronics Option, and Electrical Power Option; 2) Mechanical Engineering Technology: Machine Design Option, Manufacturing Processes Option, and Thermal Fluids Option.

The project is now beginning the fourth of a five-year contract. Contractual commitments are on schedule and possibilities for renewal will be discussed during the coming year. Additional activities that are being considered include the development of new and innovative course materials in the areas of solar energy, computer graphics, and electromechanical instrumentation, and the design of technical programs and options in chemical and civil engineering technologies.
Project PROCEED (Program for Continuing Engineering Education) originated several years ago within a group of M.I.T. professors, led by Professor Lawrence B. Evans of the Department of Chemical Engineering. It was intended to be an innovative approach to continuing engineering education which would have a problem-solving focus and relate primarily to engineers in industry who were working on problems of national importance. The Project was funded by the National Science Foundation in 1975. Dr. Myron Tribus joined Professor Evans as Co-director of the Project the same year he came to M.I.T. The Project is now a joint effort involving C.A.E.S. and the Department of Chemical Engineering. Professor Karen C. Cohen is the Director.

In the early phases of the Project, five exemplary modules were developed. The Project itself has hopes of developing both technically innovative systems for delivering continuing education (an adaptive reference system) as well as structuring a consortium of users and developers which will make the system work. Concepts key to the system are self-study modules, problem-solving cases, and adaptive referencing to help a user find the information necessary to solve a particular problem, utilizing the entire system as a data base for search and inquiry.

A needs assessment in the summer of 1977 identified four nationally important and relevant areas which PROCEED should address: industrial energy conservation, protection of workers and users from toxic substances, alternative energy sources, and waste treatment management. We expect to develop the first two next year and the last two later.

Our first topic is "Industrial Energy Conservation." Professor Elias Gyftopoulos of the Department of Nuclear Engineering is Editor-in-Chief of this series of modules and cases. We are in the process now of developing approximately 30 modules (which teach the competencies necessary to solve real problems in industrial energy conservation) and approximately 75 illustrative problem-solving cases. A focused effort to find and develop these cases was made by teams of professors and graduate students in different parts of the country during the summer of 1977. The information derived from this intensive effort was used to determine the competencies required. These cases also are integral components of the system. At this point we have received first drafts of our modules from the authors who represent special expertise in various areas, primarily industrially based, throughout the country. Our plans are to field-test the modules and the entire system from September 1978 through January 1979.

Our second topic, which we are just beginning to develop in a manner similar but not identical to that of "Industrial Energy Conservation," is "Protection of Workers and Users from Toxic Substances." To this end, we have enlisted the support of Professor Nicholas Ashford and several of his staff from the Center for Policy Alternatives.

As to the human network referenced above, we are in the process of building a constituency of users, developers, teachers, and brokers of continuing education throughout the country. We held a conference at C.A.E.S. on May 4 and 5, 1978, for university-based directors of continuing education, from all parts of the country. They all agreed to field-test our materials and help us in the development of our system. We anticipate holding a similar meeting for industrially based directors of continuing education in July 1978.

During the next 18 months, once we have demonstrated that PROCEED is viable, it is anticipated that we will form a not-for-profit corporation, which will take over responsibility for management of the PROCEED system.
INSTRUCTIONAL TECHNOLOGY

Because M.I.T. requires video services in many departments and because C.A.E.S. has been the biggest user of video, the management of the entire operation has been delegated to C.A.E.S. For the last three years it has been proposed that since video usage at M.I.T. has been growing very rapidly, the responsibility for video should be transferred to some other institute enterprise. In preparation for this move, as much of the video operation as possible has been budgeted as a separate accounting entity, and a Video Management Task Force appointed by the Provost's office has administered the Sloan II funds which help support some of the video facilities.

The following services are provided to members of the M.I.T. community including faculty, students, staff, and the administration: running the cable television system; renting equipment for production, editing, and viewing; providing video instruction; maintaining three studios for video productions; running the T.V.I. classroom.

The cable television spine connects all key locations on campus including departments and dormitories.

Under Sloan Grant I, the M.I.T. cable installation proceeded in two phases: 1) installation of the main cable spine connecting all cardinal points on campus; and 2) installation of distribution systems within departments and dormitories.

The equipment dedicated to the head-end of the cable is in the C.A.E.S Master Control Room. Students trained by the C.A.E.S. staff are responsible for putting the tape on the air at the scheduled time and for monitoring the program for possible problems.

Since March 1977, M.I.T.'s cable system has been connected to Harvard University via a microwave link. Cable programs from M.I.T. are distributed to several viewing stations at Harvard's Cambridge campus and at the School of Public Health.

The first test of the two-way link was a series of lectures on mathematics presented at Harvard and of interest to mathematics students at M.I.T. The M.I.T. class could see and hear the lecture as it was taking place; the Harvard class could hear the questions but could not see the person in the M.I.T. class. Several flaws in the system were ironed out and the link is now open at all times.

Several programs on the M.I.T. Cable are taped by Harvard and replayed on their weekly "Noon Hour Theatre" show.

M.I.T. also receives all Harvard University's programming on M.I.T.'s cable and their cable lectures are publicized on M.I.T.'s cable schedule in the campus newspaper.

Video Development (Sloan II)

The Alfred P. Sloan Foundation has made two grants to M.I.T. in support of video development: $620,000 in 1974 (Sloan I) and $490,000 in 1976 (Sloan II).

The first grant was used to install a cable system and to fund several video projects at the Institute. The second grant was used to fund additional projects which would help objectives developed by the Pool committee. An in-depth annual report on C.A.E.S.'s development of video and cable television at M.I.T. has been issued. Among the several categories of projects funded under Sloan II were the following:
Tutored Video Instruction. For minority students (under Professor Wesley Harris, Office of Minority Affairs); and for students in industry (under C.A.E.S.).

Live and Recorded Cablecast Reviews. For students in the classes of Professors Alvin Drake, Hermann Haus, James Melcher, Robert Rose, and Herman Chernoff.

Artistry and Research. By the Film Section, the Center for Advanced Visual Studies, and the Committee on the Visual Arts.

Assistance and Documentation of Public Decision Making. By the Department of Urban Studies and Planning, for cities and towns as well as the Commonwealth of Massachusetts (Professors Lawrence Susskind and Tunney Lee), and for energy conservation in buildings (Professor Thomas Nutt-Powell).

Courses which focus on professional and commercial T.V. By the Department of Political Science (Edwin Diamond's course on American Television and Cultural History).

Courses using video as an integral teaching aid. In the Department of Humanities to teach Acting, Media Design, and writing.

Short video interviews. By the Oral History Program, to document controversies involving science, technology, and society (nuclear power, recombinant DNA research).

Self-Study Programs. At the Center for Advanced Engineering Study.

New programs and specials. By student video groups like M.I.T.V., Video Club, and Basement Video and 'independent' student producers.

Replay of recorded lectures and talks. By M.I.T. and visiting faculty.

Link-up with Harvard University. On the M.I.T. cable. Lectures are sent to Harvard and regular educational programming is picked up from Harvard.

MYRON TRIBUS

Center for Policy Alternatives

The Center for Policy Alternatives is chartered to study and investigate substantive issues facing society, particularly those in which technology and engineering could play significant roles. The Center's basic purpose is to foster informed decision making for public and private policy by increasing our knowledge of the nature of the complex and interrelated problems of technological societies and by contributing to the practical understanding of effective policy formulation and evaluation. Among the Center's primary functions are the identification of major sociotechnical issues facing society, the assessment of the consequences of present policies and practices, and the development and appraisal of alternative actions for government, industry, labor, and education which will respond effectively to society's needs.

In carrying out its sponsored and ongoing research programs, the Center serves as a focal point for some of the policy-oriented activities of M.I.T. departments, centers, and laboratories, and seeks to stimulate faculty and students to participate in projects which have the greatest potential for social and economic utility.
Technology Policy and Innovation

One dimension of the Technology Policy and Innovation Program is concerned with the influence of national policies on innovation and technical change within various industries and national settings and with the formulation of alternative policies for the US and foreign environments. The second, and complementary, research interest focuses on understanding the processes of innovation and technical change within the firm, and the private practices and public policies that influence these processes at the level of the firm.

Research was completed in fall 1977 on a 14-month project sponsored by the Delegation a l'Amenagement du Teritiore et a l'Action Regionale (DATAR), an agency of the French government responsible for national programs of regional development. This program identified and examined the conditions under which successful, self-sustaining implementation of technology-oriented complexes can and do take place. The second phase of the project focused on the special problems of traditional industries in acquiring and implementing new technologies. The research team consisted of Dr. J. Herbert Hollomon, Director of the Center and Japan Steel Industry Professor of Engineering; Dr. Marvin A. Sirbu, Research Associate; and Professor Thomas J. Allen of the Sloan School of Management.

Under a National Science Foundation (NSF) grant, Dr. James M. Utterback, Research Associate, continued to direct an examination of the relationship between evolving product and process technology. This project seeks to develop a conceptual framework and a consistent set of hypotheses that account for the dynamics of firms' processes of innovation. The work draws upon the findings and results of a large number of descriptive studies and information that to date have provided diverse and fragmented views of the innovation process. The intent of the research is to integrate, synthesize, and extend existing knowledge into a framework that has utility for managerial and government decision makers. Participants included Dr. Linsu Kim, Research Associate; Dr. Jinjoo Lee, Visiting Research Associate on leave from the Department of Industrial Science at the Korea Advanced Institute of Science in Seoul; Dr. Paul Horwitz, part-time Research Fellow on leave from Avco Everett Research Laboratories, Inc.; Dr. Meir Weinstein, Research Fellow on leave from the Interdisciplinary Center for Technological Analysis and Forecasting (ICTAF) at Tel Aviv University; and several graduate students.

During fiscal year 1977, a Center research team developed a resource document that identified key issues for government actions affecting technological innovation in the civilian US economy. Prepared for the Office of Technology Assessment (OTA) Panel on the Applications of Science and Technology, the document included a series of explicit policy issues concerning how government action in market-oriented economies could influence the direction and character of innovation for civil purposes. In fiscal year 1978, this research was extended to analyses of the policies and practices by which the US government has and is affecting the climate for innovation in the unique US environment. The research team included Dr. Hollomon, Dr. Nicholas A. Ashford, Senior Research Associate, Research Associates George R. Heaton and Byron F. Battle, Dr. Kim, Dr. Sirbu, and Dr. Utterback.

In February, the Center began an 18-month study sponsored by the Ministry of Industry, Commerce and Tourism of the Government of Israel to examine government policies to encourage industrial innovation in the civilian Israeli economy. The overall program involves examination and analyses of financial and investment incentives for private firms, direct aid to firms for development of new products and processes, the changing role of universities and research and development institutes, and implications of the Israeli experience to other developing countries. The participation of ICTAF at Tel Aviv University in data collection, documentation, and on-site analyses is a central aspect of this program which also provides for Israeli officials in residence at the Center for short periods throughout the program. Dr. Hollomon, Dr. Rao, Mr. Battle, Dr. Weinstein, and two students were initial project participants.
As the fiscal year came to a close, arrangements were completed for a three-year study of the recently established Israel-US Binational Industrial Research and Development Foundation (BIRDF). The goal of BIRDF is to promote and support joint, non-defense industrial research and development activities by Israeli and US companies that lead to viable commercial products and processes. Research will commence July 1 and involve Dr. Rao and a graduate student.

**Manpower Policy**

The influence of public policy and private practice on the supply, demand, and training of professional and technical manpower is a long-standing Center research interest. The Center's major research thrusts have focused on developing econometric models for forecasting the market for college-trained manpower in the US and in foreign countries. These models relate demographic information, enrollment, salary, market demand, and government support for education to the supply of young people opting for certain professions.

The completion of the three-year Venezuela manpower project in fall 1977 represents the first application of these models at a national level for manpower policy planning purposes. The program was funded by the Fundacion Gran Mariscal Ayacucho (FGMA) scholarship program, the largest scholarship program in Venezuela. Under the direction of Dr. Rao, the research effort analyzed supply and demand phenomena in Venezuela for engineers, managers, school teachers, and technicians in order to provide policy guidance for the FGMA scholarship program. An important part of the overall program was the training of Venezuelan professionals in the new methodologies and techniques of manpower forecasting. Orlando Lokpez-Lovera, who served as project manager, has returned to Venezuela and is working with FGMA's manpower research and analysis division. Arnoldo Gutierrez, a member of the research team in fiscal year 1977, currently directs the manpower analysis group in Venezuela's National Institute for Industrial Training (INCE).

Dr. Rao continued to participate in the Joint M.I.T.-Wentworth Institute program assisting the Imperial Organization for Social Services (IOSS) of the State of Iran in establishing the Shariz Technical Institute. In addition to serving on the joint M.I.T./IOSS advisory board for the new institute, Dr. Rao carried out a series of analyses related to long-range planning for enrollment and instructional staffing, extension training programs, and new curricula in engineering technologies.

Under the direction of Dr. Sirbu, a research group continued to extend and refine existing econometric models used for forecasting the supply and demand for graduates in science and engineering in the US. Particular attention is being given to the relative demand for scientists and engineers compared with other occupations, and to the development of models that encompass the total stock of scientists and engineers and thus take into account attrition and inter-industry mobility. The two-year research program is being funded by NSF and involves Professor Richard B. Freeman of Harvard University and several graduate students.

**Consumer Policy**

The Consumer Policy Program is broadly concerned with government policies affecting consumer health and welfare and with consumer behavior patterns, particularly the economics of consumer choice, including elements of life-cycle costs, product life, and consumer protection. The warranties, service contracts, and alternatives project directed by Robert T. Lund, Senior Research Associate, is being completed as the fiscal year comes to a close. This three-year program examined the warranty and service contract system for consumer appliances, including its legal context, the pattern of consumer behavior, and the economic
and social consequences of various alternatives to the present system. Participants during the final year of research included Mr. Heaton; Dr. Stewart A. Butler, Research Associate; Judith I. Katz, Research Associate; Professor Warren H. Hausman of Stanford University; Professor Leon Courville of Ecole des Hautes Etudes Commerciales in Montreal; Professors Keith Bryant and Jennifer Gerner of Cornell; and several graduate students.

In July, the Center conducted a two-day conference entitled Consumer Research for Consumer Policy under an NSF grant. The conference addressed the policy implications of recent consumer research and identified ideas and recommendations for improving the ways in which research can contribute to the formulation of consumer-related policy. Chaired by Mr. Lund, the conference included more than 100 invited attendees from government, industry, education, and consumer-related interest groups. It represented one of the first attempts to bring consumer advocates, consumer researchers, and private and public decision makers together at a national conference on consumer research issues. Dr. W. Michael Denney, Visiting Research Associate, served as conference co-chairman and edited the proceedings that will be distributed during summer 1978.

With support from the Federal Trade Commission, Mr. Heaton directed a 10-month project focusing on advertising, marketing, product labeling, and other market information that influences consumers' energy consumption patterns; the project also investigated possible government roles to encourage energy conservation via influences on these kinds of information. A focal point of the program was a small workshop held in the spring that addressed the current state of knowledge about these topics and considered policy issues for government action. Research participants included Dr. Denney, Dr. Butler, Mr. Lund, Ms. Katz, Dr. Ashford, and a graduate student.

**Industrial Productivity Policy**

Industrial Productivity Policy activities are concerned with identifying new opportunities for technology in industry and with the relationships among productive processes, technology, job design, and social goals. Mr. Lund continued his participation in the joint M.I.T.-Industry Polymer Processing Program directed by Professor Nam P. Suh of the Department of Mechanical Engineering. This NSF-supported experimental program completed its fifth and final year, and Mr. Lund has been responsible for the overall evaluation of this unique cooperative program. Mr. Lund also participated in a new Air Force program examining Integrated Computer Aided Manufacturing (ICAM) technology. Through a subcontract from Softech, Inc., of Waltham, Mr. Lund and a graduate student conducted a preliminary appraisal of the scope of possible ICAM technology impacts on the structure of industry, manufacturing strategy, employment, the nature and organization of work, as well as the physical environment. This effort also defined a broader initiative to examine potential ICAM impacts in more detail as an integral part of the overall Air Force program.

The possible employment and organizational consequences of introducing sophisticated manufacturing systems is a continuing concern of industry, both here and abroad. With support from Novaction, S.A., of France, Mr. Lund with Dr. Sirbu and two graduate students examined the pattern of introduction and implementation of numerical control (NC) machine tools for the purpose of gauging the impacts of NC and group technology on the organizational structure of firms. The basis of this modest effort was that the introduction of NC might provide some insights by analogy to the probable consequences of more sophisticated forms of automation. In late spring, the Center began a research program focusing on the nature, effects, and management of industrial automation with support from General Motors Corporation. This program is being directed by Mr. Lund and will involve a number of staff and graduate students during the coming year.
An 18-month research program on innovation in housing production in Israel was completed in January under the direction of Professor Robert D. Logcher of the Department of Civil Engineering. The program was funded by the Jewish Agency for Israel for the Israeli Ministry of Housing and involved a participating research group at the Institute for Technology at Haifa (Technion). Participants included Research Associate Henry Irwig and several graduate students from the Department of Civil Engineering.

Workplace and Environmental Regulation

Research concerned with workplace and environmental regulation has continued to expand and broaden over the last two years. These activities generally involve identification of alternative strategies for regulation and evaluation of regulatory impacts by a variety of techniques. They are concerned with the effects of regulation on worker and community health and safety and on the connection with the manufacturing process. The continuing development of analytical and methodological techniques for the complex technical, economic, political, and legal issues involved is an integral part of all of the Center's efforts in this area.

An NSF-funded program examining the multiple impacts of Federal, state, and local regulations on the copper wire industry was completed under the direction of Professor Joel C. Clark of the Department of Materials Science and Engineering. The development of a methodology for assessing the costs and benefits of multiple levels of regulatory involvement, ranging from tax depletion allowances to air pollution control, was central to this project. The participation of representatives from industry, state and local governments, labor, and public interest groups with the Center's 10-member research team and graduate students was an important dimension of this program.

Dr. Ashford continued to direct an NSF-funded project examining the relationships between environmental/safety regulation and technological responses and innovation in selected production segments of the chemical and allied product industries. Research is nearing completion and involves Mr. Heaton, Ms. Katz, Dr. Dale Hattis, Research Associate, and several graduate students.

Research activities for the Occupational Safety and Health Administration (OSHA) of the Department of Labor (DOL) were carried out under the direction of Dr. Ashford. One OSHA research activity focused on the development of a five-year strategic plan for occupational disease abatement efforts. This work was carried out in collaboration with ICF, Inc. of Washington, DC, and involved Dr. Hattis and Research Associates Sally T. Owen and Robert Gecht. An important product of this research was a health hazard-based industrial classification system that represents a new tool for OSHA planning as well as a possible organizing device for future population studies of occupational disease.

A series of research efforts were undertaken by the Center to help clarify the health and economic implications of alternative occupational lead exposure regulations then being considered by OSHA. Funded by OSHA and the Office of the Solicitor in DOL, the economic analyses of proposed medical removal protection provisions were based on the application of biological models of lead transport in humans to predict dynamic changes in blood lead levels. Research in this area is continuing and involves Dr. Ashford, Dr. Hattis, and Ms. Katz.

In December, a one-year effort was undertaken to explore generic issues and alternative policies available to OSHA for reducing occupational disease and injury. This multi-task effort involves an examination of legal and technical issues related to the removal of workers from hazardous conditions, studies of supplementary approaches to worker health and safety in addition to the standards approach, and analysis of mechanisms for improving both standard
and non-standard approaches to the prevention of occupational injury and illness. Project participants included Dr. Ashford, Ms. Katz, Dr. Hattis, and Mr. Gecht.

With support from the Experimental Technology Incentives Program in the National Bureau of Standards, an initial feasibility study was made by Ms. Owen with Dr. Hattis of two experimental programs that could enhance OSHA's ability to better achieve its regulatory missions. The programs examined were the establishment of experimental health maintenance organizations and the establishment of joint labor/management safety and health committees. Late in the year, Dr. Hattis and a graduate student began a modest activity examining hypothesized relationships between noise stress and cardiovascular disease under a grant from the Environmental Protection Agency.

Communications and Office Automation

Dr. Sirbu's continuing research on the adoption of word-processing and mini-computer systems in the office environment came to fruition in fiscal year 1978. The focus of this work is on the potential impacts of office automation on traditional employment patterns, the nature of office work and organizational structure, as well as the effects on industries producing office equipment. At mid-year a study of terminal-to-terminal electronic communication systems was completed that examined current technological and market trends, delineated policy issues posed by such systems, and suggested possible monitoring and research efforts that could be initiated. This work was carried out in collaboration with Kalba-Bowen Associates of Cambridge under a Federal Communications Commission contract and involved Dr. Sirbu, Professor Ithiel de Sola Pool of the Department of Political Science, Research Associate Albert Vezza of the Laboratory for Computer Science, and a graduate student.

In May, Dr. Sirbu chaired a two-day symposium entitled "Office Automation: What the Future Holds" under the auspices of M.I.T.'s Industrial Liaison Program. Over 250 people attended this symposium focusing on the technologies being developed at M.I.T. and elsewhere to facilitate the long-range development of office systems and on the economic and managerial implications of those technologies. A further indication of M.I.T.'s growing research interest was the formation of a working group consisting of faculty and staff to examine and develop research initiatives and proposals. Dr. Sirbu serves as key staff of this working group.

Educational Activities

The active participation of undergraduate and graduate students with Center staff in sponsored and developmental research projects is one dimension of the Center's role in the education and training of engineers and students in the School and the Institute. Center staff also contribute to the development of new degree programs, design and teach new subjects, and serve as advisors to students.

Dr. Sirbu, Professor Thomas B. Sheridan of the Department of Mechanical Engineering, and Dr. David Noble, Research Associate in the School of Humanities and Social Science, continued to teach the Proseminar in Technology and Policy, a core offering of the Master's-level Technology and Policy Program. Mr. Lund, also Lecturer in the Department of Mechanical Engineering, and Professor David P. Hoult of the Department of Mechanical Engineering again taught 2.96J Management in Engineering, a joint offering of the Departments of Mechanical Engineering and Electrical Engineering and Computer Science. Mr. Lund also taught 2.863 Elements of Manufacturing during the first term. Dr. Ashford assisted by Ms. Katz taught 16.793 The Law/Technology Interface, as part of the Institute's Law-Related Studies Program. With the assistance of Ms. Owen, Dr. Ashford presented 3.575J/10.805J Technology, Law and the Working Environment for the first time in fall 1977. Dr. Ashford also re-structured and
School of Engineering

offered the Department of Civil Engineering’s two-subject sequence on environmental pollution. Dr. Utterback taught 15.795 Seminar on Operations Management jointly with 2.95 Innovation and Industrial Development with the participation of Professor Sheridan.

J. HERBERT HOLLOMON

Center for Transportation Studies

The Center for Transportation Studies (C. T. S.) was established in 1973 to coordinate the transportation activities at M.I.T. Prior to the formation of C. T. S., transportation activities at M.I.T. were focused toward particular transportation modes (rail, highway, air, ocean, etc.) with major emphasis on vehicle design and the infrastructure facilities to support the vehicles (guideways, terminals, etc.). The formation of C. T. S. represents a broadening perspective of transportation at M.I.T. In particular, the following considerations influence the C. T. S. approach to transportation:

1) Provision of transportation services is not the final objective. Transportation is utilized to achieve other societal objectives, thus transportation problems cannot be addressed in isolation from the other concerns of society.

2) Transportation systems are impacted by many considerations, such as energy, the environment, the economy, and the users and nonusers of the systems we design. Recent negative reaction to the interstate highway program is a good example of what can happen when these impacts are not properly considered.

3) Transportation problems are increasingly multimodal. A systematic approach is required to select between and interface the appropriate modal subsystems. Although the modes differ, a common frame of reference is possible to address basic transportation issues.

Transportation is thus inherently intermodal and interdisciplinary. C. T. S. provides both the intermodal and interdisciplinary linkages for numerous research and educational transportation activities at M.I.T. involving the following departments: Aeronautics and Astronautics, Civil Engineering, Mechanical Engineering, Electrical Engineering and Computer Science, Ocean Engineering, Political Science, Economics, Urban Studies, and the Sloan School of Management.

A Steering Committee has been established to oversee the activities of the Center. The Steering Committee meets monthly and for the 1977-78 academic year had the following professors as members: Paul Roberts, C. T. S. Director, Civil Engineering; Daniel Roos, Civil Engineering; Herbert Richardson, Mechanical Engineering; Robert Simpson, Aeronautics and Astronautics; Ernst Frankel, Ocean Engineering; Ralph Gakenheimer, Urban Studies; Joseph Sussman, Associate Dean for Educational Programs, School of Engineering; William Wheaton, Economics; Alan Altshuler, Political Science; and Peter Lorange, Sloan School of Management.

Over 40 faculty and staff members and 150 graduate students participate in the activities of C. T. S.
Center for Transportation Studies

Transportation Master's Program

One of the primary objectives of the faculty affiliated with the Center is the development of a new Master's Program in Transportation. M.I.T. is in a unique position to develop such a program which combines technology, systems analysis, planning, policy analysis, and management; all important components of transportation.

Many high-quality transportation students do not come to M.I.T. because of a lack of identification with an M.I.T. department, or because there is no transportation program in the M.I.T. department with which they identify most closely. Other transportation students do come to M.I.T., but do not feel comfortable in their home departments. The proposed new program would attract high-quality transportation students who would not otherwise come to M.I.T., and who would provide a broader program and better environment for many existing students.

In spite of the complex relationships of transportation with other societal problems and the need for diverse backgrounds in the solution of transport problems, a coherent field of study is now possible. Theoretical approaches to various transport problems involve a common set of analytical tools and methodologies (e.g., economics, simulation, optimization methods, control systems, institutional analyses, network theory, dynamics, etc.). These methodologies are applied to a variety of transportation contexts: 1) Modal (air, rail, truck, marine, etc.); 2) Geographic (urban, intercity, regional, international, developing country); and 3) Market (passenger, freight).

Faculty interested in transportation have now reached consensus on an educational program. The proposed program would establish the basic methodological framework to understand transportation problems and provide a number of options reflecting the numerous transportation contexts. Students from a variety of backgrounds would enter the program, primarily from engineering, but also those with interests in social sciences and management. The approach of all students regardless of their backgrounds would be quantitative and analytical -- reflecting the basic orientation of M.I.T.

The proposed new program has been approved by the Engineering Council. It will be presented to the Institute faculty and then to the Corporation for approval early in the 1978-79 academic year so that the program's first students can be admitted for September 1979.

Transportation Summer Programs

To provide an opportunity for professionals now practicing in transportation or related fields to explore a multimodal, multidisciplinary perspective to transportation, and to acquire new techniques for application to their specific problems, C.T.S. is offering a coordinated set of Transportation Summer Programs. Some of these Programs are focused on a particular mode or topic area. Others are more general, designed to provide coverage of basic concepts and techniques. Some sessions will be common to many Programs.

Participants in any individual Program are able to attend selected sessions of other Programs given the same week. Thus, attendees are able to tailor a broad multimodal perspective for their individual needs, as well as concentrate on topics in their own area of professional interest.

The Programs are designed for transportation managers, planners, analysts, and engineers in both industry and government, as well as university faculty interested in transportation.

Programs are offered in: Transportation Systems Management and Analysis; Air Transportation; Port Planning and Development; Urban Transportation; Freight Transportation; and
School of Engineering

Forecasting Transportation Demand. Students may attend one or both weeks of the Programs offered.

The Programs in the first week generally concentrate on basic concepts and techniques. Those in the second week are in-depth treatments of the issues actually faced in the particular problem area addressed by the Program at the professional level, and assume prior knowledge at the level of the material covered in the first week.

During the summer of 1977 the Programs attracted over 120 students. They will be presented again this summer.

Research Activities

C. T. S. oversees more than $1 million of sponsored research projects a year. A good example of C. T. S. research is a recent project initiated in conjunction with the M.I.T. Energy Laboratory. The project, sponsored by the US Department of Energy, involves the development of transportation energy contingency plans for use in the event of a major oil shortage. An objective of the research is to be able to respond to a national emergency similar to the 1973 oil embargo. An interdisciplinary team has been formed to generate and evaluate alternative strategies. M.I.T. is not only concerned with the technical approaches to the problem, but also is examining legal and regulatory issues, public participation in generating the plans, and the implementation process.

This project illustrates an important objective of C. T. S. research: to apply innovative approaches to transportation problems of national and international concern. Mission-oriented research demonstrates how traditional academic research results can be applied in a real-world setting.

Other Activities

C. T. S. has entered into a cooperative arrangement with the MIT Press to publish a major series on transportation. The first four volumes in this series are scheduled for publication this fall.

The Center sponsors a weekly seminar series which brings to the campus experts in transportation. The 25 seminars sponsored this year attracted 30 to 75 people per week. An information center which has major periodicals and books in the transportation field is also operated by C. T. S. In addition, M.I.T. research reports are distributed by the Center, and a quarterly newsletter is published by C. T. S. summarizing major transportation activities at M.I.T.

PAUL O. ROBERTS

Innovation Center

The grant from the National Science Foundation (NSF), which enabled M.I.T. to establish its Innovation Center in 1973, will expire in the fall of 1978, concluding a five-year "experiment" in engineering education. As is the nature of such pioneering efforts, there has been a necessity for redefinition of objectives, reallocation of assets, refining of perspectives, and rededication to those facets of the program which are deemed to be of enduring value.
Innovation Center

The conclusion of this NSF funding was marked by a Symposium on Innovation and Innovation Centers held at M.I.T. and attended by more than 250 individuals from government, industry, and the scientific and academic communities representing the United States, Canada, and Europe. It was most gratifying to note the enlarging interest in innovation education worldwide.

Professor Frank Press, on leave from M.I.T.'s Department of Earth and Planetary Sciences and serving as President Carter's Science Advisor, called the Symposium "well-timed," coinciding as it does with planned government support for innovation. As a result of the Symposium, extensive communications here and abroad concerning the future of innovation have begun. In recent weeks, Professor Y. T. Li, Director of the Innovation Center, has participated in a workshop at (and welcomed dignitaries from) Delft University where a new innovation program is under way and has had substantive talks with representatives from the ministries of Great Britain, France, and Finland, and from the government of Holland. He has begun setting the groundwork for a documentary on the Center to be produced by Canadian Public Broadcasting; he has begun work with the University of California at Santa Cruz where an Innovation Symposium is planned, and will journey to Mainland China in mid-August to encourage liaison between the United States and the People's Republic in the field of innovation.

The world trend is clearly to take up the cause of innovation as a unified approach to problem solving in technology; even as our NSF grant expires, the momentum of the innovation movement is building, and the M.I.T. Innovation Center stands at the crossroads.

Yet while the need for innovation is apparent and national and international interest in its development is evident, the nature of the role to be played by the university remains to be determined. A first step would seem to be the establishment of a methodological base. This is undertaken in a draft manuscript entitled Technological Innovation in Education and Industry due for publication by Van Nostrand Reinhold. In a following text, views will be presented on how a workable university-based Innovation Center can be structured on the basis of past experience.

During the past year, the Center has been involved with 10 student, eight industry, and nine faculty-initiated innovations. Direct funding from industrial and NSF sources for these projects over their lifetimes has totaled approximately $500,000 and has resulted in eight patent awards, 10 additional patent applications, and a number of venture businesses in various stages of development. From an examination of these activities, one concludes that students have benefited greatly from developing an expertise in the innovation process and that this has led to meaningful innovations. However, tangible returns from such undertakings are long-range in nature. Industrial contracts and faculty-initiated innovations offer opportunities to partially underwrite student projects, thus continuing this important aspect of the Center.

If the Innovation Center is to continue to derive revenue from faculty and industry participation in its activities, permitting the goal of entrepreneur training to be fully developed, it will be necessary to:

- encourage the full participation of the faculty by recognizing that patentable ideas result from a significant investment of time, with further effort required to reduce a concept to practice and attract serious licensees. Current Institute patent procedures may not provide incentives sufficiently attractive to induce innovative faculty to become earnest partners with the Institute in seeking marketable products.

- attract venture capital by developing a program through which the potential of aspiring entrepreneurs can be assessed by the investor, and by providing an incubation environment so that the aspiring entrepreneur can get the needed help during the crucial initial period.
Looking to the future, the Center's philosophy must recognize that innovators are a special breed, combining skill in product development, the ability to envision the development process from need to marketplace, the technical expertise to link concept and execution, and the drive to commit their time and the time of their associates far beyond a 40-hour week. The training of such individuals requires a new methodology as a corollary to the conventional engineering and management curriculum -- executed in an environment which is conducive to such a hyperextended work effort.

While a basis for the philosophy underlying this new methodology is incorporated in Technological Innovation in Education and Industry, implementation of such a methodology is a significant undertaking. One possible avenue for collaboration might be with Professor Jack L. Kerrebrock's Unified Engineering group. Over the past few years, this group in the Department of Aeronautics and Astronautics has assumed a direction in this regard similar to that of the Innovation Center.

Funding is an important issue for the Center's future and promising prospective donors have been identified. Yet, a far more critical concern is the solidification of the Innovation Center's program and the development of an organizational structure appropriate to its goals. Major funding for the Center's operating activities for the next two years is available from the National Bureau of Standards, the Department of Energy, and industrial contracts.

YAO TZU LI

Electric Power Systems Engineering Laboratory (E.P.S.E.L.)

The Electric Power Systems Engineering Laboratory (E.P.S.E.L.) is an interdisciplinary laboratory in the School of Engineering engaged in a breadth of educational and research activities relating to the generation, transmission, processing, and utilization of electric energy. Personnel in the laboratory supervise both undergraduate and graduate theses encompassing the many disciplines within the field of electric power systems engineering.

The following brief description of activities in E.P.S.E.L. illustrates the diversity and scope of its research. An accurate physical-scaled model of a power system is being used to study the effect of system switching on shaft fatigue of large turbo-generator rotors. This same facility is used to develop and evaluate control strategies and techniques to maximize a power system's integrity under emergency conditions.

Power electronics activities in E.P.S.E.L. have continued to expand. A major activity has resulted in the development of a new technique, called Parity Simulation, to investigate the behavior of electromechanical systems containing power semiconductor devices.

Research on the characterization of the large power supplies used for magnetic confinement fusion experiments is also in progress. This work has resulted in significant improvement in both the behavioral understanding and operational reliability of these exceptionally large and complex energy conversion systems.

Systems incorporating both electric machines and solid-state control and power conditioning networks constitute an important area of activity within E.P.S.E.L. One result of this work is a computer program to provide optimized designs of high-speed rotating machines. Another program in this area has resulted in the conceptualization and experimental investigation of
a new machine drive system designed to improve reliability through electrical phase redundancy applicable to such systems as traction drives.

A major effort continues in the Laboratory in conjunction with the Cryogenic Engineering Laboratory to extend the state of the art in turbine-generator technology through the application of superconducting magnets to the field windings of such machines. This project is aimed at meeting the needs of future electric power systems via generators of higher power ratings, smaller size, increased terminal voltage, and superior stability. The program will yield an advanced concept 10MVA machine for planned tests in 1981.

A study of the energy dynamics of electric machines is focusing on commutation problems in machines supplied through power switching control devices.

The Laboratory consists of 10 faculty members from the Department of Electrical Engineering and Computer Science and the Department of Mechanical Engineering, six staff members and approximately 40 students.

GERALD LOOMIS WILSON
School of Humanities and Social Science

The past year was essentially a year for the laying of new foundations. In the Department of Linguistics and Philosophy, Professor Samuel Jay Keyser, who became Department Head in July 1977, took the first steps towards setting up a new research enterprise in Cognitive Sciences. In the Foreign Languages and Literatures Section of the Department of Humanities, Professor Margery Resnick, who became Director of Modern Languages in July 1977, was able to fill no fewer than seven vacancies for junior faculty members in a way which will make possible a great strengthening of that Section. At the same time, significant changes were made in the Spanish and Chinese offerings. At the very end of the academic year Professor Emma Rothschild was appointed Director of the Writing Program. She will bring to the Program considerable distinction as a writer and a special concern for science policy. Finally, the new Program in Science, Technology, and Society was launched, with the appointment of Associate Dean Donald Blackmer as Director. At the end of the year, it incorporated the Technology Studies Program. The effect of these changes will not be fully felt for another two or three years. But all of them indicate the emergence of strong fields of research and teaching which will be of great importance in the years ahead.

Meanwhile, the annual cycle has brought its crop of changes. Professor Alan Altshuler succeeded Professor Myron Weiner as Head of the Department of Political Science, bringing to the job the efficiency which he had displayed as Secretary of Transportation and Construction of the Commonwealth of Massachusetts. Professor Robert Rathbone served as Acting Director of the Writing Program for the year 1977-78. Professor Leon Trilling of the Department of Aeronautics and Astronautics continued as Chairman of the Committee on the Institute Humanities, Arts, and Social Sciences Requirement. And Professor Carl Kaysen spent the major part of his time as Vice Chairman and Director of Research of the newly established Sloan Commission on Government and Higher Education.

One change which many of us have been working for will take place on July 1, 1979: there will at last be a significant number of tenured women on the faculty of the School. Five years ago the number of tenured women faculty members was only three. Next year it will be 11. The following year it appears likely to be 14. Given the slow rate of faculty turnover in the academic world these days, this is a very gratifying change. Moreover, it is clear that the women faculty who have achieved tenure at M.I.T. are remarkably distinguished in their own fields and unusually active in their professions. Junior faculty, men and women, may safely look to them to provide role models for the future.

His many friends on the faculty were delighted when Professor Morris Halle was named Killian Award Lecturer for 1978-79. Professor Halle is not merely the builder, along with Professor Noam Chomsky, of the internationally renowned Linguistics program, he is justly regarded as one of the wisest and most good-natured, as well as the most scholarly, professors at M.I.T. It gives those of us in the School great satisfaction that the Killian Award has now for three consecutive years been held by members of the School: the late Professor Hans-Lukas Teuber, Professor Robert Solow, and now Professor Halle. Professor Solow's lectures on the most pressing of current economic ills, inflation, drew overflow audiences in the spring and were among the major academic events of the year.
Following the graduation of the last substantial group of students whose studies were begun before the change in the Institute Humanities, Arts, and Social Sciences Requirement in 1974, the time is now ripe for an examination of the way in which the new requirement has functioned. Such an examination will necessarily take several years to complete. Meanwhile it seems that the Requirement has achieved many of its purposes. By allowing students a good deal of freedom, it makes allowances for differences of interest, training, and background. Yet it does require students to explore several fields of study, and it also requires some study in depth in one field.

The main functions of the current M.I.T. Humanities, Arts, and Social Sciences Requirement now appear to be four: 1) To ensure that no undergraduate can leave M.I.T. without a substantial exposure to a wide range of educational experiences, at least some of them in fields previously unexplored. 2) To build on strengths which students have already developed in non-scientific fields before they come to M.I.T. This has been most conspicuously achieved in music, where a substantial number of students have had some prior musical training. But many students also build on substantial previous acquaintance with foreign languages, English literature, and the visual arts. 3) To enable students to extend their studies into areas which will help them to enrich their individual lives. Literature, language, history, psychology, anthropology, writing, art, and music subjects are most commonly studied for this purpose. 4) To help students develop competence in areas outside science and engineering which will be of use to them in a scientific or engineering career. Most engineering students for this reason take at least one economics subject; increasingly they are also showing an interest in public policy subjects and in subjects in writing. A few students also study foreign languages because they expect to work abroad after graduation.

There have been some difficulties in the administration of the Requirement, which make it necessary for us to continue to give it a good deal of attention. 1) We have fallen behind any reasonable timetable in our attempts to fill some well-known gaps in the curriculum (notably in History) and we have not always been able to provide subjects at the right level for students with strong high school backgrounds in the humanities. 2) In spite of the rapid proliferation of Humanities Distribution subjects, we have not as yet found ways of meeting one of our original objectives, which was to offer advanced subjects, for which there might be stated prerequisites, as well as introductory ones. 3) The attempt to put backbone into the Concentration provision of the Requirement which was carried over from the previous requirement has achieved only partial success. Though we are still trying, we have not yet found a way of persuading the Registrar's computer to keep an adequate check on what happens in the case of individual students, and some departments are less active in counseling students than we had hoped. 4) We have not been able as yet to supply faculty advisors all over the Institute with adequate information on which to base the advice they must give to students. The result is that most faculty advisors appear to offer very little advice about the Humanities, Arts, and Social Sciences Requirement. Clearly we need to be more helpful to faculty advisors and to students than we have been and in particular to distribute to them materials which will help them to understand the purposes and functioning of the Requirement.

During the last five years my annual reports have reflected the high priority given by the administration to the strengthening of the Humanities at M.I.T. We are now perhaps halfway along the road that will, I hope, lead eventually to the recognition of M.I.T. as a major intellectual force in the Humanities as well as in the Social Sciences. The next step will be to undertake both a reorganization of the Department of Humanities and the drawing up of a development plan for the next five years. It is particularly important at this stage to think carefully about how best to sustain the activities of young faculty members, of whom there are a considerable number. We must find ways of counteracting the sense of isolation that comes from the total absence of graduate students and the relatively small number of majors. This can only be done by adopting a multiplicity of strategies: a campaign to reach the public...
School of Humanities and Social Science

and the high schools, a campaign to raise new funds, especially for research, and the development of a distinctive intellectual style in the various disciplines that will give M.I.T. a special character. Such objectives clearly involve the adoption of a new style of leadership such as already exists in the Modern Languages, and the creation of a number of planning task forces. These are the objectives for next year.

A separate report deals with the gradual merging of the Technology Studies program into the new Program in Science, Technology, and Society. Here, however, I should like to recognize the extraordinary effort which Dean Donald Blackmer has put into the developing of the new Program. Last year Dean Blackmer was Acting Director of the Modern Languages Program, helping to review and reshape it in preparation for the coming of a new Director. This year he became Director both of the Technology Studies Program and the Program in Science, Technology, and Society, which if all goes as planned will develop into a College of Science, Technology, and Society. This College will in time no doubt find its proper niche as an inter-School body.

HAROLD J. HANHAM
### TABLE I

**Enrollment in Distribution Subjects: 1977-78**

<table>
<thead>
<tr>
<th>Field</th>
<th># of Subjects</th>
<th>Total</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4 &amp; 5</th>
<th>Graduate</th>
<th>M.I.T.</th>
<th>Wellesley</th>
<th>Harvard</th>
<th>GRAND TOTAL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of Art and Architecture</td>
<td>6</td>
<td>294</td>
<td>50</td>
<td>75</td>
<td>71</td>
<td>76</td>
<td>18</td>
<td>290</td>
<td>4</td>
<td>0</td>
<td>294</td>
<td>6.4%</td>
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<tr>
<td>Humanities:</td>
<td>63</td>
<td>2811</td>
<td>1026</td>
<td>730</td>
<td>564</td>
<td>446</td>
<td>31</td>
<td>2797</td>
<td>14</td>
<td>0</td>
<td>2811</td>
<td>61.6%</td>
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<tr>
<td>American Studies</td>
<td>1</td>
<td>8</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0.2%</td>
</tr>
<tr>
<td>Anthropology/Archaeology</td>
<td>4</td>
<td>176</td>
<td>65</td>
<td>33</td>
<td>38</td>
<td>35</td>
<td>1</td>
<td>172</td>
<td>4</td>
<td>0</td>
<td>176</td>
<td>3.9%</td>
</tr>
<tr>
<td>Creative Writing</td>
<td>2</td>
<td>224</td>
<td>68</td>
<td>66</td>
<td>48</td>
<td>40</td>
<td>2</td>
<td>224</td>
<td>0</td>
<td>0</td>
<td>224</td>
<td>4.9%</td>
</tr>
<tr>
<td>Crossroads</td>
<td>8</td>
<td>242</td>
<td>60</td>
<td>70</td>
<td>63</td>
<td>47</td>
<td>1</td>
<td>241</td>
<td>1</td>
<td>0</td>
<td>242</td>
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<td>Foreign Languages</td>
<td>13</td>
<td>301</td>
<td>125</td>
<td>74</td>
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| %                                   | 33.4%         | 26.4% | 21.4%  | 16.7%  | 1.2%    | 99.1%      | 0.9%     | 0.0%   | 100%      |

Enrollment data are taken from the Registrar's fifth-week report.
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<th>Year 4 &amp; 5</th>
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The figures include all subjects listed in the catalogue as routinely eligible toward the Institute Requirement. Other subjects approved by petition have not been counted. The data are taken from the Registrar's fifth-week report.
TABLE III

Fields of Concentration Selected
Under the Humanities, Arts, and Social Sciences Requirement

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### TABLE IV

**Undergraduate Majors in the School of Humanities and Social Science**

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### TABLE V

**Graduate Students in the School of Humanities and Social Science**

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*As registered in the second term of academic year 1967-68 to 1977-78 (omitting freshmen and undesignated sophomores).

**As registered in the second term of academic year 1967-68 to 1977-78 (including special graduate students).

***Includes students in linguistics.
Department of Economics

Both undergraduate and graduate enrollments in 1977-78 have continued at approximately the same levels as in the last few years.

Undergraduate Program

The rise in undergraduate enrollment of about 30 percent experienced after the 1974 revision of the Humanities, Arts, and Social Sciences Requirement continued through this academic year. Economics continues to be the single largest field of concentration in the H.A.S.S. program.

The undergraduate program for majors under Professor Peter Temin has continued without important changes in size or requirements. More emphasis has been placed on increasing undergraduate involvement in research with faculty, and that part of the program is slowly expanding.

Graduate Program

The largest number of Ph.D.s were awarded in our history this last academic year -- 30 in all. Since our entering classes have remained approximately of the same size, the yield of entering students to the Ph.D. program appears to be increasing. The two largest recent fields offered for the Ph.D. continue to be econometrics and monetary economics, accounting for about one-fifth of all fields offered.

Our major worry concerns the competitive financing of our graduate students. The cumulative effects of the sharp cutbacks in governmental and private support in the last several years are beginning to be felt.

The number of students supported in their first two years by the National Science Foundation (NSF) or other foundations has fallen from 32 to 20 in the past two years; the number of students in the first two years with partial or no support has risen from a dozen a few years ago to twice that number. With but modest discretionary support of our own for the first two years of graduate study, further reduction in national fellowships or in the number of fellowship holders who elect to come here would create serious problems.

Research

Research programs have continued largely as reported last year. Two developments should be especially noted. The Sloan Foundation renewed its grant for two years to support education and research in applied microeconomics. The grant will continue to support the Applied Microeconomics Workshop which has a major focus on the economics of regulation. Major faculty participants were Professors Temin (the drug industry), Paul L. Joskow (hospitals, competition, and energy), William C. Wheaton (land use), and Jeffrey E. Harris (hospitals and health) along with six graduate students working on dissertations.
The Technology Adaptation Program has had a number of faculty participants in its joint program in Egypt with Cairo University supported by the Agency for International Development. Professor Richard S. Eckaus has been a member of its Executive Committee as well as a principal investigator, and other faculty participants have been Professors Wheaton (housing and construction industry), Lance Taylor (health care delivery), and Martin L. Weitzman (investment planning for electric power).

Publications

In addition to a large number of papers in professional journals and chapters in symposia volumes, two timely volumes contained the proceedings of M.I.T. Bicentennial Conferences arranged by Departmental faculty: Professor Jagdish Bhagwati (ed.), The New International Order and Professor Ann F. Friedlaender (ed.), Approaches to Controlling Air Pollution. Manias, Panics, and Crashes was the product of Emeritus Professor Charles P. Kindleberger. The fourth volume of the Collected Scientific Papers of Institute Professor Paul A. Samuelson also appeared this year.

Faculty

Visiting faculty this year included Professor T. N. Srinivasan from the World Bank for the whole year, and Professors William E. Taylor, Bell Laboratories, and Ray C. Fair, Yale University, in the fall term. Faculty on leave for the year were Professors Bhagwati, Peter A. Diamond, and Robert E. Hall; for the fall, Professor Franklin M. Fisher; for the spring, Professor Jerry A. Hausman. Professor Stanley Fischer ably filled in as Associate Department Head in the absence of Professor Diamond.

It is a pleasure to report the appointment of Professor Bhagwati as Ford International Professor of Economics, the promotions to Professor of Rudiger Dornbusch and Paul L. Joskow, and to Associate Professor with tenure of Jerry A. Hausman. Assistant Professor Thomas J. Teisberg, from the University of California at Berkeley and the US Department of the Interior, will be added to the younger faculty ranks; Assistant Professor Kevin W. S. Roberts will return to Oxford University after one year in which he showed great promise. We regret deeply the loss to Stanford University of one of our productive younger faculty members -- Professor Hall. He has been a member of the Department since 1964, first as graduate student then as faculty member on his return from the University of California at Berkeley, in 1970. He was an active intellectual force in shaping the departmental activities and will certainly be missed.

Professor Michael J. Piore completed his first year as Associate Chairman of the Faculty. Professor Franklin M. Fisher was chosen by the graduate students as this year's outstanding teacher. Next year he will complete his term as First Vice President of the Econometric Society, to which Professor Stanley Fischer was elected a Fellow. Institute Professor Franco Modigliani was elected Vice President of the International Economic Association, and received another honorary degree from the University of Bergamo, Italy. Professor Charles A. Myers was recipient of the Cardinal Cushing Award as outstanding neutral in labor-management relations. Professor Kindleberger was awarded the Bernard J. Harms Prize given for outstanding contributions to international economics. Professor Samuelson
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added an L. L. D. from Stonehill College to his long list of honorary degrees. Institute Professor Robert M. Solow will serve next year as President of the American Economic Association. His Killian Award Lectures on inflation were given this spring to an overflowing and appreciative audience.

E. CARY BROWN

Department of Humanities

On occasion during the past year, I had the sense of being head of a talent search group, rather than a Department of Humanities. I state the matter this way because, in fact, the Department had the opportunity to make an unusually large number of new appointments, which required us, or allowed us, to conduct innumerable interviews and evaluations. In the Foreign Languages and Literatures Section alone, we made seven new appointments; in the History Section there were two; and in the Literature Section two. In addition, a number of visiting appointments were made. In almost all cases, the new appointments were replacements. The fortunate occurrence of some of these vacancies, however, permitted us to redefine positions and to move in a number of cases toward a more solid, tenure-track, professorial status. It is extremely gratifying to report that almost all of the people whom we appointed chose M.I.T. after receiving competitive invitations from major universities across the country.

In Foreign Languages and Literatures, Professor Margery Resnick, who became Chairman of the Section and Director of Modern Languages this past year, has shown great dynamism in restructuring the Section. A policy decision had been taken to move from a plethora of part-time and non-tenure track appointments to full-time, professorial ones. Professor Resnick has vigorously pursued this new policy in terms of the new appointments. These appointments reflect our desire to maintain the strongest possible commitment to superb teaching of language at the same time as we improve our commitment to the teaching of foreign literatures at the most challenging level.

In History, we have moved to fill a vacuum in the teaching of modern American history. I am delighted to say that we have appointed the first woman full professor in the History Section, Professor Pauline Maier, who leaves a named chair at the University of Wisconsin to come to us, and Assistant Professor Alan David Brinkley, who has just finished his doctorate at Harvard University. Professors Maier and Brinkley will design new offerings in American history, especially a survey of American history from Colonial days to the present, as well as more specialized courses in the 19th and 20th centuries, with an emphasis on political history. Along with some other developments to be mentioned further on, the presence of Professors Maier and Brinkley will go far toward revitalizing the role of historical studies at M.I.T.

In the Literature Section, I call special attention to two appointments, Assistant Professor Susan Dickman, whose work is in the medieval and early Renaissance period, and Instructor Wilburn Williams, Jr., who specializes in black literature. Mr. Williams' presence in the Department is especially gratifying, because it comes at the end of a two-year search. As reported in last year's issue, the search at that time for an appointment in black and general literature was not successful. This year, however, the renewed search, under the leadership of Professor Irene Tayler, resulted in the appointment of Mr. Williams, who leaves the faculty at Wesleyan University to come to us. He will bring strength to the teaching of black literature and black studies as well as to the Literature Section in general.
The Writing Program has been restructured after the controversy of the last few years. The general policy recommended by Dean Harold Hanham in his discussion paper of December 7, 1976 is now gradually being implemented. Professor Robert Rathbone agreed to serve as Acting Director during a transitional period. A search committee was then set up by Dean Hanham to look for a more permanent director of the Program. Given the range of the Writing Program, stretching as it does from creative writing through expository and science writing to technical writing, and the need to satisfy various constituencies concerned with the nature of writing instruction at the Institute, the committee, initially chaired by Professor Leo Marx, faced a most difficult task. It is no reflection on its efforts or abilities to say that the initial search committee was unable to come up with a satisfactory candidate. Its endeavors, however, defined more clearly the problem involved in the search; therefore, a reconstituted committee under my chairmanship had a greater chance of success. At this writing, the committee to search for a new director is on the verge of making a recommendation; if all goes well, we can expect to have a director with us next year who should be able to offer sustained and innovative leadership to the Program. Meanwhile, compliments and thanks are due to Professor Rathbone, who has led the Program during a most difficult year, often at the sacrifice of his own time and work.

The Anthropology/Archaeology Program, after five years of successful growth, was given a review of its activities and future plans by an ad hoc outside committee composed of Professors Ernestine Friedl (Duke University), Dell Hymes (University of Pennsylvania), and David Reisman (Harvard University). All of the members of the review committee were impressed with the Program as it now stands. They felt that the faculty had managed to preserve an enviable commitment to both teaching and research at a high level. Generally approving of the existing Program, the visitors perceived differences between what might be referred to as the "material" and the "cultural" aspects of the Program. By and large, they felt that the material side is successfully connected to general Institute work in science and technology. They questioned, however, whether the Program was making the maximum appeal to the general body of Institute students in terms of cultural anthropology. They especially felt a lack of sufficient attention to contemporary society. The members of the Anthropology/Archaeology Program have considered carefully the findings of the review committee and are now preparing a five-year projection for the future as well as recommendations for the further development of work in both archaeology and cultural anthropology.

Drama is progressing vigorously under the direction of Assistant Professor Robert Scanlan, with the assistance of a committee on drama chaired by Professor Albert R. Gurney, Jr. Administrative support for a strengthened program in drama has been forthcoming, and hopes are high for securing badly needed space. In addition, funds have been provided for a part-time teacher of acting, supplying a badly needed adjunct to the directorial efforts of Professor Scanlan.

The Literature Workshop has continued to flourish, as described in Professor Alvin Kibel’s section of this report. However, I am sorry to state that a hiatus has occurred in the History Workshop; with the new appointments in the History Section, however, we can look forward to a renewed effort.

The Department has continued its effort to connect and work with other parts of the Institute. Outstanding in this regard is the work of Professors Rathbone and James Paradis, and Lecturer John Kirsch, who have been teaching technical writing within various of the Engineering departments; and of Professor Rae Goodell, who has collaborated with Course XXV in the development of a Master’s degree in science communication.

Future collaboration is envisioned with the prospective College of Science, Technology, and Society which is under the direction of Dean Donald Blackmer. The Literature Section has been in frequent communication with Professor Leo Marx of the new Program’s faculty. A
strong historical presence is manifesting itself in the Program, with the filling of a position for the social study of science by an historian, Professor Loren Graham, and the appointment of two historians in the field of the history of technology, Professors Merritt Roe Smith and David Noble. We have great hopes that the historians in the Department and those in the prospective College will join forces in areas and concerns of common interest. It must be reported, however, that the emergence of the prospective College has aroused some apprehension in some faculty in the Department, as well as in some members of the Visiting Committee, who are not clear as to the nature of the College and are concerned as to its general impact on the Department. Future discussions, now being planned for, should go far to allay these concerns. I must register here my own, personal view that the new College seems prospectively to be more of a support and a stimulus than a rival force to the Department and its work.

American studies is another area in which interdisciplinary and interdepartmental work should be strengthened. The appointment of Professors Maier and Brinkley in American history will help in a more sustained development of a full-scale American studies program. They will be associated with Professors Arthur Kaledin and Monroe Little, along with some of the new people on the new Program's faculty, and others in the Political Science, Economics, and Urban Studies departments.

Once again, the Department has enjoyed the moral and financial support of the Friends of Humanities. The role of I. Austin Kelly III in fostering the Friends of Humanities remains, as ever, crucial. An unexpected and additional source of support for the music activities of the Department has been forthcoming in the shape of a three-year grant by the Hoffmann-La Roche Foundation. This has allowed us to bring Andras Kovach as Visiting Professor for the next three years. Professor Kovach is a distinguished conductor and composer, and his presence will lend luster to the already fine Music Section.

It is a pleasure to report that the Department and its various sections have achieved a better shared sense of what is involved in the affirmative action searches, in promotion and tenure cases, and in general review of the faculty. The reviews are now both more systematic and formal, and are undertaken earlier in a given individual's career. Discussions have taken place concerning mentorship proposals and, with the appointment of new junior people, the review system can be put into operation from the very beginning of their careers at M.I.T.

The core of any department is its faculty. A note of intellectual and pedagogic excitement is present in this Department, and the new appointments will add to and amplify that excitement. One also senses a positive response in many students to the Department's efforts. Often, one must rely on subjective experience to underline this fact. It is heartening, however, also to report continuing and growing student enrollment in various sectors of the Department's offerings, as well as a substantial growth in the number of Course XXI majors (increasing from 40 to 55 in a year's time). At a time when there is growing recognition of the need for the humanities in American life and thought, the Department sees itself in a continually strengthened position, supported by the administration and students, and moving confidently ahead.

BRUCE MAZLISH
ANTHROPOLOGY/ARCHAEOLOGY PROGRAM

During the academic year 1977-78 the members of the Anthropology/Archaeology Program were actively engaged in several important Program undertakings as well as in their own ongoing teaching and research efforts.

Over a year ago the members of the Program began planning a collaborative effort with the staff of the Anthropology Department at Wellesley College. Some of these plans have now been realized. Professors Sally Merry of Wellesley and Jean Jackson of M.I.T. have organized the first of a three-year series of cultural anthropology seminars to be taught jointly by M.I.T. and Wellesley faculty. The first seminar, "Colonialism, Development, and Nationalism: The Impact of the State on Traditional Society," will be offered as an upper-level subject for M.I.T. and Wellesley students during the spring of 1979. A number of distinguished scholars are scheduled to participate in some of the seminar sessions. A public lecture series will be held concurrently with the seminar, featuring some of the seminar guests as speakers. A grant providing partial support for the first seminar was awarded by Wellesley College from its R.K. Mellon Fund. In future years the seminar will focus on other issues of current concern in the field of anthropology, such as Marxist analysis.

In the summer of 1977 the Center for Materials Research in Archaeology and Ethnology was established after several years of effort on the part of the Program archaeologists (Professors Heather Lechtman, Arthur Steinberg, and Wilma Wetterstrom) in collaboration with colleagues from eight other Boston area institutions. The National Endowment for the Humanities (NEH) awarded the Center two grants totaling $350,000 for a three-year period, July 1977 to June 1980, to support its education program and to allow for planning its research activities. Professor Lechtman, the Center's first Director, devoted much of this past year to establishing the Center and developing its teaching program.

In November 1977, a Visiting Committee was invited to M.I.T. to evaluate the Program's accomplishments during the first five years of its operation. The visitors, Professor Ernestine Friedl of Duke University, Dean Dell Hymes of the University of Pennsylvania Graduate School of Education, and Professor David Riesman of Harvard University, were impressed with the Anthropology/Archaeology staff and with its teaching program, and offered suggestions for the future growth and development of the Program. The members of the Program have continued discussions on Program development, and plans are now under way to establish an Anthropology/Archaeology Laboratory. This facility would be used in teaching undergraduate subjects in archaeology and cultural anthropology and promises to broaden and strengthen the Program's offerings. During the next few years, the Anthropology/Archaeology staff plans to develop a curriculum of laboratory subjects and design and equip a laboratory facility.

Professor Shelton Davis was Visiting Professor of Anthropology during the academic year 1977-78. He taught subjects on the American Indian in the United States, Poverty and Ethnicity in the United States, and Peasants and Social Change, and participated in team teaching an Introduction to Anthropology. During I.A.P., Professor Davis organized a very successful film festival on Native American peoples and cultures. He supervised two students conducting independent projects, one of whom received the I. Austin Kelly III Writing Prize for this work. During the past year, Dr. Davis also continued his activities as Director of the Anthropology Resources Center (ARC, Inc.) in Cambridge. As Director of ARC, he chaired a special panel discussion at the annual meetings of the American Anthropological Association entitled, "The Public Uses of Anthropology." In November 1977, Cambridge University Press published his book, Victims of the Miracle: Development and the Indians of Brazil. Since the publication of this book, he has delivered lectures at Boston University, Brown University, the City University of New York, Columbia University's Latin American Seminar, and the New School for Social Research.
Professor Martin Diskin, after having spent the previous two years on leave engaged in field research in Oaxaca, Mexico, devoted much of his energy this year to the analysis of his field data. His major project concerns the demographic characteristics of a peasant-Indian village over the past century and is based on the community's birth and death records. Thus far the data have been encoded in preparation for computer compilation and analysis. In December Professor Diskin attended the annual meetings of the American Anthropological Association where he cochaired a symposium entitled, "Regional Modes of Production in Oaxaca" and presented a paper, "Production and Reproduction of Poverty in Oaxaca." He is now working on several articles and a book dealing with aspects of peasant life. In conjunction with a UROP student, Eric Andersen, an architecture major, he set up a photo exhibit entitled "The People of San Sebastian," on display in the Humanities Library. This summer he will be writing the text for a book of his photographs.

Professor James Howe was promoted to Associate Professor of Anthropology. Supported by a grant from the Social Science Research Council, he spent the academic year 1977-78 on leave conducting field work among the San Blas Cuna of Panama. He collected data on political behavior and political language for a monograph on Cuna politics which he is now writing. While in Panama, Professor Howe gave two seminar talks at the Smithsonian Tropical Research Institute. One of his papers was read at a symposium on Politics in Central America at the 1977 annual meetings of the American Anthropological Association. Professor Howe organized and coedited a book with Joel Sherzer and Mac Chapin entitled Cantos y Oraciones del Congreso Cuna which is in press at the Panamanian National University Press. His introductory essay, "Una guía a la literatura oral del congreso Cuna" appeared in this volume. "War, Infanticide, and Statistical Influence: A Comment on Harris and Divale" which Professor Howe coauthored was published in the March 1978 issue of the American Anthropologist. His article entitled "Algunos problemas no resultas de la etnhohistoria del esta de Panamá" was published by Revista de la Asociacion Panamena de Antropologia and his paper on "The Consejo as an Aspect of Cuna Culture" appeared in Patrimonio Historico. Ethnology will be publishing his article on "The Effects of Writing on an Indigenous Political System" later this year.

Professor Jackson received tenure this spring and also was nominated for membership on the Committee on Curricula. She taught a new course on "Language and Culture" jointly with Professor Wayne O'Neil in the spring and is currently designing a research project with him to investigate certain aspects of language use among selected ethnic groups in the Boston area. She is also organizing, with Professor Merry of the Anthropology Department of Wellesley College, the joint M.I.T.-Wellesley seminar for the spring semester of 1979 on "Colonialism, Development, and Nationalism: The Impact of the State on Traditional Societies." She gave two talks in the Boston area during the spring, one at Wheaton College and one at the University of Massachusetts at Boston, the latter on "All's Fair in Love and War: Sexual Opposition and Hostility in the Northwest Amazon." At the annual meetings of the American Anthropological Association in December, Professor Jackson was a discussant for the symposium on "Lowland South America: Social Correlates of Kin Terminology," and she also gave a paper on "Traditional' Ethnic Boundaries and Acculturation in the Northwest Amazon." She wrote a review of E. Basso, ed., Carib-Speaking Indians: Culture, Society and Language for the American Ethnologist and finished a book manuscript on The Bara: Individual and Group Identity in Tukanoans of the Northwest Amazon.

Professor Lechtman spent a busy year pursuing her research and shepherding the newly formed Center for Materials Research in Archaeology and Ethnology (CMRAE), of which she is Director, through its first year of activities. In September 1977, Professor Lechtman received an 18-month grant from the National Science Foundation to pursue a field-laboratory research project entitled "Andean Bronze Metallurgies: Technological and Sociocultural Considerations." With the NEH grant to the Center, she designed and equipped a new Central Teaching Laboratory for CMRAE which will open in Building 20 at M.I.T. in September 1978.
under her direction. In her capacity as Director of the Center, Professor Lechtman also was awarded a grant from the Wenner-Gren Foundation for Anthropological Research which allowed the Center to hold its first professional workshop, on the subject of "Materials Research in the Future of Anthropology," from March 9-11, 1978. She was elected an editor of Art and Archaeology Technical Abstracts and also became a member of the Committee on Regional Conservation Centers of the American Institute of Conservation. At M.I.T., she participated in the ad hoc search committee for new appointments in the history of technology for the proposed new College. In December of 1977, Professor Lechtman received an award from the Triopian Foundation for Archaeological Research in recognition of her achievement in the field of ancient metallurgy. In July 1977, her anthology Material Culture -- Styles, Organization, and Dynamics of Technology, edited by her and Robert S. Merrill, was published by West (St. Paul). It includes her article "Style in Technology -- Some Early Thoughts."

Professor Steinberg, after returning from a year's leave of absence, was active again in the Center for Materials Research in Archaeology and Ethnology. He participated in the Center's fall seminar on stone materials and in its workshop on Materials Research Directions in Archaeology held in March 1978. He is now planning the Center's ceramics seminar for 1978-79, which he will coordinate. During the past year, Professor Steinberg continued his research on ancient Cypriot copper smelting technology with Dr. Frank Koucky from the College of Wooster. Professor Steinberg is now completing his research on Ubaid ceramic technology with Dr. Diana Kamilli, a former Research Associate in the Anthropology/Archaeology Program. In the spring Professor Steinberg delivered an inaugural lecture on Technologies in Ancient Societies to the M.I.T. chapter of Phi Beta Kappa. At the annual meetings of the Society of the History of Technology, held in Washington, DC, he delivered an invited paper on "The Development of Ancient Cypriot Metallurgy." As in past years, Professor Steinberg again coordinated the monthly Materials and Archaeology Discussion Group.

Professor Wilma Wetterstrom began preparations for a research project to be conducted during her leave of absence next year. She will be joining a team of interdisciplinary scholars, headed by Dr. Fekri Hassan of Washington State University, to study Egypt's Predynastic period. Professor Wetterstrom's work will focus on the plant remains from Predynastic archaeological sites and on Egypt's early agriculture. This past year she continued research on floral materials from archaeological sites in the Hueco Bolson of Southwest Texas, a project which was begun last year. An article on this work, "Plant Remains from Mesilla and El Paso Phase Sites of the Hueco Bolson: A Preliminary Report on the Plant Foods," will be published this summer in Settlement Patterns of the Western Hueco Bolson by Michael E. Whalen, an Anthropological Research Paper of the University of Texas at El Paso. Professor Wetterstrom's article on "Plant Foods from the Gypsy Joint Site," a prehistoric Indian village in Missouri, appeared in Prehistoric Patterns of Behavior: A Case Study in the Mississippi Valley by Bruce D. Smith, published this spring by Academic Press. A short comment she wrote for Current Anthropology appeared in the March 1978 issue. At M.I.T. this year, Professor Wetterstrom served on the Committee for the Institute Requirement in the Humanities, Arts, and Social Sciences and was coordinator of the Anthropology/Archaeology Program.

WILMA WETTERSTROM
This year was one of extensive changes in the program in Foreign Languages and Literatures. During the year the Section completed a recruiting effort which will bring seven new faculty members to the Institute in the academic year 1978-79. The energy, imagination, and seriousness of the faculty who devoted enormous amounts of time to the selection process have enabled us to attract candidates whose scholarly credentials, teaching expertise, and preparation meet with the rigorous standards of excellence which guide all tenure-track appointments at M.I.T. In the process, more than 800 dossiers were read and 73 interviews completed.

In our nationwide searches we competed favorably with the most distinguished universities in the country. While our Section continues to be strengthened by the presence of faculty members whose intellectual interests are shared with members of the Department of Linguistics and Philosophy, these new appointments of scholars whose work is in the field of literature mark an affirmation of the Section's role in the Department of Humanities. Appointed as Assistant Professors in German were David Dollenmayer, who received his Ph. D. from Princeton, and Jay Rosellini, who earned his Ph. D. at Indiana University. In French, Dr. Edward Baron Turk will join the faculty as an Associate Professor, coming from Yale University. Isabelle de Courtivron, who earned her Ph. D. from Brown University and has taught at Wellesley College for two years and at M.I.T. as part of the exchange for one year, will join our Section as Assistant Professor. Kathryn Crecelius, a recent recipient of the Ph. D. at Yale, becomes an Assistant Professor and Frederick Hodgson, who is completing his dissertation at the University of California at Santa Barbara, will be Instructor. In Russian, Julia Alissandratos, who completed her Ph. D. at the University of Chicago, was named Assistant Professor. It is our expectation that the combination of literary training and language teaching expertise of our new faculty members will lend greater flexibility to our course offerings. We are confident that their continued scholarly activity will enrich the lives of our students and Section and will strengthen our national standing among similar Foreign Languages and Literatures programs. The Section has spent considerable time designing a program for these new faculty members which will, we hope, encourage them to reach their full scholarly potential during their years at M.I.T. We are grateful for the full support of the M.I.T. administration which has made this recruiting effort possible.

During this year Claire Kramsch, whose invaluable contributions to students and faculty are well known throughout the Institute and who is a recognized leader in the field of language pedagogy, was promoted to Senior Lecturer under the new guidelines for Lecturers in the School of Humanities and Social Science.

Curriculum Development

Major curricular changes have been effected in Chinese, Spanish, and English for Foreign Students during the past year. A new sequence of subjects designed to meet the special needs of M.I.T.'s foreign students has been approved and will be offered during the 1978-79 academic year. A system for testing all incoming foreign graduate students who are not native speakers of English will be implemented this fall. The data we collect will be distributed to graduate departments so that they may advise foreign students as effectively as possible. This year, three courses in Chinese were taught on our campus by Professor Yih-jian Tai of Wellesley College. Professor Tai and an assistant will teach a full complement of Chinese subjects including an advanced Chinese literature course at M.I.T. next year.
Spanish, intermediate language subjects and a literature subject were offered for the first time. Enrollments in all levels of Spanish subjects were high, and student interest led to the creation at the Institute of an Hispanic Cultural Committee which sponsored several speakers during the year. Ongoing discussions concerning the establishment of a Spanish House at M. I. T. make us hopeful that such plans will come to fruition by 1979.

With the support of the Dean of Humanities and Social Science, we have begun major remodeling of the language laboratory which will be completed by September. The new cassette system we are installing will provide our students the greatest flexibility and range of services available. As part of the renovation of teaching facilities, we are installing audio equipment in four classrooms over this summer. These changes will substantially improve teaching effectiveness.

In Foreign Languages and Literatures, the Wellesley Exchange has continued to enhance the variety of subjects offered at both institutions. In French, Wellesley Professors Barry Lydgate and Isabelle de Courtivron taught a literature subject which held alternate sessions on the two campuses. This subject attracted over 50 Wellesley and M. I. T. students. Professor Carlo François of Wellesley taught a subject on French classical drama at M. I. T. this spring. Through consultation with the Wellesley French Department, Professor Robert Jones of M. I. T. will offer a Wellesley course next fall, and Professor George Stambolian of Wellesley will teach a course at M. I. T. next spring. Several meetings were held with the Spanish faculty at Wellesley, and, during the 1978-79 academic year, a Wellesley course on Arts and Letters of Mexico will be given at M. I. T. The participation of Wellesley faculty members at several colloquia at M. I. T. during the past year provided opportunities for intellectual discourse on pertinent themes in our shared disciplines.

Although the searches occupied a great portion of our time, the faculty and staff of Foreign Languages and Literatures served the Department and Institute in a variety of ways. Professor James Harris chaired the Department Personnel Committee, and Professor Catherine Chvany chaired the Department's Special Topics Committee. Professor Margery Resnick served on three Search Committees for the Writing Program. Five of our staff members read admissions folders, and Ms. Kramsch served as freshman advisor. Professor Jones was a member of the Committee on Academic Performance. Instructors Kathy Irving, Abby Mason, and Linda Sibley have continued to work with the Foreign Student Office. Professor Resnick participated in the Experimental Study Group where she gave a seminar during the fall semester. Moreover, the Section offered 15 activities during I. A. P.

Our activities have extended beyond the confines of the Institute. Ms. Kramsch conducted an experimental exchange in German between M. I. T. students and Boston high school students. M.I.T. served as a center for both German and French films during the past year. Ms. Kramsch arranged for 14 German films to be shown, many in cooperation with the Goethe Institute, while Robert Frye organized a French Classic Film Series at M. I. T.; both series were open to the public and drew large audiences. Professor Chvany served as a judge in the State Olympiada of high school Russian. As a member of the Mayor's Steering Committee for Hispanic Theatre in Boston, Professor Resnick arranged for several Spanish plays to be given at M. I. T. during the citywide festival next October. M. I. T. has been a center for that committee's activities during the year.

Scholarly Activities of the Section

A number of individuals in the Foreign Languages and Literatures Section were invited to deliver papers at national and international meetings during the year. Papers were given by Professor Chvany at the Slavic Syntax Colloquium, Professor Martin Dyck at the Kentucky Foreign Language Conference, Professor Harris at the Asociación de Linguistica
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y Filología de América Latina in Venezuela, Lecturer Kramsch at the American Council on the Teaching of Foreign Languages, and the Massachusetts Foreign Language Association, Professor Krystyna Pomorska at the Conference on Structural Analysis of the Narrative Text, and Professor Resnick at the American Association of Teachers of Spanish and Portuguese, and the International Conference on Latin American Writers in Mexico. Presentations were made by Lecturer Ilona Ricardo at the Northeast Modern Language Association, Instructor Sibley at the Third Annual Boston University Conference on Language Acquisition, and Lecturer Lilian Willens at the Pacific Northwest Council on Foreign Languages and the American Association of Teachers of French Convention. All of the above gave visibility to M.I.T. in the field of Foreign Languages and Literatures, and underscored the commitment of the faculty and staff to sharing their scholarly activities within the profession. Furthermore, individuals in Foreign Languages and Literatures have given a number of lectures at other universities: Instructor Patricia Chaput, at Tufts University; Professor Harris, at Indiana University; Professor Pomorska, at the University of California at Los Angeles and Ohio State University; Professor Resnick, at Amherst College, Yale University, the City University of New York, and Boston College.

In addition to book reviews and essays accepted for future publication, articles by members of the Section appeared during this year. In the field of literature, Instructor Lorraine Ledford's "Luis Cernuda's Demonio: Devil or Divinity?"; Professor Jones' "Sexual Roles in the Works of Tennessee Williams"; Professor Pomorska's "Observations on Ukrainian Erotic Folk Songs," "The Dramatization of Science," and "Roman Jakobson and the New Poetics"; Professor Resnick's "La poesía española y el desafío de la historia," and "La Inteligencia Audaz: Vida y poesía de Concha Mendez"; and Lecturer Willens' "Voltaire et l'Amérique: des colonies anglaises aux treize États-Unis," all published in major journals or collections suggest the range of the Section's work in literary criticism.

The linguists in our Section were equally active. The publication of Professor Chvany's articles "Proceed with Caution," and "Some New Directions in Slavic Transformational Syntax Since 1973," and Professor Harris' articles "Remarks on Diphthongization in Spanish," and "Two Theories of Nonautomatic Morphological Alternations: Evidence from Spanish" marked their continued dedication to scholarly work.

MARGERY RESNICK

HISTORY SECTION

The decision to fill the gap in American History caused by the recent retirements of Professors Lynwood Bryant and Neal Hartley was good news to the Section. A search committee consisting of Professor Bruce Mazlish, ex officio, and Professors Robert Fogelson, Arthur Kaledin, Thomas H.D. Mahoney, and Robert Rotberg was augmented by Professor Walter Dean Burnham of the Department of Political Science.

The consistently high quality of the applicants for the two positions was impressive, thus making the process of selection extraordinarily difficult. The final choices, both of whom have accepted and will begin teaching here in the fall, were Professor Pauline Maier, holder of a chair in American History at the University of Wisconsin, and Dr. Alan Brinkley of Harvard. They will supplement the Section's offerings in the American field now being taught by Professors Fogelson, Kaledin, and Monroe H. Little.
It is with regret that we note the leaving of Dr. Lewis Wurgaft, whose dedication to his students and whose devotion to the Department of Humanities were especially noteworthy.

As usual, members of the Section were active in professional society meetings. Professor Little was a discussant at a session of the Social and Behavioral Scientists in Dallas. Professor Mahoney chaired a session of the American Historical Society in Dallas. Professor Rotberg participated in the Council on Foreign Relations meetings on Africa, in New York, and the World Jewish Congress on the black and white diaspora. Finally, Professor Emeritus Cyril Stanley Smith organized an exhibition at the National Museum of History and Technology, Washington, DC.

Publications

Professor Mazlish's book, *Kissinger* (New York, 1976), was translated into French, and published by Editions Complexe, while another of his books, *The Revolutionary Ascetic* (New York, 1976), has been issued as a McGraw-Hill paperback.


Professor Rotberg's *The Black Homelands of South Africa* was published by the University of California Press as was his *Black Heart: Gore Brown and the Politics of Multiracial Zambia*. He also contributed "Achieving the New Zambia" and "Options & Prognoses for Zimbabwe" to the Institute's Center for International Studies.

THOMAS H. D. MAHONEY

LITERATURE SECTION

As usual, the Literature Section represented the presence of humanistic studies at M.I.T. through a variety of activities. To begin with notable awards received and major scholarly work published: Professor Peter Donaldson's edition of the pre-Elizabethan text, *A Description of England, 1556*, has been scheduled for fall publication by the Royal Historical Society in its Camden Miscellany Series; Professor Donaldson has been awarded a summer grant from the National Endowment for the Humanities (NEH). Professor Albert P. Gurney, Jr. saw two new plays performed this year: *The Wayside Motor Inn*, by the Manhattan Theatre Club, where he was Rockefeller Playwright-in-Residence for fall of 1977, and *The Middle Ages*. Both were published in *Dramatist's Play Service* magazine in the March and May 1978 issues, respectively. Professor Wayne O'Neil has been selected to conduct an NEH-funded seminar for college teachers for summer of 1978; the seminar will be held on the M.I.T. campus and will study linguistic change in English. Professor Ruth Perry has been awarded a Radcliffe Institute Fellowship for next year. Professor David Thorburn's edition of critical views on novelist John Updike has been scheduled for early publication by Prentice-Hall. A new collection of Professor Barry Spacks' poems, *Imagining a Unicorn*, has been published by the University of Georgia Press. Professor Stephen Tapscott was awarded a grant from the National Endowment for the Arts to underwrite the compilation of a new manuscript of poems.
In addition to this, the usual lot of articles and reviews were published or accepted for publication by Professors O'Neil, Perry, Spacks, Thorburn, Louis Kampf, Alvin Kibel, and Irene Tayler; several public readings of their works were given by Professors Spacks and Tapscott; papers and lectures were read at professional conferences by Professors Donaldson, Kampf, O'Neil, Perry, and Thorburn; and a number of poems were published by Professors Spacks and Tapscott. At least three further activities should be mentioned: Professor Kampf continued on the editorial board of Radical Teacher; Professor Gurney was appointed Theatre Editor of the newly founded Decade magazine; and Professor Tayler convened the biography section of the English Institute, the most important annual conference on literary criticism and theory in the US.

The M.I.T. Literature Workshop, founded last year, continued with enthusiastic participation by 35 faculty members from departments of English and Literature at Harvard University, Wellesley College, Boston College, Boston University, Tufts University, Brandeis University, and the University of Massachusetts, in addition to members from M.I.T. Seven meetings were held, at each of which a major scholar from England, Europe, or America led a discussion of work-in-progress, manuscript selections of which were circulated in advance. This year the presence of the Seminar was felt as far afield as Amherst College, one member of whose faculty journeyed to Boston solely to attend its sessions; another mark of success is the fact that guests at the workshop often waived fees in exchange for the opportunity of exposing work to the criticism of the group. There is little doubt that the workshop fulfills a need long-felt in the Boston-Cambridge area for some kind of intellectual community among scholars otherwise separated by their institutional affiliations. Should the workshop continue its success, there is little doubt that it will afford the Institute a major chance to publicize the reality of its commitment to humanistic scholarship.

As part of its continuing effort to shape the literature curriculum at M.I.T., the Section has established a series of six literature seminars open to Course XXI majors, at each of which a member of the Section will discuss the rationale animating his or her scholarly career. It is hoped that the series will promote a greater sense of group identification among the students and become an annual event at the Institute.

The Literature Section is pleased to announce the appointment, after an extensive national search, of two new members to its faculty: Wilburn Williams, Jr. and Professor Susan Dickman. Mr. Williams comes to us after two years of teaching experience at Wesleyan University in Connecticut and will teach black literature and American literature. Professor Dickman will teach in Medieval and Renaissance literature. Mr. Williams will be an Instructor and Dr. Dickman an Assistant Professor. Although young, both have already achieved standing in the profession.

ALVIN C. KIBEL

MUSIC SECTION

Interest in musical studies remained strong during the 1977-78 academic year. The student enrollment has stabilized: in academic subjects the figure went above 1,200, and there were about 450 participants in performing organizations. Significant is the gradually changing ratio in enrollment between the introductory music subject and the more advanced theory and history subjects. Whereas in previous years the Introduction to Music, a Humanities Distribution course, held an edge over the others at more than 50 percent, in the last two years the ratio has tilted toward the theory and history subjects. One of the new popular courses is ear training, teaching skills in musical literacy and perception, with an enrollment of some 200 students.
This year the music office organized 62 public performances and visits by four visiting lecturers. They included concerts of the M.I.T. Symphony Orchestra, Choral Society, Concert Band, Chamber Music Society, Faculty Artist Series, Guest Artist Series, Thursday Noon-Hour Concerts, and sponsored events. The estimated total attendance at these concerts was 25,000.

Highlights of the Guest Artist Series were the American Brass Quintet, the Performers' Committee for Twentieth Century Music, and the Alban Berg Quartet.

Our student performing organizations are becoming nationally recognized for their outstanding performances. The M.I.T. Symphony Orchestra, under Professor David M. Epstein's leadership, has come out with three recordings on the Vox label. The reviewers' comments on them are: "splendid performance" (Piston's Incredible Flutist), "throughout warm and rhythmically vital" (Frank Martin's Sonata and Hindemith's Schwanendreher), and "altogether a first class university orchestra."

Equally successful were the performances of the Choral Society, under the leadership of John Oliver. During this year's scheduled performances, Verdi's Requiem received the Boston critics' acclaim for the unusual dramatic impact and structural clarity of the performance.

Following is a report on individual faculty activities: Professor Epstein was invited to guest conduct the Beer Sheva Orchestra in Israel and the Bamberg Symphony Orchestra in Germany. He has completed his cello concerto, commissioned by the New York National Council for the Arts, and is a recipient of an American Society of Composers and Performers award and a Massachusetts Arts and Humanities Foundation Fellowship.

Professor John Buttrick has toured extensively, giving piano recitals in Heidelberg, Munich, and Saarbrucken, Germany; and in Zurich, Winterthur, and Basel, Switzerland. He recorded the 24 Preludes of Chopin for Swiss Odein and taught a course in the kinesiology of piano playing at the Conservatory in Basel. His American concerts included the cities of Denver, Bloomington, Pittsburgh, and Boston.

Professor John Harbison has been the recipient of a Guggenheim Fellowship in composition and has spent a productive year on the family farm in Wisconsin.

Professor Barry Vercoe continued his research in connection with the M.I.T. Experimental Music Studio, sponsored by a grant from the National Science Foundation. He also has been invited to be a guest lecturer on the subject of electronically generated music at the University of California at San Diego.

Professor Stephen Erdely continued his field work, researching ethnic music in Boston and vicinity, sponsored by the National Endowment for the Arts for the third consecutive year. Papers on the partial results of his work were presented at meetings of the International Folk Music Council in Honolulu, the International Musicological Society at Berkeley, California, and the Music Librarians' Association in Boston. His monograph on the interrelationship of tradition and individual traits in folk singing is in the process of publication in Selected Reports, a University of California publication. The Erdely Duo is now engaged to record for Educo California, and the first disk of Mozart and Beethoven Sonatas appeared on the market in January.

Professor Marcus Thompson received wide acclaim for his recording as a viola soloist with the M.I.T. Symphony in Frank Martin's Sonata and Hindemith's Schwanendreher. While on an Old Dominion Fellowship during the spring term, Professor Thompson appeared with the M.I.T. Symphony in Avery Fischer Hall, New York, as soloist in Berlioz' symphonic poem, Harold in Italy, and was lauded for his elegant performance.
School of Humanities and Social Science

Among the lecturers, Edward Cohen's *Elegy*, commissioned by the Berkshire Music Center and the Fromm Foundation, received its first performance by the New Repertory Ensemble in New York, concurrently with the performance of his *Madrigal*, conducted by Gunther Schuller at a New York Philharmonic-sponsored event.


The Music Section has had a full and productive year in the areas of teaching, research, and performance. With the current enrollment at peak level, the program is operating at its fullest capacity.

STEPHEN ERDELEY

THE WRITING PROGRAM

Five new staff members joined the Program in September: Dr. Rae Goodell (Assistant Professor, Science Writing), Dr. Barbara Hartmann (Lecturer, Expository Writing), Jennifer Humphrey (Assistant Professor, Creative Writing), Dr. James Paradis (Assistant Professor, Technical Communication), and Dr. Thomas Postlewait (Assistant Professor, Creative Writing). Searches for a lecturer in basic writing skills and an associate professor of fiction began in January. The lecturer position has been filled; the appointee will begin teaching in the fall. The search to fill the senior position has been suspended until after the appointment of a permanent director.

New Subjects and Teaching Projects

Professor Goodell initiated an excellent sequence of beginning and advanced science writing subjects, plus an apprenticeship program. Expository writing returned after a six-year absence. Lecturer David Breakstone and Dr. Hartmann ably handled the rebirth. Co-op instruction in technical communication was expanded to cover at least one undergraduate subject in all eight engineering departments. Financial assistance from the School of Engineering made it possible to hire John Kirsch full time for this job. Professor Paradis, assisted by Professor Robert Rathbone and Mr. Kirsch, conducted seminars and workshops during I.A.P. to train graduate T.A.s and engineering instructors in evaluating the writing in their students' reports. Instructor Kenneth Skier continued as M.I.T.'s representative to the Conference of Seven Writing Programs, and was the principal investigator of a project on Text Editors and The Teaching of Writing.

Four new subjects will be introduced next fall. Two of these, Writing: Meaning and Expression and Writing and Reading Essays, have been accredited for Humanities Distribution. The staff who worked to develop these subjects deserve our thanks.

Major Research

Professor Elzbieta Chodakowska, on leave under an Old Dominion Fellowship, worked on selecting and translating letters of Rosa Luxembourg for the MIT Press. Professor Patricia Cumming continued preparing "A Writer's Handbook" and "In the World: an Anthology of New England Poets." Professor Goodell was the principal investigator of a project...
to draw up specifications for a Master's Program in Science Writing for Course XXV. Mr. Kirsch prepared an extensive report for the Committee on Engineering Education, summarizing the work accomplished during the year in the co-op program. Professors Paradis and Rathbone worked with Professor Ain Sonin of the Department of Mechanical Engineering to develop writing instruction for mechanical engineering graduate students. Professor Paradis designed a diagnostic test to be administered at the start of this program in September. Professor Postlewait began research for a book on Ibsen's influence on English Drama. Professor Rathbone completed planning for an international conference on "Communicating Technical Information" which he will direct at Utrecht, The Netherlands, next November. The conference will be sponsored jointly by the Royal Netherlands Industrial Fair and M.I.T.'s Center for Advanced Engineering Study.

**Publications**

Professors Cumming and Humphrey and Lecturer Robin Becker all had poems published in various magazines and journals such as The Real Paper, Green House, and Sojourner. Professor Goodell published articles on "Science Writing" and "So You Want to be a Science/Medical Writer?" in the Word Guild Magazine for October 1977 and January 1978 respectively. Professor Paradis's "Underwater Electrical Cable Seals: In-House and Commercial Options" appeared in the Proceedings, Oceans '77. His final manuscript on T.H. Huxley has gone to the printer. Professor Postlewait's article, "Beckett's Drama: Self-Performing Voices," has been accepted by Twentieth Century Literature. Mr. Skier's text, "A Writing Process Handbook," will be published by Prentice Hall in the late fall.

**Other Activities**

Many members of the Program gave outside readings during the year. Several conducted writing workshops and seminars; others gave papers at professional society meetings. Professors Cumming, Goodell, Paradis, and Rathbone and Mssrs. Kirsch and Skier did consulting work. Especially noteworthy is the excellent series of readings that the Readings Committee brought to M.I.T. this year. The members of the Writing Program on this committee were Ms. Becker, Mr. Breakstone, and Professor Humphrey.

**ROBERT RATHBONE**

**CAMBRIDGE HUMANITIES SEMINAR**

The Cambridge Humanities Seminar continues as a collaborative effort of universities in the Boston-Cambridge area to enrich and diversify their curriculum offerings in the humanities. The program includes faculty from M.I.T., Boston University, Boston College, and Wellesley College, and represents a variety of disciplines. Its central feature is a faculty colloquium that meets on a biweekly basis for three hours, with additional meetings scheduled for curricular planning and discussion. The Seminar is unique as the only continuing collaborative body of its kind in the area.

By the close of the year, the Seminar had virtually fulfilled its original mandate. Four institutions of higher learning in this area -- M.I.T., Wellesley College, Boston College, and Boston University -- have agreed to permanent membership, and a fifth -- Brandeis
University, one of the Seminar's founding group -- has initiated discussions for joining. With the costs of operation divided among five institutions, it seems likely that the Seminar will be a feature of the Boston-Cambridge area for some time to come.

This year the Seminar offered six interdisciplinary subjects, all generated out of the ongoing concerns of the faculty colloquium during the preceding year. Two of these subjects were offered at M.I.T., and two were taught jointly by faculty members of different disciplines, each affiliated with a different institution. All subjects were listed in the catalogues of participating institutions and open to students on a cross-registration basis. Next year, 1978-79, the Seminar will offer seven subjects, four of which are new, generated by this year's discussions.

The topic set for this year's faculty discussion was "Representation," and as usual we found ourselves dealing with a variety of overlapping or mutually relevant issues in the criticism of the literary and visual arts and the practices of historiography and social theory. Following established practice, this year's work was reviewed and the initial agenda for next year was set on the basis of a common understanding of this year's concerns and unresolved problems. By general agreement, the colloquium will begin with the subject of "Interpretation and Explanation." An initial series of readings has been planned, drawing on works by Dilthey, Gathamer, Barthes, and Richard Bernstein, and a set of presentations commissioned for the first four meetings.

ALVIN C. KIBEL

COURSE XXI

This has been a busy year for Course XXI, with significant developments in population, improvement of procedures, and a variety of social activities. At the same time there have been clear signs of even more promising prospects for the year ahead.

Enrollment

The number of Humanities majors in all Course XXI programs increased from 45 to 52 in a year's time, a gain of over 10 percent. More impressive, perhaps, was a solid jump in the office's contact with interested freshmen and sophomores. Well over 50 prospects were interviewed during the year, roughly half of whom have already elected to join the Department. The file of active prospects is twice as full as it has been in recent years past. There has been an especially encouraging surge of early interest among members of the freshman class.

Thesis Procedures

Concern over equity in standards and quality of product led the Course XXI office to initiate several changes in the procedures for senior thesis projects. The new structuring specifies several stages at which the student must describe the state of the project in detail. It also makes mandatory for all theses an evaluation by a faculty committee of at least three, including the student-selected thesis tutor and a chairperson selected by Course XXI. The committee as a whole meets with the student twice: first at a thesis-in-progress presentation in mid-spring, open to other interested faculty and students; and finally after the thesis has been submitted, to discuss its successes and limitations and to determine a grade. Each
member of the committee fills out an evaluation form discussing the quality of the work, and students are given space to respond to these individual commentaries. The hoped-for effects of these procedures -- a sharper scrutiny of standards and a useful sense, for the student, of writing for a wider and somewhat more disinterested expert audience -- are already clearly being achieved. Further adjustments of the system will be undertaken next year.

**Intellectual and Social Identity**

Working with Professor Bruce Mazlish and the Department's Policy Committee, we explored to some extent the possibilities for stronger identification of students' intellectual commitment by specific discipline. A joint meeting of majors with the Policy Committee (19 out of 52 majors attended) revealed that: 1) our majors generally enjoy and profit from the association with students in allied fields which a unified Course XXI office tends to encourage; 2) most are in favor of an increase in serious intellectual contact with faculty in their own field and in the Department as a whole. Next year the several sections, assisted by Course XXI, will seek a workable level of extracurricular student/faculty interaction, via colloquia, lectures, symposia, and the like.

In the meantime, Course XXI's year was enlivened by a highly satisfactory Christmas party, an April Open House geared chiefly to freshmen and undesignated sophomores, and a Commencement Day breakfast for graduates, their families, and their faculty friends.

The Humanities Student Association was inactive for the second year running, many of its members devoting their energies instead to RUNE, the M.I.T. Journal of Arts and Letters. Several students have expressed an interest in reactivating the H.S.A. next year.

**State of the Programs**

These remain substantially as characterized in last year's annual report. The proposed revision of XXI-A and XXI-B, 1 has been effectively stymied, pending development of the new supradepartmental Program in Science, Technology, and Society.

Professor Margery Resnick and her colleagues in the Foreign Languages and Literatures Section have been working on a proposal for separate major programs in French, German, Russian, and Spanish literature to be considered by the Committee on Curricula next fall. The addition of these programs would substantially strengthen the array of majors available in Course XXI, creating an unambiguous relationship between the Foreign Literature programs and those in Literature (where most of the material is natively in English or read in translation).

Next fall will be the time for serious reconsideration of the major program in Writing and Literature, whose content and structure have been problematic since their inception. The imminent appointment of a director for the Writing Program makes revision a real possibility after two years of delay.

**Miscellaneous**

The Course XXI Senior Humanities Seminar (21.901) was taught this year by Professor Peter S. Donaldson of the Literature Section.
The I. Austin Kelly Competition in its fourth year attracted entries from several fields. David O. Knuttunen, Class of 1978, was awarded a prize for his paper, "Brazilian Indian Policy and the Real Cost of Development in the Amazon."

Alison D. Kohler, Class of 1978, a Writing and Literature major, was nominated for the Compton Award by this office. She was selected for this honor by the awards committee for her significant contribution to the M.I.T. Symphony, and the Women Students Association.

TRAVIS MERRITT

Department of Linguistics and Philosophy

The year 1977-78 marked the second year of the merger between the Department of Philosophy and the Linguistics Section of the former Department of Foreign Literatures and Linguistics. It also marked the first year of operation under the new Department Head, Professor Samuel Jay Keyser.

Initiatives of special interest during the past academic year included preliminary approval of a joint Linguistics and Philosophy graduate program leading to the Ph.D. The program is part of a major effort to combine, insofar as possible, the educational programs of both Sections of the Department.

Considerable time also has been spent in developing the undergraduate Language and Mind program. Enrollment is now quite high in the introductory subjects and the Department has developed a grant proposal for the creation of specific teaching materials in connection with the program.

During the past year the Department also has been engaged in the planning and execution of a series of workshops in Cognitive Science sponsored by M.I.T. and supported by a grant to M.I.T. from the Sloan Foundation. Three such workshops have taken place: one on mental representation, one on maturational development, and one on the biology of language. These workshops have been extremely successful in helping to establish an environment of interdisciplinary research in cognitive science at M.I.T. They also have been useful in bringing the work ongoing at the Institute to the attention of the wider research community.

A particularly useful interdisciplinary activity that has been initiated by the Department is the Joint Language Processing Seminar. This seminar met once every two weeks for the purpose of discussing important new papers in the field of language processing and in language acquisition. The seminar was run jointly by representatives from the Departments of Linguistics and Philosophy, Psychology, Electrical Engineering and Computer Science, and the Artificial Intelligence Laboratory. It continued through June 1978 and will resume in the fall.

Finally, the Department has taken the initiative in bringing into existence an Interdisciplinary Program in Cognitive Science. Discussion with the Department Heads of Psychology and Electrical Engineering and Computer Science have paved the way for the formation of a committee to forge such an interdisciplinary program for presentation to the respective faculties for approval.
The Department has continued its M.I.T. Philosophy and Linguistics Colloquium, a series of invited lectures, open to the M.I.T. community, by philosophers, linguists, and psychologists on topics related to language. Among speakers invited this past year were Professors Ian Hacking, Saul Kripke, and Raymond Smullyan. In addition, the Linguistics Section has continued its student-run colloquium with invited speakers including Professors Lee Baker, Carlotta Smith, Henk van Riemsdijk, William Leben, and David Lightfoot. These speakers are affiliated, respectively, with the University of Texas (Baker and Smith), the University of Amsterdam, Stanford, and McGill.

The year was marked by a rich array of special seminars, including a seminar in lexical representation run by Professor Joan Bresnan and involving a number of guest lecturers. In addition, workshops in metrical structure and in tone were held.

During I.A.P., the Department offered several subjects, including two major lecture series, What is Linguistics and What is Philosophy. Irish was offered as well as the Formal Theory of Musical Structure and Semantics.

RESEARCH

The Linguistics Faculty

Professor Bresnan, in collaboration with Professor Jane Grimshaw of Brandeis University, has completed a detailed syntactic analysis of the structure of English free relative clauses.

Secondly, Professor Bresnan is nearing completion of a monograph entitled Grammatical Interpretation in which she has further developed and extended a proposed new theory of surface structure interpretation.

Professor Bresnan's investigation of syntactic binding and lexical coding of grammatical relations has, she contends, important implications for a third area of research: the design of a cognitive model of grammatical processing in which linguistic universals can be theoretically identified and experimentally investigated. She is collaborating with Dr. Ronald Kaplan of Xerox PARC on a computer simulation of such a model.

Professor Noam Chomsky's work is an extension of the previous year's research. The technical focus lies in two basic areas, a theory of opacity and a theory of case. The theory of opacity offers a somewhat deeper grounding of the system of conditions on rules of grammar that he has developed in the past several years. The theory of case, according to Professor Chomsky, is closely related. Assuming that certain syntactic categories assign case in a way that modifies certain traditional assumptions, one can derive principles that are rather close to the system of filters discussed by Professors Chomsky and Lasnik in previous research.

Professor Kenneth Hale continues research on the potential role of linguistics in education -- particularly in bilingual education programs, and with special emphasis on the possible use of linguistics in the teaching of the methods and attitudes of scientific inquiry.

He also is conducting research in language typology, with particular attention to non-Indo-European languages.

A third emphasis of Professor Hale's research has been on the X-bar systems of Hopi, Navajo, Papago, and Walbiri.
Fourthly, Professor Hale has been pursuing a detailed analysis of Papago phonology.

During the academic year 1977-78 Professor Morris Halle was on sabbatical, which he spent conducting research and writing papers. His most recent research has explored the role that metrical structures play in phonology.

Work on Indo-European accentuation that had been going on for some time was put aside temporarily as Professor Halle became interested in metrical structures. He will return to IE accentuation in the fall in connection with his seminar on IE accentuation.

During the past year, Professor Halle has written a rejoinder to an attack on some old work on the phonology of Kasem, a West African language; completed a lengthy manuscript on the accentuation of Russian verbs; finished a short paper on the controversy regarding the exceptionless character of the sound laws; and prepared an article on Roman Jakobson for inclusion in the next edition of the International Encyclopedia of Social Sciences.

Professor James W. Harris's research this past year has continued to center on the investigation of morphological and phonological (especially syllabic) properties of Spanish. One major paper, "Two theories of non-automatic morphophonological alternations: evidence from Spanish," provides a deep critique of so-called "Natural Generative Phonology." Other work has attempted to clarify the notion "morphophonology."

During the spring of 1978 Professor Paul Kiparsky has continued work on metrical theory (stress and syllabicity). This work has led to a reexamination of cyclic rules in segmental phonology.

Professor John Ross has been working on four broad topics during the past year: 1) the sound of meaning, 2) the analysis of poetry, 3) niches, and 4) grammaticality.

The Philosophy Faculty

Professor Ned Block has been working on issues having to do with computational theories of the mind. In the past year Professor Block wrote a meta-theoretical paper on the philosophy of psychology, arguing that the problems that philosophers have thought of under the rubric of philosophy of mind illuminate and are illuminated by problems raised by research in psychology, and that they form a set of issues which can be equally well classified as philosophy or as psychology.

Continuing the line of work in which he has been engaged for the past four or five years, Professor Block wrote a paper on sociobiology which was delivered at the annual meeting of the Society for Philosophy and Psychology.

Professor George Boolos has continued his research into systems of modal logic that are of interest in the investigation of the concept of probability in formal deductive theories. He has completed a book on the subject, called The Unprovability of Consistency: An Essay in Modal Logic, to be published this fall by Cambridge University Press.

Professor Boolos has obtained some new results about a system of modal logic that formalized the notion: provable and true. He has obtained a simplified completeness proof, a proof of the interpolation theorem for this system, and a proof that the usual axiomatization of the system is redundant.
Professor Sylvain Bromberger's research has been primarily in two areas: erotetic logic, i.e., the logic of questions; and philosophy of language. Professor Bromberger is concerned with elucidating the structures by virtue of which certain propositions give rise to certain questions or to certain sets of questions, and the nature of the rules which determine what counts and what does not count as an answer (correct and incorrect) to a question.

Professor Bromberger's work in the philosophy of language has been addressed to issues about the nature of meaning and the possibility of constructing a theory of meaning.

Professor Richard Cartwright is doing research on several interrelated questions concerning identity and quantification. One such has to do with the so-called principle of the indiscernibility of identicals, the principle that (roughly) an object $x$ is identical with an object $y$ only if whatever is true of $x$ is also true of $y$.

Joshua Cohen has been working toward the completion of the third of three thesis essays. This essay is on Hobbes' political theory, and considers Hobbes' conception of the person in connection with his theory of the state in a way which is intended to illuminate: a) some difficulties with Hobbesian political theory; and b) the role of conceptions of the person in providing foundations for political philosophy.

Professor Jerry Fodor's work tends to fall in one of two areas: more or less experimental studies in psycholinguistics and more or less philosophical studies of problems of methodology and explanation in 'cognitive science.

With respect to experimental studies, he has just completed a cycle of experiments which provide (what he takes to be) strong prima facie arguments against the claim that morphologically simple items from the lexicon of a natural language have internal structure at the 'semantic' level of linguistic description.

With respect to philosophical studies, Professor Fodor is interested in providing a coherent account of the nature of explanation in the cognitive sciences; in particular, in viewing recent computational models as versions of "representational" theories of the mind and as providing relatively explicit theories of the nature of propositional attitudes.

Professor Irving Singer has continued writing and research for the sequel to his book The Nature of Love: Plato to Luther. During 1977-78, he has mainly been working on the chapters that deal with 19th-century concepts of romantic love, particularly as they center about the contrasting philosophies of Hegel and Schopenhauer.

Professor Judith Thomson's research this past year dealt with Part I of a three-part project which she hopes to complete during her sabbatical leave. The project concerns itself with human rights: what it comes to to have a right, and what sorts of considerations settle which rights we have. Part I is entitled "The Internal Logic of Rights;" in it Professor Thomson singles out a class of ascriptions of rights and examines the logical relations among statements in that class.

PERSONNEL

The Philosophy faculty conducted a wide search for three positions vacated by departed (Jerrold Katz and Miles Morgan) and departing (James Kostman) faculty members. Effective July 1, 1978 Professors Edwin McCann and Judith DeCew will be joining the Department. It is noteworthy that of the three top young people seeking positions in the field this past year, the Department of Linguistics and Philosophy was successful in attracting two of them.
In addition, the Linguistics Section has invited two visiting faculty members, Dr. Mark Liberman of Bell Laboratories and Professor Edwin Williams of the University of Massachusetts at Amherst, to spend one semester each as visiting faculty members. Dr. Liberman will spend the fall term 1978 at M.I.T. and Dr. Williams will be here spring term. These appointments compensate for a reduction in subject offerings which would otherwise have resulted from the absence in 1978-79 of Professor Chomsky, who will be on sabbatical leave.

Honors

Professor Morris Halle was the recipient of the James R. Killian, Jr. Faculty Achievement Award for the academic year 1978-79.

SAMUEL JAY KEYSER

Department of Political Science

Notable events during 1977-78 have included the inauguration of a new undergraduate program in public policy with the aid of a grant from the Sloan Foundation, approval by the M.I.T. faculty of a new Bachelor of Science degree entitled Political Science: Public Policy, the election of Professors Suzanne Berger and Walter Dean Burnham to the American Academy of Arts and Sciences, the hiring of Thomas Ferguson as an Instructor in the field of American Politics, and the resignations of Professors Douglas Hibbs and Lorenzo Morris.

Undergraduate Program

The most significant development of this past year was the initiation of a new undergraduate program in public policy. The primary aim of this program, directed by Professor Michael Lipsky, is to provide M.I.T. undergraduates with improved opportunities for understanding the ways in which substantive policies evolve, are implemented, and affect socioeconomic outcomes. Though intended to serve as part of a broad liberal education rather than as a training program in preprofessional job skills, it is expected to be of particular interest to students considering public service careers. More broadly, the hope is that its subjects will attract many students who now anticipate other types of careers but who desire improved understanding of how their professional and personal lives are likely to be affected by the public policy environments in which they occur.

The planning year (1976-77) and first operational year (1977-78) of the public policy program have been financed in substantial part by a grant from the Sloan Foundation. Sloan funds have been utilized primarily to support the development and teaching of new courses and the expansion of undergraduate internship opportunities. The most significant new course has been developed as an introduction to the public policy program, entitled Politics and Public Policy. Offered both semesters this past year (by Professors Michael Lipsky and Deborah Stone), it attracted a gratifying total of 95 students. Other new subjects included one on Systematic Analysis and Public Policy and one on Comparative Social Policy.
Under the leadership of Professor Martha Weinberg and of Patricia Joffee, administrative officer of the public policy program, the Department substantially expanded both its summer and academic year internship programs. During the summer of 1977, 26 students were placed in summer internships (12 of them in Washington, DC), by comparison with seven the previous summer. This expansion was made possible by a collaboration with the Department of Urban Studies and Planning, the Undergraduate Research Opportunities Program, and the Work Study Program, as well as by the new availability of Sloan funds for this purpose. A similar program was mounted this year in preparation for the summer of 1978, though the number of interns will be slightly fewer in 1978 because of a decision to increase the standard stipend per student from $1,000 to $1,300. During the academic year, Senior Lecturer Edwin Diamond offered a new media internship option in one of his courses. And the internship course in state and local government that Professors Weinberg and Alan Altshuler have taught for the past three years offered a second section, taught by Professors Leonard and Suzann Buckle of the Department of Urban Studies and Planning.

In May the M.I.T. faculty approved, upon the Department's request, a new major entitled Bachelor of Science in Political Science: Public Policy. The title was chosen to make clear that the new major is concerned mainly with the interplay of politics and policy, and to differentiate it from a public policy option offered by the Department of Urban Studies and Planning within the framework of its major. The Urban Studies public policy program, it should be noted, is much more preprofessional in its orientation than that of Political Science, as well as more focused on urban topics. There are significant areas of overlap between the two programs, however, and the departments have made substantial progress in the past year toward integrating their efforts with respect to these. Most notably, several of the core public policy subjects are joint-taught by members of the two faculties, and both the summer and academic year internship activities of the two programs have been largely consolidated.

Graduate Program

Attention focused increasingly during 1977-78 on the paucity of departmental resources available for graduate student support. The Department is widely recognized as one of the top half-dozen in the country, but its capacity to attract the best graduate students has significantly declined in recent years. Its leading competitors were much less dependent during the 1960s and early 1970s on Federal and foundation support. Thus, as such support has contracted since 1973-74, their ability to compete for graduate students has significantly improved relative to M.I.T.'s Department of Political Science. Some indication of the magnitude of the problem is suggested by the following data.

Between 1973-74 and 1977-78 tuition increased by 40 percent, and we estimate that student living costs grew by a similar proportion. In the same period financial aid declined by 11 percent. In short, on an inflation-adjusted basis, financial aid declined by nearly two-fifths.

The most obvious consequence of this decline is that only a small proportion of the top applicants for graduate admission are now opting to enroll in the Department. Of the top 10 candidates for 1978-79, only two chose to accept the Department's modest offers. Nearly all of the others indicated that they were accepting much more generous offers from other leading departments -- specifically, Harvard, Princeton, Stanford, and Berkeley.

On the positive side, applications were up about 20 percent over the previous year, and in the one area (Arms Control) where the Department did have the ability to offer fairly generous, multiple-year support, all three of the top-ranked applicants accepted. It also should be emphasized that the overall quality of the Department's graduate student body
continues to be very high, and that both students and faculty have continued to enjoy considerable success in raising outside funds. Sources of graduate student fellowship support during 1977-78 included the National Science Foundation, Canada Council, the Institute for the Study of World Politics, the Danforth Foundation, the Scripps-Howard Institute, the Social Science Research Council, the Harvard-M.I.T. Joint Center for Urban Studies, the Institute for International Education, and the Fulbright Program.

During this past year the Graduate Program Committee devoted substantial effort to revising the Department's Political Analysis requirement, which must be satisfied by all Ph.D. candidates. The most significant outcome of this review was agreement that a new year-long seminar on the scope and methods of political science should be developed as a centerpiece of the first-year doctoral curriculum. This seminar will be offered by Instructors Donald Morrison and Frank Lerman in 1978-79, with contributions from numerous other members of the Department.

A number of new subjects were introduced into the graduate program, including one on the political economy of urbanization by Professor Wayne Cornelius, one on African political thought by Professor Willard Johnson, and one built around an effort to simulate US foreign policy planning by Professor Lincoln Bloomfield. The syllabus of Professor Cornelius' course is scheduled for publication in the journal Comparative Urban Research.

Though the job market remains very tight, the Department's placement record continues to be a good one -- in no small part because of the energetic activities of its director of placement, Professor Lucian Pye. This past year graduates found teaching appointments at the University of California at Berkeley, the University of Washington, Holy Cross, and M.I.T. One obtained a two-year postdoctoral fellowship at the Harvard School of Public Health and another accepted a research position at the Boston University Medical School.

Publications

The faculty's scholarly activities may usefully be subdivided into the following categories: comparative politics, international relations and foreign policy, and American politics and public policy.

Studies that appeared or went to press in the comparative area included: a volume edited and coauthored by Professor Cornelius, Metropolitan Latin America: The Challenge and the Response (Sage Publications); a book by Instructor Morrison entitled Social Change and Nation Building in Africa (Frem Press); a revised edition of Professor Pye's China: An Introduction (Little, Brown); and two books by Professor Myron Weiner, Sons of the Soil: Migration and Ethnic Conflict in India (Princeton University Press) and India at the Polls: The Parliamentary Elections of 1977 (American Enterprise Institute for Public Policy Research).


Professors Burnham and Weinberg coedited and contributed to a volume in memory of Professor Jeffrey Pressman, American Politics and Public Policy (MIT Press, scheduled for publication in November). Other studies in the area of American politics and policy included: a book by Professor Altshuler, The Urban Transportation System: Politics and
Policy Innovation (MIT Press); an extended article by Professor Burnham on "The Politics of Crisis" (Journal of Interdisciplinary History); several important and widely publicized papers by Professor Cornelius on the issue of illegal Mexican migration to the United States; and a book by Senior Lecturer Diamond, Good News, Bad News (MIT Press).

Public, Professional, and M.I.T. Community Service Activities

Professor Ted Greenwood was on full-time leave during this past year as a senior staff member at the US Office of Science and Technology Policy (OSTP) in the Executive Office of the President, and Professor Eugene Skolnikoff served as a senior consultant to the director of OSTP. Professor Bloomfield drafted a foreign policy speech for President Carter and served on the Board of Directors of the United Nations Association of the United States. Professor Cornelius advised several members of Congress on policy with respect to illegal Mexican migration to the US. Professor Griffith served as a consultant to the National Security Council. And Professor William Kaufmann was a consultant to both the Secretary of Defense and the Secretary of Energy.

Additionally, Professor Hayward Alker served as an advisor to the US District Court for Eastern Massachusetts on biases in jury selection. Professor Lipsky was a consultant to ACTION (the federal volunteer agency) and a member of the Board of Directors of the Justice Resources Institute. Professor Ithiel de Sola Pool served as a member of the Department of Commerce Technical Advisory Board. Professor Pye visited Mainland China as part of a US delegation negotiating cultural exchanges, and served as a director of the Council on Foreign Relations, the World Affairs Council, and the Asia Foundation. Professor Weiner served as a consultant to both the National Security Council and the State Department.

Turning from public service to professional activities: Professor Alker served very actively as a member of the Committee on Undergraduate Education of the American Political Science Association. Professor Berger continued as chairperson of the Committee on Western Europe of the Social Science Research Council. Professor Cornelius served as program director for the Joint National Meeting of the Latin American Studies Association and the African Studies Association in November 1977. Professor Johnson joined in founding the Association of Concerned African Scholars, and he has been nominated as vice president of the African Heritage Studies Association. Professor Pye served as a member of the Board of Governors of the East-West Center in Honolulu, and as chairperson of a dissertation award committee of the American Political Science Association. Professor George Rathjens was chairman of the Federation of American Scientists and a member of the Steering Committee for the Pugwash conferences.

Within the M.I.T. community, the most notable development was Professor Donald Blackmer's appointment as director of the new Program in Science, Technology, and Society. Professor Nazli Choucri served as a member of the three-person executive committee of the Technology Adaptation Program, a large-scale multidisciplinary research effort in Egypt funded by the Agency for International Development. Professor Rathjens served as a member of the Steering Committee for this program, and Professors Berger and Pool directed component research projects within it.

Professor Altshuler continued as chairperson of the Advisory Committee on M.I.T.'s pairing with a "magnet" school in East Boston as part of the Boston school desegregation program. Senior Lecturer Diamond advised The Tech, Thursday, and M.I.T.'s cable television service for students; he also offered a seminar for M.I.T. student journalists. Professor Pye chaired the M.I.T. United Way Fund Drive. Professor Rathjens was chairman of the Committee on International Institutional Commitments. Professor Harvey Sapolsky chaired the R.O.T.C. Advisory Committee and served as deputy director of the Boston Area Health Policy

PERSONNEL

Two members of the Department were promoted during 1977-78, Professor Choucri to full professor and Professor Greenwood to associate professor. Additionally, Thomas Ferguson was hired as an instructor in the field of American Politics. He will become an assistant professor upon completion of the requirements for his Ph.D. from Princeton, hopefully before September.

Professors Berger and Burnham were elected to the American Academy of Arts and Sciences. And Professor Cornelius received the Latin American Studies Association Citation for Distinguished Scholarly Contribution, in recognition of his "efforts to explore systematically, discuss seriously, and publicize thoroughly, both to policy makers and the public generally, the impact of illegal Mexican migration on both the United States and Mexico."

Professors Douglas Hibbs and Lorenzo Morris resigned during the past year, Professor Hibbs to accept a generous offer from Harvard and Professor Morris to take up a research position at Howard University.

Faculty members on leave during 1977-78 included Professor Hibbs at the Center for Advanced Study in the Behavioral Sciences and Professor Greenwood at the US Office of Science and Technology Policy. Additionally, Professors Cornelius and Johnson each took off one semester to carry out field research.

ALAN ALTSHULER

Department of Psychology

At the end of 14 years as a Department, Psychology is continuing its busy pace of research and teaching, of providing service to the Institute and to the profession, yet is also looking ahead to its future development, concerned with change, continued growth, and possible expansion.

Modest changes have been made in some aspects of our program. New areas of research have been investigated, new approaches to old teaching formats have been tried, and new courses were introduced. Larger changes are, however, increasingly to be desired if we are to maintain the continued health and prosperity of this Department. The reasons for such anticipated developments emerge from the following review of our situation.
RESEARCH

The laboratories of individual faculty members have, for the most part, continued at a high level of productivity and support from external granting agencies. However, support from block grants given to groups of faculty has been declining, without replacement, for several years. Although individual grants can take up the slack to some extent, block grant funds are essential for several purposes: flexibility in starting new research, funding the research of young members of our staff, and maintaining costly services not fully covered by other funds.

We are currently making efforts to recoup our fortunes for these purposes through at least two sources. An application for core support to the National Eye Institute has met with tentative approval and will, we hope, enable us to extend our work further into study of the basic processes of vision and visuomotor coordination. A major effort is being made to obtain support for a program in the cognitive sciences which will include several members of our faculty and staff. The outcomes of these and other efforts at fund raising are of critical importance for our future research programs.

Our current viability in research is indicated by the visibility of faculty and staff: during the past year, members of this Department have published more than 100 articles. The faculty orally presented the work of their laboratories at 73 invited colloquia and conferences across the US and gave 24 lectures abroad, while their students and associates accounted for another 20 talks. But these are mere statistics: they do not convey the excitement of new discoveries that are being made in our laboratories. These discoveries come in the form of newly traced connections among the neurons of the brain and insights into how they are made; in understanding the actions of the nervous system both by physiological and behavioral experiment as well as by theoretical modeling; and they provide new insights into vision and its development and into the elaboration of thought processes. Credit for this atmosphere is due to all who share in the collaboration, but much of it goes exclusively to the investigators who run our laboratories.

FACULTY AND STAFF

New Appointments

Professor Richard Held became the official head of the Department at the start of the year, having been Acting Head since Professor Hans-Lukas Teuber's death in early January 1977. At the same time, two new appointments became a reality: Dr. David Marr, formerly in the Artificial Intelligence Laboratory, to which he had come from the University of Cambridge, joined our Department as Associate Professor. Dr. Marr works on modeling the visual nervous system with mathematical and computer-aided techniques, and will work closely with Professor Whitman Richards while maintaining his association with the A.I. Laboratory.

Dr. Suzanne Corkin, who had worked with Professor Teuber as a research associate since 1964, was appointed Lecturer. She is directing the work of the clinical neuropsychology laboratory and will, as during the past year, continue to participate in teaching efforts in that area.

We are anticipating two new joint appointments beginning in the coming academic year which will greatly strengthen our existing programs. Professor Norman Geschwind of the Harvard University School of Medicine will, in conjunction with the Division of Health Sciences and
School of Humanities and Social Science

Technology (H.S.T.), become a part-time member of the departmental faculty. Professor Geschwind, a clinical neurologist with a worldwide reputation as an aphasiologist and brain scientist, will be of crucial importance to our efforts in neuropsychology. Dr. Daniel Osherson, formerly of the University of Pennsylvania, will hold a professorial appointment in this Department, jointly with the Division for Study and Research in Education. Dr. Osherson is an extremely well-regarded cognitive and developmental psychologist whose work will dovetail nicely with that of our investigators involved in the study of cognition. Both of these appointments add strength to the coalition of psychologists, linguists, educators, philosophers, and practitioners of artificial intelligence -- a coalition which is developing into a new program in cognitive science.

Honors, Promotions, Awards

As in previous years, promotions and honors have come to several members of our faculty. Professor Walle Nauta was the Annual Distinguished Visitor Lecturer at the University of Southern California for 1977, and just recently received the prestigious award for "Excellence in Teaching of the Preclinical Sciences" from Harvard University's Boylston Medical Society.

Professor Gerald Schneider was promoted to full Professor in recognition of his international reputation and service to the Department.

Dr. Ann Graybiel, Associate Professor of Psychology and Brain Science, became a tenured member of M.I.T.'s faculty, and won the Charles Judson Herrick Award, in May 1978, from the American Association of Anatomists.

Dr. Susan Carey, Associate Professor of Psychology, began the second year of her Radcliffe Institute Fellowship, and Professor Emilio Bizzi received the first Alden Spencer Award, given by the College of Physicians and Surgeons of Columbia University.

Visitors

The fact that the Department has not lost its attraction as a national and international center for research is witnessed by the many visitors -- faculty, research associates, and postdoctoral fellows -- who joined us this fall. To mention just a few, we are hosting Professor Barbara Sakitt from Stanford University; Professor Hiroto Katori, a visiting psychologist from Tokyo University; Dr. Janette Atkinson, from Cambridge University, in Dr. Held's laboratory; and Dr. Oliver Braddick, also from Columbia University, collaborating with Drs. Marr and Richards. Dr. Maria Eugenia Moschen from Bologna, Italy, and Dr. Paul Schönle from Tübingen, Germany, are working with Dr. Corkin on behavioral aftereffects following brain trauma; Dr. Ita Abramov, from Case Western Reserve, spent several months of her sabbatical in neuroanatomy with Professor Nauta; Dr. Francis Lestienne came from the University of Paris to collaborate with Professor Bizzi on problems of motor control; Dr. Stanley Schein is working on visuomotor function with Professor Peter Schiller; Dr. José Garcia-Albea has come from Madrid to work in psycholinguistics with Professors Jerry Fodor and Merrill Garrett; Dr. Laszlo Lēhârd, from Pecz, Hungary, is training with Professor Nauta; and Drs. Murray Grossman, Helene Intraub, and Joseph Thomas are engaged in postdoctoral work in problems of cognition, perception, and infant vision, respectively. Through the year, the Department sponsored a total of 12 postdoctoral fellows.

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Our own faculty, in turn, has not been idle. On campus, our faculty of 14 accounted for 17 positions on official Institute Committees: such service ranged from the Committee on International Institutional Commitments to the Committee on the Use of Humans as Experimental Subjects, and from the Faculty Advisory Council of the Whitaker College of Health Sciences, Technology, and Management to the Faculty Advisory Council of the College of Science, Technology, and Society. They provided a total of 73 colloquia and conference participations across the US and gave 24 talks abroad. The invitations they followed took them to such places as Tübingen, Germany, as part of the celebration of its University's 500th anniversary; to the Brain Research Laboratory in Zurich, Switzerland; to São Paolo, Brazil, where a new Functional Neurosurgery Research Center was inaugurated at the University; to the King Edward's Memorial Hospital in Bombay, India; and to the Max-Planck-Institutes in Göttingen, Germany and Nijmegen, Holland.

Postdoctoral fellows, research associates, and advanced graduate students accepted numerous invitations to universities and conferences and accounted, on their own, for almost two dozen presentations.

Eleven members of our graduate student group earned doctorates during the past year. Two of them continue to work in this Department, while the others are representing the Department in a wide variety of institutions, among them the University of Toronto, Rockefeller University, Harvard Medical School, Brown University, the Jet Propulsion Laboratory in Pasadena, and the Centre Nationale de Recherche Scientifique in Marseilles, France. And one, Kwok-Fai So, has just recently departed (after one postdoctoral year here) for his native Hong Kong where he will assume his post as Assistant Professor at the University of that city.

The new graduate student class has finished its first year. It is a small group of six selected from about 20 times that number. Three women and three men, they came from such diverse institutions as the University of Michigan, Princeton, Wayne State University, Radcliffe, Yale, and Northeastern University.

The Department regretted losing three of its long-term staff members: Ann-Marie DeLuca, whose name and skill could not be divorced from the Department's Practicum subject, left after 15 years to take a position in Washington, DC; Dianne Rice, who also had spent 15 years with the Department in her capacity as secretary, and later as administrative assistant to the psycholinguistics group, joined another department at M.I.T.; and so did Lydia Snover, our former Administrative Officer, who, after five years, left our group to take on a larger department and greater responsibilities. We wish all of them well!

**TEACHING**

A great deal of faculty time and effort was spent on attempts at restructuring a number of course offerings. The introductory course 9.00, lacking its creator, Hans-Lukas Teuber, was team-taught, troika-fashion, by Professors Graybiel, Alan Hein, and Mary C. Potter. They made a valiant effort to keep the spirit of 9.00 alive for almost 300 students so shortly after the death of its founder. We shall revert to the former, one-professor format, and Professor Stephan Chorover will be teaching 9.00 in the fall.
On the graduate level, the Brain and Behavior Seminar (9.021) was given a clinical perspective by joining it with Professor Geschwind's Neuropsychology Seminar at Harvard Medical School. While the arrangement at times had students travelling to the Boston campus, the course was generally well received.

As a result of restructuring, the Department offered only 14 undergraduate courses during the past year (in contrast to the previous 17) and taught 570 undergraduate students. One hundred and forty of them (graduating seniors) had declared their humanities concentration in Psychology, with the class of 1979 already 62 strong. Thus, Psychology is continuing as one of M.I.T.'s largest undergraduate concentrations in humanities.

Graduate courses kept their attendance at the usual level. Twenty-one graduate subjects were offered to 94 students during the past year; one of them (9.016J) jointly with the H.S.T. Division, 9.652J jointly with the Division for Study and Research in Education, and 9.653J together with the Department of Linguistics and Philosophy.

The Proseminar, our first-year seminar, was redesigned to accommodate the students' needs with particular reference to the current state of the field and became a two-term sequence. This format will allow greater blocks of time for particular subject areas and thus facilitate in-depth presentation.

Thanks to newly granted support from the Institute, the departmental colloquium program, well-known to fellow professionals in the Boston area and beyond, takes on ever greater significance as a teaching tool in the behavioral and brain sciences. We officially hosted 27 colloquium speakers, 21 from domestic institutions and 6 from abroad, and offered 26 in-house seminars, 12 of them given by speakers from foreign institutes and universities.

January's Independent Activities Period provided a convenient vehicle for a one-day meeting, chaired by Dr. Corkin, on New Approaches to the Study of Reading Disorders. It also gave a chance to present a two-week lecture series on Representation in the Cognitive Sciences, given by visiting Professor Thomas Bever from Columbia University, which was jointly sponsored by the Departments of Linguistics and Philosophy and Psychology.

The month of June saw a series of well-attended weekly seminars hosted by the Department of Psychology but sponsored by the Department of Linguistics and Philosophy. Its Sloan Foundation-funded program of Visiting Scholars in Cognitive Science had as its residents Drs. Herbert and Eve Clark from Stanford University and Dr. Jacques Mehler from the Centre Nationale de Recherche Scientifique in Paris.

**Concluding Remarks**

We know that we must pursue new directions vigorously if we are to maintain, let alone extend, our leadership in the fields we represent. The very success of our program, ranging from aspects of neurobiology bearing on brain function and its realization in behavior, to sophisticated analyses of visual and motor function, and to study of the internal representation of thought and action, has led to emulation and competition. We now need to fill gaps in our coverage of certain newly important areas of neurobiology, including the chemistry of the nervous system and the study of model systems as they occur in simple organisms.

We also need to consolidate recent gains in the form of new faculty and directions of research which require the kind of nurturing difficult to obtain, in these days, from Federal sources of funding. The new directions of work may, in turn, exacerbate internal strains which have, not surprisingly, been endemic in a group which contains as much diversity as ours despite
its small size. While relations among faculty, staff, and others remain as cordial as ever -- a most valued legacy from the leadership of Professor Teuber -- space restrictions and funding stringencies are increasing sources of frustration. We must expand while maintaining the cohesiveness and high standards of the Department as it now exists. The coming year should see the beginning of such expansion.

RICHARD HELD

Program in Science, Technology, and Society
Technology Studies Program

For the past five years this School has sought to develop teaching and research programs in which the characteristic concerns and methods of the humanities and social sciences could be brought to bear on issues relating to the role of science and technology in modern society. The first such effort, undertaken in 1973-74 under the initiative of Professor Nathan Sivin (now at the University of Pennsylvania), resulted in the creation of the Technology Studies Program. Professor Louis L. Bucciarelli, Jr. was named Director of the Program and a small interdisciplinary faculty was appointed whose members, in addition to Professors Sivin and Bucciarelli, came to include Professors Irving Kaplan, Kenneth Manning, Sherry Turkle, Charles Weiner, Langdon Winner, and Joel Yellin. This group, with the collaboration of faculty members from other Schools, developed an increasingly popular set of undergraduate offerings, organized each year a stimulating seminar series with speakers from within and outside the Institute, and made good progress toward building an effective communications network among faculty and students concerned with the social, ethical, and political dimensions of science and technology.

At the close of the past academic year, the Technology Studies Program was brought to an honorable end, not because it had failed in its mission, nor because the job it had set out to do was finished, but because it had been overtaken by a related but broader reaching and substantially better funded enterprise, the prospective College of Science, Technology, and Society. This new venture, the outcome of a two-year faculty study group chaired by Professor Emeritus Elting E. Morison, had begun operation in 1976-77 with the appointment of three internationally-known scholars, Professors Kenneth Keniston from Yale University, Leo Marx from Amherst College, and (on a visiting basis) Gerald Holton from Harvard University. This group spent its first year consulting with members of the Institute faculty and preparing a funding proposal and Prospectus for the proposed new organization. Their labors were rewarded by the receipt, last fall, of grants totaling $2.5 million.

These two groups, the faculty of the Technology Studies Program and that of the proposed new College, separate in origin but overlapping in function, have coexisted peacefully for the past two years on the same corridor of Building 20 awaiting the necessary clarification of their relationship. The appointment last September of Associate Dean Donald L.M. Blackmer as Director of both programs pointed toward the resolution which formally occurred this June, when the Technology Studies Program was terminated and its members were invited to join the Program in Science, Technology, and Society, which is intended as the experimental phase of the prospective College. This joining of forces, together with other appointments already made or contemplated, should soon result in a faculty strong enough, in both quantitative and qualitative terms, to begin to make its presence felt at the Institute and elsewhere. An enormous amount remains to be done, of course, to realize the promise of this new venture. The stakes are not trivial, for the linkages between "science" and "society" are, on the one hand, still poorly understood and inadequately explored by scholars, and on the
other hand, more obviously critical than ever before to the decent ordering of human affairs. M.I.T. now has the potential to become a national leader in this rapidly growing but still underdeveloped and poorly defined field of study concerned with the relations of science, technology, and society.

A summary report follows of the activities of each of the two programs during the past year.

PROGRAM IN SCIENCE, TECHNOLOGY, AND SOCIETY

Significant progress was made this past year toward realization of the Institute's commitment to developing a substantial interdisciplinary program focused on the interactions among science, technology, and society. A major prerequisite was realized with the receipt of $2.5 million in start-up funds from three foundations for the development of a new academic unit, tentatively to be called the College of Science, Technology, and Society: $1 million each from the Alfred P. Sloan Foundation and the Andrew W. Mellon Foundation, and $500,000 from the William and Flora Hewlett Foundation. The Program in Science, Technology, and Society represents the developmental phase of the prospective college.

The original Prospectus for a College suggested that it be given autonomous status, independent of and equally distant from all the Schools, on the premise that the new institution was intended to serve Institute-wide needs and potentially to involve faculty members from every School. This premise still holds, but an early decision was made that the program should, at least during its developmental stage, remain affiliated with the School of Humanities and Social Science, where the planning for it began. Several considerations lay behind that decision. One was that the educational programs of the prospective College, especially at the undergraduate level, were likely to relate particularly closely to those of several departments in the School of Humanities and Social Science. By the same token, many of the appointments to be made would be in fields and disciplines for which that School is principally responsible. The need for particularly close coordination and cooperation seemed clear. The principal means to that end is the role being played by the School Council and by Dean Harold Hanham in facilitating exchanges of information and in reviewing proposals for appointment and promotion of faculty within the new program. Thus far, the system has worked well and should continue to be an effective mechanism for coordination with the departments in the School and for quality control with respect to appointments and promotions.

It remains very much the goal of the program, however, to play an Institute-wide role and to involve faculty members from departments and disciplines outside this School.

The Program's most urgent need has been to assemble a larger group of faculty members associated with it on both a full- and a part-time basis. The core group this past year has been limited to the director, two full-time faculty members (Professors Keniston and Marx), and three part-time visiting or emeritus faculty (Professors Holton, Elting Morison, and Robert Morison). A good deal of time has thus been spent on faculty recruitment, both from the outside and from within the Institute.

Outside recruitment has been going forward in several areas, in each of which an interdepartmental search committee or planning committee has been at work. Under the heading of the Social Study of Science, we were looking for a person in one of several possible disciplines whose career has shown a particular concern for the interaction between scientific thought and 20th-century social, political, and cultural issues. This search was successfully concluded with the appointment of Professor Loren Graham from Columbia University, an historian widely known as a specialist in the history and philosophy of Soviet science. Professor Graham is currently engaged in an interesting study of the interactions between science and social and political values in various historical and cultural settings.
Two appointments were made in the History of Technology, a field of central importance to the Program in which, as a result of recent retirements, there has for several years been no full-time representative on the Institute faculty. We were pleased to conclude this search with the appointments of Professor Merritt Roe Smith from Ohio State University, a distinguished historian of early 19th-century American Technology, and Assistant Professor David Noble, an historian of 19th- and 20th-century American Technology. Professor Noble has been at M.I.T. for several years as a postdoctoral fellow and research associate in this School and a lecturer in the Technology and Policy Program of the School of Engineering. Recruitment will continue next year in two fields where preliminary searches have already been made -- the history or sociology of the life sciences, and the study of contemporary industrial societies -- as well as in other areas to be determined.

Equal attention is being given to what might be called "recruitment from within." The prospective College must involve present members of the Institute faculty in its work. They are needed to help plan the program, to attract and teach students, and to participate in research projects, seminars, study groups, and other activities. Several concrete steps have been taken in this direction, including most notably an invitation to the members of the Technology Studies Program to join in the new enterprise. One early result of that collaboration is a combined listing of undergraduate subjects which will appear in next year's catalogue under the heading of Science, Technology, and Society. Arrangements also have been made for two members of the engineering faculty to join the Program for the next two or three years on a half-time basis. They are Professor Leon Trilling of the Department of Aeronautics and Astronautics, whose research and teaching interests have long included the historical and social dimensions of technological change; and Dr. Michael Meyer, a specialist on transportation who is being given a joint appointment as assistant professor in this Program and in the Department of Civil Engineering.

Major Program tasks on the agenda for the next two or three years include the following:

1) Selection of priority fields in which additional faculty recruiting should take place and organization of the searches;

2) Organization of faculty seminars or study groups in areas of interest to people in several disciplines; plans have been laid this year to sponsor two such seminars, one on environmental questions, the other on issues having to do with the impact of computers on society and on individuals;

3) Preparation of specific proposals for an undergraduate curriculum in Science, Technology, and Society for discussion with the Committee on Educational Policy and other bodies of the faculty;

4) Exploration of the potential for a graduate program, either independently or in collaboration with relevant departments; and

5) Development of faculty research and of a research-oriented postdoctoral fellows' program.

Faculty Research and Other Activities

The dominant emphasis which this report has given to matters of Program development is, alas, a fairly accurate reflection of the way in which its members have had to invest their energies this year. The demands on a small faculty for participation in administrative and
planning responsibilities have been quite intense, leaving too little time for research and writing. A good deal has been accomplished all the same, of which the following items represent some highlights.

The spring 1978 issue of Daedalus on "The Limits of Scientific Inquiry" was edited by Professors Holton and Robert Morison from papers prepared for a faculty seminar which they organized under the Program's auspices during the 1977-78 academic year. Contributors to the volume included Professors Graham, Holton, Marx, and Robert Morison. The Cambridge University Press published Professor Holton's recent book of case studies in the history of science, entitled The Scientific Imagination: Case Studies. The same press has accepted for publication a book on American Science and Modern China completed last year by Dr. Peter Buck, research associate and lecturer in the Program. Professor Marx wrote several articles and reviews, continued work on a book tentatively entitled The Pandering Landscape: American Pastoralism Reconsidered, and among other outside commitments, served as President of the American Studies Association. Professor Keniston was the author of a book All Our Children: The American Family under Pressure and of several articles and reviews on children and the family; these resulted from his earlier responsibilities as Chairman and Executive Director of The Carnegie Council on Children.

TECHNOLOGY STUDIES PROGRAM

During the past year, the Technology Studies Program continued its efforts to further the humanistic, interdisciplinary study of science and technology. The activities of the Program centered around teaching, developing undergraduate subjects, and organizing a year-long seminar series. Simultaneously, the faculty members of the Program carried on individual research projects covering an impressively broad range of topics.

Undergraduate Offerings

Student interest in the Technology Studies Program remained active. Seventy-three students enrolled in the six Program courses carrying Humanities Distribution credit, and an additional 80 signed up for the nine elective courses offered this past year. Two undergraduate students pursued special topics in Technology Studies, and four participated in a seminar in public interest science offered jointly with the Department of Physics. To date, 27 students from the Classes of 1978-81 have chosen Technology Studies as their field of concentration. A new course, Medicine and Its Critics: A Study of Medical Practices as a Paradigm for Expert-Client Relations, was added to the previous year's Technology Studies subjects.

Technology Studies Seminars

The Program organized a year-long series of 12 Technology Studies Seminars on "Perspectives on the History of Technology." The speakers were Professors Marx, Noble, Dolores Hayden, and Jerome Lettvin from M.I.T., and Carroll Pursell, Patrick Malone, Ruth Schwartz Cowan, Alan Trachtenberg, Daniel J. Kevles, Diana Long Hall, Merritt Roe Smith, and Reese Jenkins from other universities around the country.
Faculty Research

The diversity of the research conducted by faculty members of the Technology Studies Program reflected the scope of the Program itself.

With Nancy Dworsky, Professor Bucciarelli worked on the final manuscript revision of their book on Sophie Germain and her contributions to early 19th-century developments in the theory of elasticity. In addition, Professor Bucciarelli published several technical articles and is now investigating power loss and power flow in photovoltaic systems.

Supported by a grant from the Alfred P. Sloan Foundation, Dr. Kenneth Manning, Assistant Professor of the History of Science, is writing a biography of Dr. E. E. Just (1883-1941), a specialist on cell life and metabolism and considered by many to be the greatest black scientist, living or dead. Through his research, Professor Manning hopes to shed light on the role of blacks in American science and on the history of 20th-century biology. He also is preparing a study on "The Concept of Rigor in the History of Mathematics."

Dr. Sherry Turkle, Assistant Professor of Sociology, has completed a book on Psychoanalytic Politics: Freud's French Revolution, which deals with both the politics within the psychoanalytic movement in France and the interaction of this movement with society and with other intellectual currents. Supported by a grant from the National Science Foundation, she is now investigating the social and psychological impacts of the computer on the individual and the ways in which concepts, metaphors, and models from the world of computation diffuse into psychology, philosophy, and people's "common-sense" understanding of themselves.

With Alice K. Smith, Dr. Charles Weiner, Professor of the History of Science and Technology and Director of the Oral History Program, is currently preparing a selection of the letters of Robert Oppenheimer for publication. Professor Weiner is also continuing his work on nuclear physics in Japan and is documenting the emergence and implementation of safety guidelines for research on recombinant DNA in his book The Recombinant DNA Controversy: Historical Sourcebook and Archive. (See the report on the Oral History Program, below.)

Dr. Langdon Winner, Associate Professor of Political Science, is preparing several essays dealing with various aspects of technology, philosophy, and political theory. He has been on research leave this spring, with support from the Old Dominion Foundation, for work on a book entitled Emancipation and Obsolescence: The Search for Alternatives to Technological Society, which will examine the central themes and problems in attempts to propose alternatives to the large-scale, resource-exhausting technologies of our age. Because of the interest aroused by his earlier book, Autonomous Technology, Professor Winner was also invited to give lectures and participate in symposia across the country.

Dr. Joel Yellin, Associate Professor of Social Sciences, continued his work with Professor Paul Samuelson on models in human population growth, and has participated in a project funded by the Ford Foundation to research the future of the international nuclear power industry. In addition, Professor Yellin has received a grant from the Twentieth Century Fund for the preparation of a book-length manuscript on Legal Institutions and Technological Change: Risk, Uncertainty, and the Judicial System. In this work he will explore the relations between technological change and environmental controversies.
As a continuation of the Oral History Program's effort to document the historical development and social impact of 20th-century science and technology, 143 hours of tape recorded interviews were conducted with 54 individuals during the past year. More than 490 hours of interviews with 217 individuals have been recorded since the Program's birth in 1975. This year's major projects covered three topics: the recombinant DNA controversy, the history of computers at M.I.T., and women scientists and engineers.

Documentation of the recombinant DNA controversy received the most attention. The project, supported by a joint grant from the National Science Foundation and the National Endowment for the Humanities and coordinated by Lynette Maloney, aims to create a fully catalogued collection of source materials to be made available for research and education through the M.I.T. Archives. Since the project's inception in early 1975, interviews have been conducted with 118 individuals involved at the international, national, and local levels of the controversy, and over 7,000 archival documents have been collected. When possible, actions and deliberations of concerned groups and governmental agencies and legislatures have been covered. The project is attracting the attention of researchers around the country and is coming to be viewed as a model method for studying evolving social problems.

During the past year a project on the life histories of nine women scientists and engineers was completed. In 60 hours of interviews, the project explored the personal and professional experiences of these women as well as their views on the special problems confronting women in science and engineering. The interviewees, most of whom are M.I.T. professors or graduates, were: Professors Mildred Dresselhaus, Ellen Henderson, Vera Kistiakowsky, Lisa Steiner, Giuliana Tesoro, Sheila Widnall, and Christina Jansen and Christine Jones.

A project on the history of computers at M.I.T. is currently being prepared and should be completed by September 1978. In order to trace M.I.T.'s involvement with the development of computers, five participants in Professor Jay Forrester's Project Whirlwind, which was started in 1944 and made significant breakthroughs in automatic computation, were interviewed: John Carr, Robert Everett, Alan Perlis, and Professors Forrester and Harold Hazen.

Other projects completed during the year include the development of ocean engineering as a research field, the New England nuclear power controversy, and the initial phase of the recording of the life histories of M.I.T. faculty members. In addition, the Program sponsored several experimental projects using videotape as an oral history medium. The DNA project made videotape records of several public meetings on recombinant DNA experimentation and edited the tapes of the Cambridge City Council hearings on this question into a half-hour documentary. The project on the New England nuclear power controversy videotaped the activities of the Clamshell Alliance and the confrontation between opponents and proponents of nuclear energy.

The Program has encouraged the use of oral history both as a teaching aid and as a technique of inquiry into issues involving the interaction of contemporary science, technology, and society, and oral history materials have been used for Technology Studies classes at M.I.T. and other institutions.

DONALD L. M. BLACKMER
The Sloan School's program in teaching and research and its participation in a broad array of related professional activities have continued to focus on the advancement of managerial practice as one of the School's principal missions.

The School's high standards have continued to be reflected this year in the exceptionally high national and international rankings of the quality of its management education programs. The School's reputation for breadth and quality in research has permitted us to continue to attract and retain an outstanding faculty and exceptionally fine students and special program participants.

The tasks for the future reflected in some of the subsequent discussions of our teaching and research programs are twofold. They entail, first, our continued efforts to sustain a pioneering vitality at the frontier of intellectual and professional excellence. Second, we must continue to improve the quality of life for our program participants and faculty by improving the physical environment in the School. The simultaneous improvement along each of these dimensions will permit us to build on and extend the School's already substantial strengths.

The problems of management in private and public organizations continue as a matter of major concern in all countries of the world. The School's ongoing efforts to advance our own understanding and, in turn, the practicing professional managers' capacities to deal more effectively with the enormously complex managerial challenges of our era are efforts still at the crest of timeliness and urgency and our progress on these tasks continues to reward our effort.

**TEACHING PROGRAMS**

**Undergraduate Program**

Again this year, management subjects were elected by an increasing number of M.I.T. students majoring in other fields, in particular science and engineering, reflecting a growing recognition of the need for management skills in diverse professional careers. Although the enrollment in the undergraduate degree program remains at the level of recent years, we anticipate a continuation of the trend toward greater service to the M.I.T. community as a whole.

A major development within the School was the inauguration of an Honors Program leading to a combined Bachelor's/Master's degree. Undergraduate management students may now be admitted to the graduate program in the spring term of their third year at the Institute. To be selected for the Honors Program, a student must have demonstrated outstanding academic performance and unusual potential for a management career. Two students were admitted this spring.
Senior Lecturer Stanley M. Jacks continued to serve as chairman and Esther Merrill as coordinator of the undergraduate program. Mr. Jacks and Ms. Merrill also served as counselors for undergraduates, along with Professors Thomas J. Allen, Jeffrey A. Meldman, Arnold I. Barnett, and James M. Lyneis. Professor Peter P. Chen continued as coordinator for the Sloan School in M.I.T. 's Undergraduate Research Opportunities Program.

**Master's Programs**

In 1977-78 the School continued to offer the accelerated (12-month) and regular (two-year) programs leading to the degree of Master of Science in Management, with a 1978 graduating class of 38 and 120 respectively.

The School's experience with both programs continues to be excellent. In total, applications for the Master's programs in 1978 were approximately the same as last year, namely, 1,225. The numbers of applications from women increased by 15 percent over 1977 to a total of 256, or 21 percent of all those received. However, the School experienced a decrease of 30 percent in the number of minority applicants (56 in total this year). There has been a decrease in the number of minority applicants at all of the other major business schools contacted, but ours has been more severe than the average. To turn these results around, the School proposes to invest staff time in more aggressive recruiting and we hope to report substantial progress in attracting more minority applicants for next year's programs.

We need also to continue to work on the more general question of an adequate support staff for a well-run professional school and will be considering the role and nature of the staff required to improve our placement and alumni and corporate relations in addition to the added support for recruitment.

As part of our ongoing efforts at improving the quality of our programs, we continued to experiment with modifications in our Master's programs which should keep them at the frontiers of excellence. For example, the addition of a more formal method of organizing joint thesis research, our "structured thesis" option, has proved to be beneficial to both students and faculty and will continue on an expanded basis in the future. Other modifications will be undertaken this year to improve the coordination of our offerings in the core curriculum, to review the possibilities of providing improved special concentrations for in-depth specialization, to put more emphasis on improving our students' abilities to communicate orally and in writing, and to build greater understanding of the real world in which managers must deal by providing more opportunities for contact with the best of current managerial practice. We shall continue the successful series of visits made by senior managers to the Sloan School and plan additional field trips for student visits to organizations.

In this context, we introduced a special activities fee this year as a supplement to the tuition for incoming students. This fee ($200) will be used to finance a number of these innovations in the Master's curriculum -- improvements which would have been impossible to support without the income from these additional program fees.

In program administration, we shall focus next year on improvements in financial aid and in our alumni relations. We shall continue to address the "quality of working life" issue but with our current physical facilities no radical shifts can be effected. We expect some improvement with the addition of three new tiered classrooms and some further efforts at increasing the number of School-related social events, but the longer run solution can only be put in place with new facilities, a problem which both the School and the Institute are addressing vigorously.
In summary, the 1977-78 academic year has been one of continued progress on a number of dimensions and the School is at the moment extremely strong and is increasingly being so perceived by the external world.

The following data highlight some of the major characteristics of the classes of 1978 and 1979, broken down by our two-year program (the Sloan Master's Program) and the Accelerated Master's Program (the AMP).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>1978 AMP</th>
<th>1979 AMP</th>
<th>1978 SMP</th>
<th>1979 SMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex: Female/Male</td>
<td>8/30</td>
<td>9/31</td>
<td>27/87</td>
<td>28/86</td>
</tr>
<tr>
<td>Age: Median/Range</td>
<td>27/22-38</td>
<td>29/22-38</td>
<td>24/20-40</td>
<td>24/19-48</td>
</tr>
<tr>
<td>Married/Single</td>
<td>16/22</td>
<td>22/16</td>
<td>27/87</td>
<td>44/71</td>
</tr>
<tr>
<td>Percent with Full-Time Work Experience</td>
<td>100%</td>
<td>100%</td>
<td>54%</td>
<td>70%</td>
</tr>
<tr>
<td>From: Countries/States</td>
<td>5/9</td>
<td>4/9</td>
<td>10/22</td>
<td>20/22</td>
</tr>
<tr>
<td>Mean Undergraduate Grade Point Average*</td>
<td>3.8</td>
<td>4.2</td>
<td>4.3</td>
<td>4.2</td>
</tr>
<tr>
<td>Median Admission Test Score**</td>
<td>638</td>
<td>635</td>
<td>628</td>
<td>600</td>
</tr>
</tbody>
</table>

* On 5.0 scale (excluding some foreign students).
** National average is approximately 460.

Preliminary placement information on the 1978 class of Master's graduating candidates indicates a strong M.B.A. job market this year and Sloan's continuing predominance in that market. Estimated on an initial 75 percent response, the average starting salary for Master's candidates will increase 25 percent this year, from a mean salary of $21,300 in 1977 to an estimated $26,700.

The number of organizations recruiting on campus increased about 10 percent over last year. Compared with 115 organizations in 1976-77, 140 organizations reserved recruiting dates during the 1977-78 placement season, with a lesser number (128) actually interviewing on campus. The difference between reservations and actual on-campus recruiting is largely explained by companies' cancelling because too few students were signed up for an interview to justify the recruiting visit.

The ratio of organizations recruiting on campus to students interviewing (.87) is approaching 1.0. There were about 145 students in this year's graduating class who were actively seeking employment. During 1977-78 the Sloan Placement Office arranged 224 schedules for 2,195 interviews. While some of these interviews were for first-year candidates exploring summer job possibilities, about 2,000 interviews were for graduating candidates. The average recruiting schedule permits 14 interviews, equal this year to the average number of interviews per graduating student.
Given the fact, however, that different students are interested in different industry areas and different organizations in those areas, the match of students interviewing with companies recruiting may be uneven and the total number of students seeking an interview with a given organization too small to justify, from the organization's perspective, the time and expense of the interviewing on campus.

At some point the size of the graduating class limits the quality of the placement process. Despite the strong demand for Sloan graduates, some students are limited in their exploration of individual areas of interest. Similarly, despite the existence of qualified candidates at Sloan, some organizations are not able to interview these students.

In an effort to make the current placement process as effective as possible, efforts are made to complement on-campus recruiting with opportunities generated through correspondence and the preparation and distribution of a Sloan Resume Book. In some cases organizations are encouraged to send a job description by correspondence, subscribe to the Resume Book, or both, rather than interview on campus. These other channels are particularly attractive if there is a small number of very qualified candidates interested in the opening(s). In 1977-78 the Placement Office received about 500 job descriptions by correspondence. Subscription to the Sloan Resume Book increased this year about 33 percent, from about 130 organizations ordering 140 books in 1976-77 to 174 organizations ordering 191 books in 1977-78.

Associate Dean Michael S. Scott Morton has continued to serve as chairman of the Master's Program Committee and to give leadership to their efforts at strengthening our Master's programs. Pamela Turner continued to serve as Manager of the Accelerated Master's Program in addition to fulfilling her duties as Director of Recruitment and Placement. Miriam Sherburne served once again as Program Coordinator and was assisted in these tasks by Harriet Schwartz.

**The Ph.D. Program**

The primary objective of the Sloan School's doctoral program continues to be the education of men and women pursuing academic careers in research and teaching.

The program is continually under review to assure a balance between study in the theoretical disciplines with study in broadly defined "applied" or "functional" fields. Flexibility is provided each student in the design of his or her course of studies within the framework of rigorous research requirements and a heavy emphasis on essential quantitative methods of analysis.

Perhaps the most important development in the last two years has been the increasing emphasis on stricter standards of admission. The selection process is becoming exceptionally rigorous. For September 1977, 24 were admitted from a pool of 154 applicants. Of those 24 carefully chosen finalists, nine accepted our offers (seven men and two women).

Financial aid has become scarce; in consequence, potential candidates often find it impossible to accept our admission. The demise of Ford, National Defense Graduate Fellowship Programs, National Science Foundation Fellowship Programs, and the reduction in other sources of external support have hurt the support of doctoral programs throughout the country. Efforts to uncover financial support are meeting with some success, and, as a result, we anticipate a larger entering class for September 1978.

The doctoral candidates who entered the program in September 1977 selected the following areas of concentration:
Sloan School of Management

Applied Economics 1
Industrial Relations 1
Management Science 1
Management of Technological Innovation 1
Organization Studies 2
System Dynamics 3

In the academic year ending June 1978, 18 candidates received their degrees. Graduates of the program in recent years have tended most often to accept teaching positions: of the 19 people receiving degrees in calendar year 1975, 13 accepted academic positions; of the eight receiving degrees in 1976, six went to university posts; and of the 10 graduating in 1977, eight are in teaching positions.

The Doctoral Program Committee has been reconstituted and Professor Alvin J. Silk has agreed to serve as its new chairman and to oversee an extensive program review. We are all grateful to Professor Allen for his past years of program leadership. James Gabbert replaced Jane Browning as program coordinator and Associate Dean Peter P. Gil continued to give his administrative support to the doctoral program.

Alfred P. Sloan Fellows Program

On June 5, 1978, 55 Alfred P. Sloan Fellows (Class of 1978) were awarded the degree of Master of Science in Management. Last year the class of 54 Sloan Fellows had been the largest in the history of the Program. This year the Class of 1978 set still another new record although we are anxious not to have this number grow any further.

The Class of 1978 represents perhaps the widest variety of backgrounds of any class of Sloan Fellows. There are some important organizations represented for the first time: Saga Corporation, Groz-Beckert USA, Inc., American Express International, Insurance Company of North America, Shriram Refrigeration Industries Ltd. (India), Telecommunications Company of Iran, Union Bank of Switzerland, AB Gotaverken (Sweden), Salem Hospital, Naviera Humboldt S.A. (Peru), Lien Tung Limited (Taiwan), Casa Autrey, S.A. (Mexico), Israel Air Force, and Advent Corporation.

Although this particular class reflects more than ever the heterogeneous environment within which organizations operate today, the composition of the class comes primarily from the private sector. There were in this class, for example, 40 from the private sector, two from the health management field, and the remainder from the public sector.

The demand for the Program continues to be strong and the quality of the nominations is extremely high. A small backlog continues to accumulate and the interest from the US private sector is growing ever stronger.

The Sloan Fellows Program Committee has continued to give its attention to the continuance of effective recruitment, program evaluation, and to the coordination of the curriculum and workload. Professor Charles A. Myers, the School's Alfred P. Sloan Fellows Professor, continued to support the Sloan Fellows in a number of important ways -- as a thesis advisor to a large number of Fellows, as a member of the Program Committee, and cochairman with
Associate Dean Gil of the Selection and Evaluation Subcommittee. The Program continues in its uncontested place as one of the best of its kind offered at any management school in the world.

**Health Management Executive Development Program**

As an integral part of the Alfred P. Sloan Fellows Program, the third year of operation was completed by the Health Management Executive Development Program. There were two Sloan Fellows from the medical field: Ross Markello, Chairman, Department of Anesthesiology, School of Medicine, State University of New York at Buffalo and Elizabeth M. Hastings, Assistant Director, Clinical Services Division, Salem Hospital, Salem, Massachusetts. Two others from the medical field were forced to cancel their plans to attend; the number of professional men and women concerned with the management of health services will be substantially higher next year. The interest of such professionals in the Sloan Fellows Program continues to grow. The Program is co-directed by Professor Edward B. Roberts and Associate Dean Gil.

**M.I.T. Program for Senior Executives**

1978 marked the 22nd year of the M.I.T. Program for Senior Executives. There are now over 1,000 alumni who occupy positions of leadership in many companies and organizations around the world. Demand for the 30 places in the Program continues very strong; for the past few years this demand appears to have been unaffected by the economic slowdown. Approximately one-fourth of the participants in each of the two nine-week programs offered came from abroad. Professors Arnoldo C. Hax and Donald R. Lessard served as chairmen of the Program's faculty committee; and Lecturer Alan F. White, an M.I.T. alumnus (Sloan Fellow at M.I.T. in the Class of 1971), continued as the Program Director.

**Greater Boston Executive Program (G.B.E.P.)**

The 21st Session of the Greater Boston Executive Program was held from January 20 to April 28, 1978. Interaction among the limited number of participants (17 this year) continued to be excellent, surmounting snowstorm and blizzard weather. Class members represented 10 organizations, including one company new to the program.

This 15-week, one-day-a-week program receives a very positive reception from the Greater Boston companies who participate in it and has enthusiastic support from its alumni. The 1978 G.B.E.P. Alumni Reunion in April was well attended by alumni and alumnae with their spouses and all participated in seminars given by Professors Meldman and Zenon S. Zanetos, with State Senator Chester G. Atkins as the dinner speaker. Patricia Macpherson has once again provided effective coordination for this program.

**Summer Programs**

Sloan School faculty again offered a variety of Special Summer Programs for professional men and women during the summer of 1977.

Professor Jay W. Forrester, assisted by other members of the System Dynamics Group, offered a two-week program on Corporate and Economic Policy; The Systems Dynamic Approach in which the techniques and viewpoint started at M.I.T. over 20 years ago were focused on policy formulation and analysis at the levels of the corporation and the economy.
Professor Roberts also made use of the systems dynamics approach in his one-week program, The Dynamics of Health Service Systems. This program aimed at reporting progress to date in the application of certain systems analytic methods to health care delivery, and at stimulating new attacks on the problems of health service systems. He was assisted by supporting faculty from the Schools of Medicine of Tufts University, Michigan State University, University of Cincinnati, and the Albert Einstein College of Medicine.

In addition, Professor Roberts again directed the program on Management of Research, Development, and Technology-Based Innovation. Professors Allen, Eric A. von Hippel, and Ralph Katz collaborated with him in this two-week program.

Professors Stewart C. Myers and Richard A. Cohn, assisted by Professor Gerald A. Pogue of Baruch College, the City University of New York, repeated their two popular consecutive one-week programs in finance: Modern Concepts in Financial Management and Strategy and Models for Financial Management and Long-Range Financial Planning.

Professors Edgar H. Schein and Richard Beckhard again offered the one-week "live-in" course at the M.I.T. Endicott House, New Horizons in the Management of Change and Organizational Development.

Professor Peter Lorange chaired a group consisting of Professor Hax, Lecturer J. Morrison McInnes, Senior Lecturer John F. Rockart, and Associate Dean Scott Morton that offered two one-week programs in the area of management planning and control: Strategic Control Systems and Strategic Planning Systems.


Under the direction of Professor Gary L. Lilien, the marketing group offered a one-week symposium, Marketing Science: Current Practice and New Developments. This was divided into two programs: the first two days dealt with concepts and applications and were aimed at marketing managers, while the last three days were devoted to models and methods and were designed more for marketing research professionals. Participants could attend either or both programs according to their interests. Symposium staff included Sloan School faculty as well as visiting specialists from other universities and industry.

The School's Center for Information Systems Research (C.I.S.R.) also sponsored a five-day seminar, Current Issues in Information Systems Research, concerning recent findings on major issues in the information systems area. Here the emphasis was on managerial interpretation of new knowledge being generated in the field today rather than on research techniques. Dr. Rockart, Director of the Center, and Professors Chen, Donovan, Madnick, Meldman, and Hoo-Min D. Toong and other members of the C.I.S.R. staff led the lectures and discussion groups.

Professor J. D. Nyhart, who holds appointments both in the Sloan School and in the Department of Ocean Engineering, and Professor R. R. Baxter of the Harvard Law School directed an eight-day seminar on Legal and Policy Aspects of Ocean Resources Management that was held under the joint auspices of M.I.T. and Harvard Law School. Other participating faculty were professors Chryssostomos Chryssostomidis and John W. Devaney of the Department of Ocean Engineering, Professor Louis B. Sohn of Harvard Law School, and Dr. Susan B. Peterson of the Woods Hole Oceanographic Institution.
As has been true in past years, these summer programs, although designed to give specific post-experience training to professional managers, have continued to serve as the basis for substantial improvement in the quality and teaching of the School's larger residential and degree programs by serving as "proving ground" for curriculum innovation and redesign.

**Industrial Liaison Symposia and Seminars**

Members of the Sloan School faculty have continued to lead and participate in symposia and seminars sponsored by the M.I.T. Industrial Liaison Program.

In November Professor Lorange conducted an afternoon seminar at M.I.T. on Strategic Planning Systems -- Recent Advances.

In December Professor Donovan and Adjunct Professor Benjamin C. Ball, Jr., were among the lecturers at a one-day symposium -- The Energy Challenge...The Management of Uncertainty -- that was sponsored by the Industrial Liaison Program and the M.I.T. Alumni Center of New York.

In January Professor Phyllis A. Wallace was chairperson of a one-day symposium, Women in the Workplace: Management of Human Resources. This was held at M.I.T. and other speakers and discussion leaders from the Sloan School included Associate Dean Abraham J. Siegel, and Professors Charles A. Myers, Lotte Bailyn, and James W. Driscoll.

Another symposium was held at M.I.T. in February under the chairmanship of David O. Wood, Senior Lecturer in the Sloan School and Associate Director of the Energy Laboratory. Other faculty participating in this program on Research and Modeling for National and International Energy Markets were Professors Donovan, Henry D. Jacoby, Martin B. Zimmerman, and Gordon M. Kaufman. Professor Ball participated in the panel discussion in the afternoon.

Professors Lilien and von Hippel conducted an afternoon seminar in March on Developing and Marketing Successful Industrial Products.

Management of Human Resources: New Issues and Challenges, a one-day symposium held at Kresge Auditorium in May, was under the chairmanship of Professor Schein. Other speakers from the Organization Studies Group of the School were Professors Bailyn, Driscoll, Reuben T. Harris, Ralph Katz, and John E. Van Maanen.

Another symposium, Office Automation: What the Future Holds, was also conducted at Kresge Auditorium in May under the direction of Dr. Marvin A. Sirbu, Jr. of the Center for Policy Alternatives. This was a two-day program and two of the lectures were presented by Sloan School faculty: Representation and Automation of Office Processes by Professor Michael D. Zisman and Problems of Privacy and Information Policy by Professor Meldman.

For the first time this past year Sloan School faculty conducted a Special European Program for the Industrial Liaison group. Professors Roberts and Allen went to London in January where they conducted a one-week program on Management of Research, Development, and Technology-Based Innovation, with the assistance of Alan W. Pearson, Director of the R&D Unit of the Manchester Business School in Manchester, England. This followed the format and content of the Special Summer Program that has been offered at M.I.T. for many years.
RESEARCH

The School's teaching program curricula and design derive in large part from the extensive and diverse research interests and activities of the faculty, staff, and students.

The section summarizes the major research efforts and accomplishments of the School. This work is both disciplinary and multidisciplinary in character and the groupings below are necessarily arbitrary and may not always reflect the cross-disciplinary and cross-functional mix entailed in both the design and execution of the research described.

Human Factors in Management

The faculty in the organization studies area and in the employment and industrial relations area take as their primary research focus the human issues involved in the management of an organization or in the relation of organizations to one another and to the economic, social, political, and environmental contexts within which they function. The social and behavioral sciences of psychology, sociology, economics, and so on are the disciplinary bases upon which much of the research here builds.

Organization Studies. Several members of the faculty are continuing to focus on the problems of adult socialization, career development, and the interaction of work, self, and family issues throughout the life cycle of men and women in different occupations. While work so far has tended to focus on people in technically based careers, managers, and some urban workers, plans are developing for a broader, comparative longitudinal approach to a wide range of occupations. The goals are 1) to better understand how such interactions at different life stages lead to patterns of productivity, creativity, job satisfaction, and accommodation among different life concerns; 2) to improve the activities of human resources planning and career development within organizations; and 3) to help individuals to plan more productive and satisfying lives. Specifically:

Professor Van Maanen is continuing his research on the characteristics of different kinds of work settings in different occupations and how these settings produce certain patterns of socialization of new recruits into the occupation, leading ultimately to a general theory of occupational socialization. Professor Van Maanen has carried out further participant observer studies on workers in a variety of organizations and has continued to work with Professors Bailyn and Schein on the changing relation of work and careers, family and self-development. He edited and contributed to a volume which summarizes much of the work of the Organization Studies Group in the area of career development Organizational Careers, which was published in 1977 by John Wiley & Sons. Professors Van Maanen and Schein are currently working on a more formal theory of organizational socialization.

Professor Bailyn is continuing her study of accommodation patterns in educated adults, especially in dual career families, and has contributed a chapter to a current book on "Dual Careers" edited by Robert and Rhona Rapoport. Professors Bailyn and Schein are currently finishing a major report of their alumni survey of the M.I.T. Classes of 1951, 1955, and 1959 which analyzes career patterns and the nature of work involvement in this technically trained group of people now at mid-life. Professor Bailyn also has finished a paper on patterns and determinants of work involvement in technically based careers which appears in the joint volume summarizing the group's career development research.

Professor Ralph Katz is continuing his analysis of the determinants of job satisfaction, especially as a function of career variables such as the number of years the employee has been on a given job (job longevity). This seminal research shows that people who have been in the
same job for long periods of time are much less responsive to job enrichment, getting more of their satisfaction from contextual and organizational rewards. Professor Katz is extending this work to an examination of productivity and commitment both in individuals and groups as a function of job longevity, and is starting a major new project on research and development groups.

Professor Schein is continuing his analysis of the 1961 panel study showing that career anchors develop or become manifest early in the career and subsequently serve as constraints on future career decisions. Currently he is working on more general models of how organizations plan for and develop their human resources throughout the life of the individual career occupant. This work is an effort to improve human resource management at all stages of the career, and is summarized in his book, *Career Dynamics: Matching Individual and Organizational Needs*, published in 1978 by Addison-Wesley.

Associate Dean Gil and Professor Schein are continuing studies of career paths of Sloan School alumni and are developing methods of analysis which permit the identification of such patterns from career history data. Judy Gordon, a doctoral candidate, has completed her thesis on the effects of congruence between personal orientation toward a job and actual job content on job satisfaction and organizational commitment.

The work on career development is increasingly connecting with the second major research area in the Organization Studies Group conducted by Professor Allen. Professor Allen, Professor Katz, and their colleagues, Professors Roberts and von Hippel, continue to unravel the factors which aid or hinder the process of innovation and technology transfer. A decade of research on R&D management has contributed many valuable insights which are summarized in Professor Allen's book, *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D Organization*, published by the M.I.T. Press in 1977.

Another major area of research within the group developed by Professors Beckhard and Harris is focused on the improvement of health care delivery through the design and the study of educational interventions, particularly at the management level. This research is discussed below in the section dealing with health care management.

Though the research efforts of individual faculty members continue to be largely guided by the requirements of their own project and the scientific issues they are trying to address, there is a growing communality of both scientific and practical concerns evident in the group. In particular, we see a growing concern for the development of theory in the art of applying knowledge and translating scientific findings into the practical arena of management. Many of the members of the faculty, especially Professor Beckhard and Dr. Edwin C. Nevis, are actively engaged in planned change and organization development activities, and this applied or clinical focus of the groups continues to be one of the main sources of strength.

These efforts are especially enhanced by the research projects undertaken by Professors Harris and Beckhard on the effects of different kinds of planned change interventions, especially in large and complex systems. Research in this area has been sparse, but a major effort to locate change projects and to measure the effects of different approaches to change is being launched.

Professors Beckhard and Schein have decided to add several new titles to the highly successful Addison-Wesley series on Organization Development first launched by Professors Beckhard, Schein, and Warren Bennis in 1969. Professors Beckhard and Harris have summarized much of their work in the book *Organizational Transitions*. Other books in the series deal with *Matrix Organizations*, *Career Dynamics*, *Multinational Organizations*, *New Patterns of Work*, *Team Building*, *Organizational Diagnosis*, *Work Redesign*, and *Survey Feedback Methods in Organization Development*. 
Professor Harris has studied the relation of a health care organization's orientation toward patients and the formal structure of the organization. He also has sought to discern the organizational conditions affecting the use of "physician extenders," like nurse practitioners or physician assistants, in the delivery of health care in the military services.

Professor Leo B. Moore continues to work on the factors which lead to creativity and innovation in the management process and to review a variety of experimental approaches with "management by objective" programs in a number of companies.

Employment and Industrial Relations

Most of the projects listed below have been funded from various sources named; a few are still unfunded.

Professor Wallace is continuing her study of the upward mobility of women in management, based on surveys and interviews with graduates from the Sloan School Master's Program Classes of 1975 through 1978. Women graduates are matched with male peers, in an effort to chart how young managers, particularly women, move into middle management. In January, Professor Wallace convened a meeting of faculty members who are engaged in similar research at Harvard, Stanford, and the University of Chicago. The Ford Foundation has indicated it will support regular meetings of this group, and Professor Wallace's research has been supported by a small grant from General Motors (to be renewed), with additional funds from the Sloan School.

Professor Wallace also completed this June a monograph on "Black Women in the Labor Force" for the National Council on Employment Policy, of which she is a member. This will be published in the series, Policy Studies in Employment and Welfare, by the Johns Hopkins University Press, for the Council. She is also continuing her interest in the "Dynamics of the World of Work" project, linking employment policies (internal and external to the firm) to issues of employment discrimination; and she is editing the papers and proceedings on "Women in the Workplace: Management of Human Resources," growing out of a symposium she chaired for the M.I.T. Industrial Liaison Program last January. Professor Wallace is in preliminary discussions with the US Department of Labor about funding a proposed project on how private employers might respond to subsidies to hire youths under the Youth Employment and Demonstration Act of 1977. This would fund assistantships for Master's students.

Professor Charles A. Myers, with Professor Thomas A. Barocci as the senior coauthor, completed a manuscript last November on a three-year study of the impact of the Comprehensive Employment and Training Act (CETA), as compared with pre-CETA Programs in Cambridge, Lowell, New Bedford, and the "Balance of State" (with emphasis on Newton and Quincy). Some 13 Sloan School graduate students worked on this project. After publication delays in Washington, it was published in June under the title CETA in Eastern Massachusetts, as a Research and Development Monograph of the Employment and Training Administration of the US Department of Labor. It should have very wide distribution among the thousands of CETA prime sponsors around the US, as well as in Washington. Professor Myers along with his senior coauthor, Professor Emeritus Paul Pigors, has begun work on the ninth edition of their textbook, Personnel Administration, the first edition of which appeared in 1947.

In addition to the coauthorship with Professor Myers on the CETA monograph, Professor Barocci has begun work on a major study of "Private Investment, Public Policy and the Decline of Older Regions," with Professor Bennett Harrison of the M.I.T. Department of Urban Studies and Planning and Professor Barry Bluestone of Boston College. Project funding for the period February 1978 through August 1979 is joint with the US Department of Commerce,
Professor Barocci presented a paper at the annual meeting of the Industrial Relations Research Association last December (jointly with 1976-77 Visiting Professor David B. Lipsky) on experience with last-offer arbitration for police and firefighters in cities and towns in Massachusetts. He also spoke on this topic at the annual Arbitration Day in New York City, held by the American Arbitration Association; and two articles with Professor Lipsky will appear in the Monthly Labor Review. As a future project, he is working through Sloan School student case studies for theses on Labor-Management Relations in the Hospital Industry. This is a rapidly expanding area of concern. His earlier studies on Public Jobs Programs have now been published as a working paper for Brookings, in an Employment and Training Monograph, and as part of a book edited by Robert Taggart, published last fall.

Professor Driscoll will complete this summer the three case studies of union-management cooperation, begun in the spring of 1977 under a research contract with the US Department of Labor. With two doctoral students, he is developing some guidelines for building a problem-solving capability in traditional adversary collective bargaining relationships. This is expected to result in a publishable monograph or book. Professor Driscoll has been invited to present the results of his research during this summer to national meetings of both the Academy of Management and the American Psychological Association. He also has continued his analysis of the Scanlon Plan companies, with the cooperation and assistance of Fred Lesieur, part-time lecturer here and consultant on the Plan. A preliminary report is being prepared for publication, and a longer study is contemplated if funding can be secured from a number of Scanlon Plan companies this coming fall.

Professor Driscoll also has worked with pairs of Sloan Fellows and a Master's student to develop theses which are publishable with the students and him as coauthors. The first was "The First-Level Supervisor, Still 'The Man in the Middle,'" with Daniel J. Carroll, Jr. and Timothy A. Sprecher, in the winter 1978 Sloan Management Review. Finally, he has published articles drawn from his Cornell doctoral thesis on attitudes toward unions in higher education; one in the IRRA Proceedings (1978), excerpted earlier in the Monthly Labor Review, May 1978.

Professor Kenneth S. Mericle is finishing a paper on "The Political Economy of the Brazilian Motor Vehicle Industry," drawn from his longer study originally funded by the US Department of Labor. He has met recently at Yale University with a group of researchers from other universities working on the automobile industry in Latin America, and a collaborative book will probably result. He is also reworking a paper to be delivered at the New England Conference on Latin American Studies under the title "Dependent Capitalist Development and the Working Class: Brazil Since 1964."

Professor Mericle this year published a paper, "The Impact of Paratransit Innovations on the Job Security of Conventional Transit Employees," as a part of Urban Transportation Economics, National Academy of Sciences, National Research Council, Transportation Board, Washington, DC. This was based on his earlier study as a part of a research team under the leadership of Professor Alan Altshuler of the Department of Political Science, under a grant from the US Department of Transportation.

Professor Harry C. Katz (with Michael Wiseman of the University of California at Berkeley) prepared a paper for the National Manpower Commission entitled "An Essay on Subsidized Employment in the Public Sector." He has drawn on his Berkeley doctoral thesis for two papers: one, "The Municipal Budgetary Response to Changing Labor Costs: the Case of
San Francisco, "has been accepted for publication by the Industrial and Labor Relations Review; the other, "Municipal Labor Relations in San Francisco," is a Sloan School Working Paper ready for future publication. With Professor Henry S. Farber, an Economics Department member of the Industrial Relations Section, Professor Katz has prepared a paper on "Interest Arbitration, and the Incentive to Bargain: The Role of Risk Preferences." He also has finished a paper on "The Structure of Unionization in the Public Sector: Do Private Sector Lessons Apply?"

Mr. Jacks continued his research on various current labor law questions, particularly those decided by the Supreme Court of the United States.

Dean Abraham J. Siegel, a member of the Section, is editor, along with former Visiting Professor Lipsky, of a forthcoming MIT Press book, Unfinished Business: An Agenda for Labor, Management and the Public. The book presents the papers and some of the panel discussions at the 40th Anniversary Conference of the Section and the 25th of the Sloan School, held at M.I.T. in March 1977. This conference brought five former Secretaries of Labor together, and an additional one who sent a statement to be read, to discuss labor-management relations, employment, and related issues constituting their "unfinished agenda" for the future. A panel of top-level management and union leaders discussed the Secretaries' comments in the afternoon session.

Economics and Finance

The Economics and Finance Group is the second basic disciplinary area on which the School's research and teaching programs are built.

Professor Sidney S. Alexander, head of the Economics and Finance Group, has been on leave during this academic year. He is continuing his research for the study of the foundations of social policy, concentrating particularly on the methods of choosing, or compromising, between utilitarian standards based on welfare and those on procedure in order to make valid, interpersonal judgments of social and economic policy.

Professor Daniel M. Holland together with Professor Stewart C. Myers continued research on corporate profitability and capital costs. A monograph on this subject will be published by the Committee for Economic Development in the fall. In relation to the international aspects of this research, another meeting of a group, comprising members from Japan, Great Britain, Italy, Germany, Sweden, Finland, and the United States, will take place in London in September 1978.

Professor Holland, in a joint project with Harbridge House, studied the problem of comparing the costs and the scope of public services among the states.

He also started on a study which will explore possible tax incentives for encouraging company support of basic research in universities.

Continuing his research on property taxation, Professor Holland, together with Professor Oliver Oldman of Harvard, will start on the second stage of their study of Boston's property tax problems, with particular attention to full-value assessment.

Professor Holland continues to be editor of the National Tax Journal.

Professor Lester C. Thurow is working on the direct and indirect incidence of government expenditures. The objective here is to discern whose income goes up and down when income is transferred from the private sector of the economy to the public sector of the economy after
both the benefits of government expenditures and the incomes earned by providing government expenditures are considered. Professor Thurow's publications include "Economics," Daedalus, Fall 1977; "Psychic Income: Useful or Useless," American Economic Review, May 1978; and "Inequality, Inflation and Growth in the American Economy," The Economist, December 1977.

Professor Franco Modigliani's research activities have focused on three main interrelated issues. The first is that of managing an economy in which real wages are fixed through full indexation, as illustrated by the case of Italy since 1975. Several papers analyzing this problem have been published in Italian periodicals, and an English version will appear soon. The second issue concerns the real consequences of an inflationary process. Research conducted jointly with Stanley Fischer has endeavored to establish that these consequences depend on two basic circumstances: first, the extent to which the current and future inflation is fully and correctly anticipated by economic agents. Second, the degree to which institutions both public (taxes, definition of income for tax purposes, tariffs, etc.) and private (denomination of long-term contracts, accounting procedures, etc.) are attuned to the presence of inflation. In an economy in which inflation is fully anticipated and the institutions fully attuned, the cost of inflation is nil or at worst, negligible. But when neither condition is satisfied, as has been the case for the US inflation of the last decade, real consequences are found to be widespread, much more so than is generally acknowledged. A special aspect of the real consequences of inflation which remain to be studied is the effect of inflation on the stock market. The question being asked is whether one can account for the prevalently depressive effect of inflation on the market, an effect so far that has escaped explanation.

The work just noted has served as a basis for continuing research in collaboration with Lucas Papademos on the design of the optimum path of output and employment, for the purpose of liquidating an ongoing inflationary process. Papers presenting the results of both research efforts were presented at a conference organized by Professor Modigliani bringing together academic economists and central bankers. This conference which was held in Vienna under the sponsorship of the Central Bank of Austria, was the third in a series, following one held in Helsinki, Finland, in 1976, and a second in Athens, Greece, in 1977.

The third line of inquiry is concerned with analyzing the monetary mechanism in relation to the financial structure of the economy and the specific monetary aggregate that the central bank chooses to control.

Professor Modigliani also participated in the third World Congress of the International Economic Association in Tokyo as representative of the American Economic Association and was elected Vice President for a term of three years.

Professor Edwin Kuh's research on regression diagnostics, in collaboration with Professor Roy E. Welsch, has continued in its second year with the purpose of developing and refining statistical procedures to detect the influence of anomalous data -- with a view toward assessing and improving model reliability and the use of models in the policy process. This work is supported by a four-year $1 million grant from the National Science Foundation and a three-year $120,000 grant from IBM. This research will be accelerated at M.I.T., and five researchers at other universities will be accessing the TROLL system at M.I.T. through a national network.

Professor Kuh was also engaged in two projects sponsored by the Electric Power Institute, one of them in collaboration with the M.I.T. Energy Laboratory on model assessment.

Much effort was devoted to the transfer to M.I.T. of the Center for Computational Research in Economics and Management Science, now part of the Sloan School after seven years as a part of the National Bureau of Economic Research. Research ties to M.I.T. already in existence should now become much stronger.
This past year Professor Robert S. Pindyck worked on a large econometric study of international demands for energy, and the implications for the world oil market. In addition, Professor Pindyck has been studying a number of theoretical and empirical issues in the exploration and production of non-renewable resources, including the role of exploratory activity in optimal resource production and pricing, and the effects of uncertainty on optimal patterns of exploration and production. Finally, Professor Pindyck has been studying a number of economic issues involved in American energy policy, such as the desirability of government in the commercialization of non-conventional energy sources.

In related energy policy research, Professor Zimmerman was involved in several projects that had the final goal of building a model of the US coal industry. The model is now complete and being used to analyze issues of public policy. Among the policy questions studied were the effects of environmental regulation on the price, output, and structure of the US coal industry, and the trade-offs and interactions between nuclear policy and policies toward the coal industry. Professor Zimmerman also completed a study of the process of rate determination in unit-train shipments of coal, and began a study of price formation in uranium markets.

Professor Richard L. Schmalensee has worked in a number of research areas. He has continued work in consumer product markets focusing on the economics of the ready-to-eat cereal industry with special reference to policy implications of advertising and brand introduction rivalry. Professor Schmalensee has also begun a study of the policy implications in a one-brand dominated industry where product differences are slight. With Tracy R. Lewis of the University of Arizona, Professor Schmalensee completed a study on the properties of optimal harvesting strategies for renewable resources and also has undertaken a new effort involving the relation of market structure and public policy in solar-based technologies.

Professor Robert C. Merton continued his research on options pricing and of corporate liabilities and, more generally, on the operation of financial markets. His work continues to be supported by the National Science Foundation and has resulted in a number of published papers on these topics. Professor Merton continues as co-editor of the Journal of Financial Economics, the Journal of Money, Credit and Banking, the International Economic Review, the Journal of Finance, and the Journal of Banking and Finance.

In addition to his work with Professor Holland, Professor Stewart C. Myers's research included new work with Professor Hax on mergers and diversification and he continued research on the valuation of securities and real assets, capital budgeting under uncertainty, debt policy, corporate planning models, and the financial aspects of government regulation of business. Professor Myers also continued work on a textbook on Corporate Finance which should be completed next year.

Professor Eli Shapiro continued his research efforts into the operations of financial markets and Professor Cohn continued his research on financial intermediation. In particular, he analyzed the impact of various alternative mortgage designs on institutional lenders.

During this year Professor Lessard's primary research activities continued at the intersection of finance and international management. His papers in this area included "Risk Efficient External Financing for Commodity Producing Countries," "Financial Markets and the Adjustment to Higher Oil Prices," (with Tamir Agmon and Jim Paddock), and "Evaluating Foreign Projects -- An APV Approach." In addition, as an extension of his earlier research on alternative mortgage instruments, he collaborated with Arthur Solomon and Kent Colton in a Harvard-M.I.T. Joint Center for Urban Studies National Borrower Study.

Professor Fischer Black has started a major research project that seems to show that the normal workings of competitive markets, when the future is uncertain, can account for much
or all of the cyclical behavior of the economy. To the extent that this is true, government intervention tends to make us worse off, no matter what the government does. Professor Black also has been working on formulas for valuing certain commodity options, which may start trading in the US soon.

Professor Carliss Baldwin's research was in the theory of corporate finance and is concerned particularly with the optimal allocation of human and financial capital within a corporation. She also participated in workshops in the Theory of Accounting and in Managerial Economics and has begun a study on the sources and uses of capital for the US iron and steel industry in collaboration with Professors Joel Clark and John F. Elliott in the M.I.T. Department of Materials Science and Engineering.

Management Science

The Management Science Group is the third of the Sloan School's principal foci of teaching and research. The group is broadly concerned with models, measurements, and information systems and their impact on managerial processes in a variety of settings including planning and control, marketing, and operations management. The research of the group can be divided into context-related research that deals with specific areas of management concern and into methodological research on general tools and techniques. The application contexts can be further subdivided into public and private sectors.

A major concern in the public area has been energy. The work has been heavily interconnected with other parts of the Sloan School and of M.I.T., particularly with the Energy Laboratory where Professor Jacoby is a member of the Steering Committee. In April he also became Director of the Center for Energy Policy Research. Professor Jacoby has been particularly concerned with the analysis of the world oil market and the future of the international nuclear industry, including strategies for assuring uranium supplies. Professor Gordon M. Kaufman is working on developing methods for predicting future supply of energy minerals as a function of policy choice, process, and regulatory regime. He has conducted an extensive project to model the process of oil and gas exploration and has developed methods to permit better estimates of undiscovered oil and gas reserves. He has worked in cooperation with the Interagency Oil and Gas Project in developing an official Department of Interior position on US oil and gas resources. Professor Lilien assisted by Professor Barnett has been working with the photovoltaics program to develop and apply a model for assessing the likely impact of government purchase and demonstration programs on the time and level of penetration of the new technology. Mr. Wood has been active with a wide variety of energy research with special emphasis on energy demand in US industries and policy model evaluation. Dr. Gordon F. Bloom, in his continuing work with the food industry, is concerned with energy conservation in supermarkets where refrigeration accounts for substantial national consumption.

Also in the public sector considerable work is in progress on transportation management. Professor Thomas L. Magnanti has been investigating the use of large-scale optimization techniques in network problems, particularly rail freight management and urban traffic equilibria. Professor Barnett has studied control policies in transit systems. Professor John D. C. Little continued his work on traffic signal optimization.

In other public activities, Dr. Rockart has studied the planning and control aspects of health systems and, in particular, has been concerned with a methodology for planning management information systems in public organizations. In work that is attracting considerable attention, Professor Barnett has examined the statistical evidence for the deterrent effect of capital punishment and cautiously finds that there is some.
In the private sector a variety of work has been going on, especially in the areas of marketing, operations management, and planning and control. The marketing faculty are continuing their widely known work in marketing models and measurements. Professors Silk and Glen L. Urban have devised measurement techniques and supporting models to predict long-run market shares for new products prior to the expensive and often unreliable step of test marketing. In addition, Professor Urban has developed related techniques for new product design and positioning, and Professor Silk has been studying the validity of advertising copy-testing methods and their relationship to expenditures to create advertising copy. Professor Little has been investigating the marketing measurement capabilities of point-of-sale data collected automatically through the Universal Product Code system and its implications for a theory of price-setting in supermarkets.

An important and long neglected research area in marketing concerns industrial products, i.e., those sold to organizations rather than individuals. In the past few years the marketing faculty has initiated a significant research effort in this direction. Professor Lilien is in the final phase of a major study, the ADVISOR project, in which a group of cooperating companies has provided cross-sectional marketing data on a large sample of products. The study has shown how industrial marketing budgets relate to product and market characteristics. Professors Silk and Manohar Kalwani have initiated a project concerned with developing fundamental knowledge about organizational buying behavior. Exploratory work has been done on the design of a longitudinal panel study of industrial purchasing. The goal is to determine how preferences and attitudes change over time and what factors precipitate the changes. In addition Professor Urban has finished a pilot test of an industrial selling laboratory experiment and plans further development of the technique. Professor Urban is also Director of the Marketing Center, which has been established to coordinate research in the area and seek sponsorship for new fundamental work in marketing.

Although management science techniques have long been helpful to companies in designing and installing production planning systems, a number of difficulties plague applications. Particularly serious has been the compartmentalization of problems into small systems that really should be connected into large ones. At the same time, large complicated systems have often collapsed as the designers have moved on to other responsibilities. Professors Hax and Gabriel R. Bitran are engaged in a project on hierarchical production and distribution systems which seeks to tackle these issues. In this work, models for higher level strategic decisions set constraints for more local tactical decisions from which the latter feed back information to the former. Closely related is the work of Senior Lecturer Harlan C. Meal, who is concerned with relating aggregate inventory control to individual item decisions. In addition Professor Stephen C. Graves has been developing scheduling policies for a family of products on a single production facility. He also has been studying control and design decisions for automatic warehousing systems.

Professor Hax has further embarked on new research on strategic planning for diversified operations. This includes a program of methodological and empirical research in the field of mergers and conglomerates. In related work Professor Lorange is studying formal planning systems. His goal is to develop an approach to the design, implementation, and maintenance of effective corporate planning systems. He is currently completing an empirical study based on 50 US and multinational corporations, the results of which will appear in a forthcoming book. Dr. McInnes has conducted a study of computer-based modeling activities in the financial planning and planning and control functions of approximately 20 corporations. This is leading to a typology to describe what types of models are useful in what kinds of settings. In the accounting field Professor Michael F. van Breda has been studying the relationship of the accounting rate of return and the internal rate of return under differing asset lines and growth rates.
A major methodological thrust within the group is mathematical optimization. Many large-scale systems are potentially capable of improvement by these techniques. A surge of theoretical developments in recent years has not yet been well integrated into practice because of lack of adequate computational support and because of a few important stumbling blocks in the theory. Recent research by Management Science Group faculty has been directed at these issues. Professor Jeremy F. Shapiro has been supervising the development of a modular system of mathematical programming packages. He also has focused research effort on certain outstanding issues in integer and mixed integer programming. Professor Magnanti has been attacking problems in combinatorial theory and nondifferentiable optimization. Professor Bitran has completed an analysis of zero-one linear multiple objective programs including the development of a new algorithm. Professors Magnanti and Bitran also have completed related research on the structure of admissible points with respect to cone dominance.

An emerging concern among statisticians is the distortion of estimation and inference by "bad" data. This has given rise to the field of robust statistics. Professor Welsch has been developing robust nonlinear regression techniques and implementing them on easy-to-use computer systems. In addition he has focused on the most widely used multivariate technique, multiple linear regression, and has been developing new kinds of diagnostics for understanding the statistical properties of the results. This is part of a long-range concern for the reliability of econometric models.

Computer-based information systems consume large quantities of resources in the national economy and generate more than their share of concern and controversy. Stimulated in part by the stringent requirements of energy information systems that can be used for policy analysis, Professors Donovan and Madnick have been laying foundations for a computer system architecture that allows multi-user access to a single data base and affords access to multiple and potentially incompatible data base management systems. An important motivating concept is that of a decision support system to assist managers and policy makers. Professor Donovan in a cooperative effort involving the March of Dimes and Tufts University has developed a birth defects information system using these ideas. Professor Madnick is pursuing the notion of a composite information system.

In related work, Professor Chen has worked on a theory of data base design and on analytic models for use by a data processing manager to select the most cost-effective computer system configuration. Professor Meldman has been concerned about the interface between computers and law, both from the point of view of legal issues, such as privacy, and applications of computers within the legal system. Professor Toong is studying the impact of microprocessor technology on production and managerial processes.

An emerging topic of increasing interest is office automation. Today office mechanization technologies such as word processing and electronic mail are coming into widespread use but a more important step will be computer facilitation of office procedures. Professor Zisman is conducting research on methods of describing office procedures and representing them in computer programs. In particular he has worked with augmented petri nets and has demonstrated their applicability in specific real-world situations.

The importance of computers and computerized decision support systems is further reflected in the activities of the Center for Information Systems Research (C.I.S.R.), directed by Dr. Rockart. C.I.S.R. draws on industry funds for use in critical management issues involving computers and performs a key communication function between researchers at the School and potential industrial users of the research. As part of this effort, the Center has organized two highly successful seminars on current issues in information systems research during the past year. Dr. Rockart himself is engaged in a study of distributed computing power in large organizations. This has become an area of great interest as dropping hardware
costs have brought on a new generation of mini-computers and microprocessors with a great potential for improving management processes.

Finally, we are pleased to report that in June Professor Little was presented the Parlin Award by the American Marketing Association. This award goes annually to a person who has made an outstanding contribution to the science of marketing. In addition, Professor Little has been elected to the position of vice president/president-elect of the Operations Research Society of America.

System Dynamics

System dynamics research has concentrated on the National Model. The System Dynamics National Model is now operating with several production sectors, labor mobility between sectors, pricing and accounting, wage setting, a consumption sector, and money flow between sectors. The model has reached a stage where policy analysis is beginning.

Study of the 45- to 60-year long wave or Kondratieff cycle has continued. A peak in the long wave, as generated in the model, exhibits a decline in capital investment, rising unemployment, slowing of the increase in labor productivity, falling return on investment, and increasing severity of business cycle fluctuation. Such conditions as seen in the model behavior are similar to those occurring in the actual economy in the 1920s and at the present time.

With labor movement, wage change, and price setting, the National Model generates time series like those used from the actual economy for plotting Phillips curves relating wage change to unemployment. A study has been started on the trade-off between unemployment and inflation. By providing a "laboratory" within which to observe economic behavior, the National Model is beginning to identify misunderstanding in government policy that may be contributing to inflation.

Several institutions in the state of Michigan are participating in the National Model. The System Dynamics Group is conducting training sessions for developing research competence in system dynamics and in economic modeling at Michigan State University.

The system dynamics subject, Dynamics of Physical and Social Systems, has been selected as one of the first School-wide Electives in the School of Engineering.

Management of Technological Innovation

Teaching and research in this area focused on the problems of generating effective technological innovation. The efforts fall into aspects of R&D staffing, structure and strategy, and their integration in the corporation and/or government agency.

In regard to staffing of research and development organizations, Professors Allen and Ralph Katz are continuing their work on the performance of long duration R&D project groups, under funding from the Department of Defense. The essential question of this research concerns how R&D groups and projects maintain their effectiveness (if at all) over extended periods of time. In investigating this issue, they are focusing on several important aspects of R&D groups as a function of group age: supervisory behaviors and skills, various kinds of communication patterns, relative degrees of intragroup homogeneity or heterogeneity along a number of dimensions, perceptions of job and task characteristics, and the reactions of R&D professionals to their work environment. Particular attention is being given to the overall structure of the laboratories (i.e., matrix, project-oriented, or functionally oriented) and to the career and project movements of R&D staff members. Following completion of the
first phase of the study, funding by the Ballistic Missile Command System under the direction of the Army's Chief of Staff office has now been authorized for Phase II to pursue the study in approximately 10 large corporations.

Professor Roberts has extended his interests in critical performers in the innovation process, supervising a related study by Dr. Richard Rhoades, Sloan Fellow, Class of 1977, which was awarded the S.S.M. Thesis Prize. The research in five government labs revealed special sensitivity of perceived laboratory R&D effectiveness to the entrepreneurial and market gatekeeping functions.

In the area of structure, Professor von Hippel has continued to focus on the relationships between users and manufacturers of innovative industrial goods. During the past year he completed a four-year real-time study of the user role, funded by NSF, and was awarded a 20-month grant by NSF for further research. Professor von Hippel has shown previously that the locus of innovation most frequently resides in the user organization, rather than among the suppliers of scientific/analytic instruments and semiconductor and electronic subassembly production equipment. Professor von Hippel has been developing a theoretical framework for extending the implications of this research to industrial organization and governmental policy considerations, and is extending his sampling to other fields, such as plastics and computers. Professor von Hippel has also been studying with Professor Stan N. Finkelstein the linkages between users and innovators in the area of automated clinical laboratory technology. Their joint working paper, "Product Designs Which Encourage -- or Discourage -- Related Product Innovations by Users" opens an area of research never previously covered by empirical research.

Professor Allen's book, Managing the Flow of Technology, was published in August by the MIT Press, and is now in its second printing. This book reports on 10 years of research into the communication of technical ideas.

This work has recently been extended to the international level with Professor Allen's continuing research in the Republic of Ireland, which has been partially replicated by the M.I.T. Center for Policy Alternatives. Professor Allen is now working with the Center for Policy Alternatives to perform similar studies in Israel.

In regard to strategy, Professor Roberts continued his interests in corporate new venture organizations and in the formation of new enterprises. With Professor Finkelstein, and support from the Whitaker Health Sciences Fund, Professor Roberts will be looking at the determinants of academic medical innovations and their utilization. He also is reviewing the role of technical planning as part of overall corporate strategic planning and is assessing the several new methods that are aimed at integrating technical inputs into financial and marketing-based plans.

Professor Roberts began a collaborative study during the year with Professor Herbert Hollomon of the Center for Policy Alternatives. They are studying the incentives provided by the State of Israel to encourage industrial product innovation. As part of the research Professor Robert's methodology for studying new technology-based enterprises will be applied to Israeli firms. In addition a research proposal is now being prepared by Professor Roberts and Dr. James Utterback to update the 1960s data on new enterprise formation and growth in the Greater Boston area.

Professor Ralph Katz will also be devoting a small portion of his time on a project funded by General Motors at the Center for Policy Alternatives (with Professor Hollomon, Robert T. Lund, and Dr. Utterback). For the most part, the project encompasses a number of questions concerning automation. Among the critical issues are the reactions of employees to automation, pre-conditions for successful automation, and the transfer of automated technology.
Corporate Strategy, Policy, and Planning

The group research that was initiated about a year and a half ago on the economic performance of conglomerate firms has been concluded with a symposium which was held at the Sloan School on October 6 and 7, 1977. The proceedings of the symposium will appear as a Technical Report, including the contributions of Professors Edward M. Graham, Arnoldo C. Hax, Henry S. Marcus, Stewart C. Myers, Michael E. Porter (Harvard), Nicolas S. Majluf, Research Assistant, M.I.T., and industrialists Robert S. Ames, Senior Vice President-Operations, Textron, Inc., Nathaniel S. Howe, President, New Britain Machine Division, Litton Industrial Products, Inc., Phillip H. Smith, then Chief Executive Officer of Copperweld Corporation, and P. Takis Veliotis, President and General Manager, Quincy Shipbuilding Division, General Dynamics Corporation.

One of the issues researched for the above-mentioned symposium deals with the differences between administrative and market regulation. Professors Zannetos and Porter (Harvard) are continuing their work on the impact of conglomeration on the riskiness of the investments and R&D activities of diversified firms.

The various aspects of technology transfer, especially to developing and least developed countries, are the focus of research of both Professors Graham and Zannetos. Professor Graham is concerned with the causes of technological gaps and the contributions of science and technology to economic development, while Professor Zannetos is looking at the preconditions for technology transfer, and particularly at the role of infrastructure development.

Professor Graham also continues to investigate the economic impact of direct foreign investment.

Professor Zannetos continues his investigation in the areas of oil economics, oil transportation (with particular emphasis on the level and structure of spot and time-charter rates), and the determinants of organization structures and planning and control systems. In addition, he is attempting to determine the impact of government regulation and societal pressures on the objectives of the firm, and the degree of transience or permanence of these impacts. Finally, he is attempting to unify the three main theories of the firm -- the economic theory of rational action, the behavioral theory of bounded rationality, and the bureaucratic theory of organizations -- and explain the role of complexity in the transition from one mode or organizational behavior to another.

International Management

During the fall term Professor Richard D. Robinson completed the field work for his inquiry into the quality and relevance of international management education at the graduate level in the United States. A report of the project will appear as a Sloan School working paper before the end of the academic year. He also has undertaken to organize a research conference at Sloan in July to examine the validity of the methodology and reliability of the results of a 4-year, 10-country study of labor participation in management. Three of the principal researchers from Europe have been invited to present the results to a group of some 30 invited scholars from the US and Canada. The conference is being financed by the Ford Foundation and the German Marshall Fund of the United States. Professor Robinson has proposed a joint study to a group of Yugoslav scholars. The subject: the process of technological innovation in self-managed enterprises. Finally, he has begun to assemble information relative to international technology data banks. The first to be visited was that recently started by Technotec, an activity of Control Data. In June, he looked at those data banks maintained in Tokyo by Mitsui and Mitsubishi trading companies.
Professor Stephen J. Kobrin completed the first phase of an extended research project designed to investigate both the determinants of a host country's propensity to nationalize foreign enterprise and firm/industry factors which increase a given project's vulnerability. Data have been collected and coded on 1,350 cases over the years 1960-76 in 76 countries. An analysis of the data (e.g., relationships between sector and ownership structure) is currently in progress with a working paper expected in August. During 1978-79, the second phase of the study will involve investigating the environmental determinants of nationalization. During 1977-78 Professor Kobrin also completed background work for a study of the assessment and evaluation of political risk by US manufacturing firms. Interviewing is scheduled for the fall of 1978.

Professor Nyhart continued research on the economics and regulation of deep ocean mining. He leads a research team which completed three studies during the year. The first involved development of a cost model of deep ocean mining (summarized in M.I.T. "Reports on Research," March 5, 1978). The second was a study of political risk guarantees, and the third researched waste transportation and disposal. During the summer Professor Nyhart plans to complete two additional studies in the project: a study of financial arrangements in deep ocean mining and an investigation of the processing of deep ocean mining modules in foreign countries. Research briefing for industry representatives and government officials were held during the year. Two projects are currently in progress. The first, conducted under contract with the Department of Energy, involves recommendations for US policy for a legal regime for ocean thermal conversion. The second is a study of Federal regulation of offshore structure and uses.

Professor Lessard is continuing his research on financial mechanisms for stabilizing revenues of commodity producing LDCs. In addition, he has prepared studies on the impact of host country financial incentives and restrictions on foreign direct investment and on the role of world financial markets in the adjustment to higher oil prices. He is currently beginning research on normative models for the evaluation of foreign projects and strategic and tactical management of currency risk by international firms.

Health Care Management

During 1977-78 the Sloan School continued to build its multifaceted program in health care management, introduced new academic subjects in the area, increased the scope of related research and institutional relationships, and continued efforts to expand faculty and resources in this relatively new area.

The Sloan School extended its active collaboration with the Association of American Medical Colleges in an ongoing multi-phase program involving the development and presentation of management education programs for the AAMC's constituent medical schools. Professors Beckhard and Roberts, representing the applied behavioral sciences and the management sciences, respectively, exercised joint responsibility for design and leadership of these activities, with active involvement of Professor Schein, Dr. Rockart, and numerous faculty members recruited from other universities. Phase I has involved nearly every dean of the 130 North American medical schools in a one-week management program. Over 70 medical schools have already participated in the follow-up Phase II teams program which emphasizes problem solving of real issues identified by the medical schools, with more than a dozen medical schools returning for a second time to accelerate programs of managerial improvement initiated by the earlier phases. Additional sessions of this M.I.T. /AAMC program are scheduled for coming years, under the continuing sponsorship of the Robert Wood Johnson Foundation. Additional Phase I-type programs have now been developed and are being presented on a continuing basis to directors of teaching hospitals and to chairmen of academic departments of medicine.
In a related activity with the AAMC, Dr. Rockart continued a short course for the business and planning officers of the medical schools, attended by over 150 persons thus far, and has initiated an educational effort in financial management for academic medical centers. Sloan School faculty members also have been involved in presenting similar management education efforts to deans of pharmacy schools and chairmen of surgery, radiology, and pathology departments.

Professor Harris continued his research on the client orientation of health care organizations, in cooperation with Professor Norman S. Stearns and Dr. Robert Amick of the Boston Veterans Administration Hospital. These three collaborators are developing a post-hospitalization assessment of patient care. Dr. Stearns will focus on patient compliance with doctors' orders and Dr. Amick will concentrate on measuring after-the-fact the appropriateness of medical care. A research proposal is scheduled for completion during the coming summer to generate support for these studies.

Dr. Rockart advanced into the data analysis stage of his studies of "disease costing" in in-patient and out-patient settings. Doctoral research completed during the past year by Colin Lay, under Dr. Rockart's supervision, indicates wide variations in care costs for supposedly similar disease diagnoses. Dr. Rockart's latest research interest is on the possible role of distributed information processing systems to aid patient management in hospitals. He and Research Associate Christine Bullen received funding from the Veterans Administration for testing a methodology for information system structuring, and initiating research studies at the Boston VA Hospital. They plan to expand this methodology in the coming year in several collaborating hospitals in the Boston area.

In another area Professor Alvin Drake of the M.I.T. Operations Research Center is coauthoring a book-length manuscript on blood-banking management and policy, along with Professor Finkelstein, who was appointed Assistant Professor of Health Management during the past year, and Professor Harvey Sapolsky of the Department of Political Science. New efforts continued in the transfer of research approaches developed earlier in the area of management of technology to problems of health care technology. Professors Roberts and von Hippel began a collaboration with Professor Finkelstein to examine factors affecting the development and commercialization of health innovations. Initial study was completed of user-innovator interfaces in regard to clinical laboratory instrumentation, resulting in a Sloan School working paper, and a research design has been completed for examining entrepreneurial activities in the health care area. Professors Roberts and Finkelstein have secured a second year of research support from the Whitaker Health Sciences Fund for this new area of study. Professor Finkelstein's studies have led to initial research results that challenge the heretofore presumed relationship between technological change and health services demand. His research on the impact of advances in clinical laboratory technology is continuing.

Disease-occurrence modeling for management applications is another new area of research interest for which long-term support is currently being sought. The Veterans Administration has committed support for a summer 1978 pilot study of this topic. We hope, by fall 1978, to have begun a modeling study of age specific prevalence rates for over 100 diseases currently being observed among in-patients of the Veterans Administration health care system, with an eye toward projecting future resource utilization. Other patient care data bases will also be used in the planned studies. Professor Finkelstein has assumed the lead for this research area, with collaboration in the proposed methodology development by Professors Pindyck and Welsch.

Professor Roberts participated as a member of the "health" team for M.I.T. as part of a joint M.I.T.-French National Research Council research program on "Science and Decision Making." The team includes Professor Jeffrey Harris of the Department of Economics as well as Jean-Francois Lacronique, Sloan Fellow, Class of 1977, and is focusing upon the societal
problem of cigarette smoking. Professor Roberts is developing a system dynamics model of the growth and maintenance of the cigarette problem in the US, and of society's coping responses.

Major efforts have continued to move the health management area toward having a critical mass of program, faculty, and supporting resources. Much time was spent during the year to develop comprehensive plans for launching a major research and teaching center on health care management, and substantial funding is being sought in order to implement these plans. Two major steps toward this objective were achieved during 1977-78. The joint M.I.T.-Veterans Administration Center for Health Care Management, under direction of Professor Roberts, continued in its second year of development. Dr. Rockart's hospital MIS project became the first M.I.T. research effort to receive peer-reviewed support from this new VA affiliation.

Professors Finkelstein and Roberts also participated in a successful proposal by Brandeis, Boston University, and M.I.T. to fund a Health Policy Center supported by the HEW Health Care Financing Administration.

The health policy and management programs at M.I.T. are also going to be included in Institute-wide plans to launch broader efforts relating to health care. M.I.T. has announced the formation of the Whitaker College of Health Sciences, Technology, and Management, and Professor Roberts is chairing its Health Policy and Management area. A new joint biomedicine-management Ph.D. program is now under discussion for implementation as part of this major thrust by M.I.T. and a broad research and teaching program is being planned.

As noted earlier, the Health Management Executive Development Program experienced its third year of operation in conjunction with the Sloan Fellows Program. As part of this program Professor Stearns, Associate Dean of the Tufts Medical School, led in developing and implementing a year-long Seminar in Health Management, co-taught with Professors Harris and Roberts. This seminar brought to the Sloan School 20 leaders of medical schools and hospitals, government health agencies, and health-related corporations for comparative assessments of management style and effectiveness. The seminar will be continued next year. A new group of Health Management Executives has been admitted for the 1978-79 program year and further program development is under way.

STAFF CHANGES, PROMOTIONS, AND VISITORS

During the past year Dr. Richard L. Schmalensee joined the staff of the economics area of the Sloan School as an Associate Professor. Professor Schmalensee comes to us from the University of California at San Diego.

Benjamin C. Ball and Dr. James S. Hekimian joined the Sloan School staff as Adjunct Professors. Professor Ball is concentrating his efforts in the area of energy policy and Professor Hekimian is concerned with teaching and curriculum development for the planning and control area. Both individuals have had prior research and academic associations with the School.

Professor Glen L. Urban was promoted to the rank of full professor. Professor Gary L. Lilien was promoted to the rank of associate professor.

We were very pleased to have C. Roland Christensen join the corporate strategy and policy group of the Sloan School as a Visiting Professor. Professor Christensen is associated with the Harvard Business School. Professors Zvi Bodie and Allen J. Michel, both of Boston University School of Business Administration, joined the finance group as Visiting Assistant Professors.
Dr. Carliss Young Baldwin, a 1977 DBA recipient from the Harvard Graduate School of Business Administration, joined the finance group as an Assistant Professor. Dr. Gabriel R. Bitran was appointed an Assistant Professor and is working with the Management Science Group. Professor Bitran received his Ph.D. from the M.I.T. Operations Research Center in 1975. Stan N. Finkelstein, M.D., joined the staff of the health management group as an Assistant Professor. Dr. Finkelstein was a student participant in the Harvard-M.I.T. Program in Health Sciences and Technology, and received his M.D. from Harvard Medical School in 1975. Dr. Stephen C. Graves also joined the Management Science Group and will work in operations management and operations research. Following the receipt of his Ph.D. from the Graduate School of Management of the University of Rochester in 1977, Dr. Graves was appointed Assistant Professor in the Sloan School. Professor Harry C. Katz was appointed as an Assistant Professor in the Department of Economics and the Sloan School of Management. Professor Katz received his Ph.D. from the University of California at Berkeley with a concentration in labor economics. Dr. Gilbert W. Low received his Ph.D. in system dynamics from the Sloan School in 1977 and was appointed as an Assistant Professor. Professor Hoo-Min D. Toong was named to a joint appointment in the Department of Electrical Engineering and Computer Science and the Sloan School. Professor Toong received his Ph.D. from M.I.T. in 1974. He joins the Management Science Group and will continue his work in advanced information and control systems and microcomputers. Peter Senge, a Ph.D. recipient from the Sloan School, has joined the System Dynamics Group as an Assistant Professor. Dr. Michael D. Zisman was also appointed an Assistant Professor in the Management Science Group. Dr. Zisman is a 1977 Ph.D. recipient from the University of Pennsylvania, with a concentration in management information systems. Dr. Edwin C. Nevis joined the staff of the Organization Studies Group as a Senior Lecturer. Dr. Nevis is also associated with the Gestalt Institute of Cleveland. David O. Wood, Associate Director of the M.I.T. Energy Laboratory, was appointed a Senior Lecturer and works principally in energy policy research.

Pamela Walker Turner, Director of Recruitment and Placement and Manager of the Accelerated Master's Program, was appointed a Lecturer in Administration. Among her other duties, Ms. Turner organizes and presents a seminar in administration for the Master's Program candidates.

This year, Richard A. Morse retired from his position as Senior Lecturer with the Management of Innovation Group. Mr. Morse was also the President of the M.I.T. Development Foundation, Inc. We shall miss his contribution and good counsel.

We record with regret several departures from the Sloan School. Professor Roy E. Marsten joined the faculty of the University of Arizona. Professor Frederick L. A. Grauer left to join the faculty of Columbia University. Professor William A. Shaffer left to join the staff of Pugh-Roberts.

We record with sorrow the untimely death of our colleague Professor Dale Runge. Professor Runge was a member of the System Dynamics Group.

WILLIAM F. POUNDS
School of Science

The interests of individuals and of our society in science are based both on the excitement of new knowledge and on the usefulness of that knowledge in practical affairs. This year's annual reports from the departments of the School of Science indicate some areas in which recent advances have been made. Our faculty members, research staff, graduate students, and also undergraduate students, have made significant contributions to knowledge this year, and the excitement and substance of these research activities have enriched instruction and self-education. If we sometimes worry about the public opinion of science, we can take comfort in response to the January 1978 poll by Harris Associates, Inc., which listed 20 factors that have helped make America great. Persons interviewed were asked to indicate whether they thought each factor was major, minor, negligible, or they didn't know. The leading factors in the "major" category were:

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<th>Factor</th>
<th>Percent of Respondents</th>
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<tbody>
<tr>
<td>Rich natural resources</td>
<td>89%</td>
</tr>
<tr>
<td>Scientific research</td>
<td>89%</td>
</tr>
<tr>
<td>Hard-working people</td>
<td>87%</td>
</tr>
<tr>
<td>Industrial know-how</td>
<td>82%</td>
</tr>
<tr>
<td>Technological genius</td>
<td>75%</td>
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In another question respondents were asked to look ahead and indicate the factors that would be important in making America great in the next 25 years. The same five factors led the list, but scientific research was mentioned most often:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific research</td>
<td>91%</td>
</tr>
<tr>
<td>Industrial know-how</td>
<td>80%</td>
</tr>
<tr>
<td>Technological genius</td>
<td>78%</td>
</tr>
<tr>
<td>Rich natural resources</td>
<td>77%</td>
</tr>
<tr>
<td>Hard-working people</td>
<td>76%</td>
</tr>
</tbody>
</table>

These public expectations give scientists a lot to live up to and a challenge to make the scientific enterprise as productive as possible in both new knowledge and applications.
**Academic Programs**

This year there were 959 undergraduates enrolled in departments in the School of Science. This number may be compared with 1,033 the preceding year and 1,113 the year before that. This decline has been a concern to the departments in the School, and faculty members have discussed their undergraduate offerings and their interactions with undergraduates.

The graduate enrollment in the School of Science has continued to rise. This year it was 1,063 compared with 1,031 the preceding year and 1,012 the year before that.

The numbers of undergraduate majors and of graduate students, given above, give an indication of the size of the academic program of the School of Science; but, in view of the fact that students from many departments take science subjects, a better indication is the number of credit hours taught. In academic year 1978, a total of 270,609 credit hours were taught in the School of Science compared with 274,908 credit hours in academic year 1977. Since the total number of credit hours taught in the five Schools increased from 1977 to 1978, perhaps a better way of expressing the credit hours taught is to say that 33.0 percent of them were taught in the School of Science in 1978, compared with 33.6 percent in 1977.

Last year's Report of the President and the Chancellor discussed a series of issues concerning the subjects in calculus, physics, and chemistry/biology that are required of all students and are usually referred to as the freshman core science requirements. During this year the science departments and Science Council have discussed these issues, and there have been discussions with the Committee on Educational Policy and in the group of faculty members who taught the science requirement subjects this year. As a result of these discussions, some changes will be made in the subjects offered in 1978-79. These changes may be described very briefly as follows.

The Department of Mathematics will offer a third sequence, new this year, 18.012-18.022 Calculus with Theory. This subject, which will be taught by Professor James R. Munkres, is designed for freshmen who want and qualify for a more theoretical and rigorous treatment of calculus. The Department of Physics will make some changes in the basic sequence 8.01-8.02. In particular the first and second laws of thermodynamics will be added to 8.01. Physics 8.011 will not be offered in the fall, but 8.021 will be offered in the spring for students who do not expect to take more physics. During the past year the performance of several simple experiments has been made a regular part of freshman physics subjects. Since the amount of laboratory work will be increased to about one hour per week, the units for Physics I and II are being changed from 5-0-7 to 5-1-6. The Department of Chemistry is making changes in 5.40, which will be offered by Professor Mark S. Wrighton.

The Hewlett-Packard Company made a generous gift to the Department of Mathematics of one of their series 3000 computers, which will handle about a dozen terminals simultaneously. This computer will be used by students in solving problems in 18.03 Differential Equations and other more advanced mathematics and statistics subjects.

The Department of Nutrition and Food Science announced a new doctoral program in Human and Clinical Nutrition.

Course XXV introduced a new specified program in Science Communication leading to a Master's Degree in Interdisciplinary Science. This program will be offered for students interested in science writing for the print medium or in reporting and education through the audiovisual media of film, television, and radio. An internship at the graduate level is possible as part of both tracks in order to acquire practical experience in a specific area of training.
RESEARCH

The research volume in the departments in the School of Science in fiscal year 1978 is estimated to be $24,300,000, compared with $23,090,000 the preceding year. However, the research volume attributable to the School of Science is actually larger because of the participation of faculty from the School in interdepartmental laboratories. If the research volume in interdepartmental laboratories is allocated to the School of Science according to the percentage of the faculty from the School, the research volume is estimated to be $51,696,000 in fiscal year 1978, compared with $45,434,000 in fiscal year 1977.

Professor Herbert S. Bridge deserves special credit for having served the past two years as Acting Director of the George R. Wallace, Jr., Astrophysical Observatory and as Chairman of the Steering Committee for the Observatory, as well as Associate Director of the Center for Space Research.

Between this year and last year the emphasis on laboratory safety has shifted from recombinant DNA to toxic chemicals. The Federal Toxic Substances Control Act, which became effective January 1, 1977, has led to a number of notices in the Federal Register about increased regulation and about priorities for testing chemicals. The Occupational Safety and Health Administration has also put more chemicals under controls; in particular acetonitrile and benzene now need to be held below one part per million in both laboratories and working areas. In order to coordinate the activities of various Institute Safety Committees and to check on possible gaps between these committees, President Wiesner appointed an Institute Council on Environmental Health and Safety this year with the Dean of Science serving as Chairman. The various departments and laboratories have reviewed their arrangements for safety committees and have made certain changes in the interest of greater safety.

FACULTY

On October 1, 1977, Professor John Deutch was appointed by President Carter to be Director of Energy Research in the new Department of Energy. He requested and received a two-year leave of absence from his responsibilities as Head of the Department of Chemistry. Professor Deutch has had a distinguished record in research, teaching, and service at M.I.T. and recently served on the Frank Press Committee on M.I.T. Research Structure. Professor James L. Kinsey was appointed Acting Head of the Department of Chemistry on October 1, 1977, and became Head of the Department on January 1, 1978. Professor Kinsey came to M.I.T. as an Assistant Professor in 1962, was promoted to Associate Professor in 1967, and to Professor in 1974. His research interests have included studies of chemical kinetics aimed at determining the various kinds of intermolecular forces; most recently, his research efforts have focused on the use of laser-induced fluorescence and crossed molecular beams to study the reactions of three- or four-atom systems. He recently served as Chairman of the Committee on Academic Performance.

Professor Carl I. Wunsch, Cecil and Ida Green Professor of Physical Oceanography, was appointed Head of the Department of Earth and Planetary Sciences this spring. He had served as Acting Head of the Department since the spring of 1977, when Professor Press was appointed by President Carter to be Director of the Office of Science and Technology Policy and the President's Science Advisor. Professor Wunsch's research interests have included the study of internal waves, tides, mixing processes, and dynamics of mid-latitude and equatorial circulation. In 1975 he received the Texas Instruments Foundation Founders Award.
Professor Sanford A. Miller of the Department of Nutrition and Food Science has taken leave to be Director of the Bureau of Foods of the Federal Food and Drug Administration (FDA). He will serve as Principal Advisor to FDA Commissioner Donald Kennedy, in the development of FDA regulatory policy concerning foods and cosmetics, and will administer a bureau responsible for regulating much of the nation's food industry.

Five faculty members in the School of Science were elected to the National Academy of Sciences this spring: Professors Howard Green (Biology), Bertram Kostant (Mathematics), Daniel G. Quillen (Mathematics), George M. Whitesides (Chemistry), and Carl I. Wunsch (Earth and Planetary Sciences).

Three members of the School of Science were elected this year as Fellows of the American Academy of Arts and Sciences: Professors John M. Deutch, Roman W. Jackiw, and Peter A. Wolff.

Three members of the School of Science were named this spring to the Pontifical Academy of Sciences by Pope Paul VI. They are Dr. David Baltimore, American Cancer Society Professor of Microbiology; Dr. Alexander Rich, Sedgwick Professor of Biology; and Dr. H. Gobind Khorana, Alfred P. Sloan Professor of Biology and Chemistry. The 61-member Pontifical Academy was founded in 1603 and reorganized in 1936 to promote progress in the mathematical, physical, and natural sciences. Dr. Victor F. Weisskopf, Institute Professor Emeritus, is also a member of the Pontifical Academy.

Five members of the faculty were honored this year by the award of named professorships. Professor Boris Magasanik was designated Jacques Monod Professor of Microbiology. Professor Phillips W. Robbins was selected by the American Cancer Society as an American Cancer Society Research Professor of Biochemistry. Professor Ali Javan was named Francis Wright Davis Professor of Physics, Professor George M. Whitesides was named Arthur C. Cope Professor of Chemistry, and Professor Irving M. London was appointed the Grover M. Hermann Professor of Biology.

Professor Salvador E. Luria (Institute Professor), Professor George B. Thomas, Jr., (Mathematics), and Professor John B. Stanbury (Nutrition and Food Science) will become Emeritus Professors at the end of this year.

Professor Luria came to the Institute in 1958 as a Visiting Professor from the University of Illinois. He joined the Department of Biology as Professor in 1959. He became the Sedgwick Professor of Biology in 1964, and in 1974 he was made Institute Professor. In 1969 he became a Nobel Laureate. In 1974 he became the first Director of the new Center for Cancer Research, a post he will continue to hold.

Professor George B. Thomas, Jr., came to the Institute in 1940 as an Instructor. He is the author of a calculus textbook that has been a leader in its field for many years, and he has been a very popular teacher of mathematics.

Professor John B. Stanbury has been Professor of Endocrinology at M.I.T. since 1966. He was director of the Clinical Research Center from 1966 to 1969. He has been involved with expanding medical research at M.I.T. and taught endocrinology in the Division of Health Sciences and Technology.

During the year, departments in the School of Science have appointed several new faculty members with tenure: Professor George Lusztig (Mathematics) from Warwick University, England; Associate Professor Victor Kac (Mathematics) from Moscow University; Associate Professor Michèle Vergne (Mathematics) from Centre National de la Recherche Scientifique in France; Professor Satoru Masamune (Chemistry) from the University of Alberta, Canada; and Professor Ronald C. Davidson (Physics and Director of the Plasma Fusion Center) from the University of Maryland.
Professor Henry Stommel (Meteorology) transferred to the Woods Hole Oceanographic Institution. Fortunately we will continue to see him in connection with the Joint Doctoral Program in Oceanography.

ROBERT A. ALBERTY

Department of Biology

In the past year, 355 undergraduates were listed as majors in Life Sciences and 156 students received the degree of Bachelor of Science in Life Sciences. Between July 1, 1977 and June 30, 1978, 22 Ph.D.s and four S.M.s were awarded in the Department of Biology. Three Ph.D.s were awarded in Biological Oceanography under the Joint Program with the Woods Hole Oceanographic Institution. There were 110 graduate students in the Department in the past year. The entering graduate class for the fall of 1978 will number 28, of whom 10 have National Science Foundation (NSF) Fellowships. In addition, six new students will enter the Biological Oceanography Program and three of these students have been awarded NSF Fellowships. During the past academic year approximately half of our undergraduate Life Science majors participated either in undergraduate research projects in faculty research laboratories or in research-oriented Project Laboratories supervised by faculty members and other senior research personnel. Professor David Housman has been very effective as the coordinator of our Undergraduate Research Program. The annual John L. Asinari Awards for outstanding research by undergraduates in the Life Sciences were given to Jeremy Nathans from Baltimore, Maryland, a junior in the Department, and Tim Jones from Kansas City, Missouri, a senior in the Department.

RESEARCH

The research activities of the Department are described in some detail in an annual departmental publication entitled Research Summaries. The current edition is available at departmental headquarters. Although the most effective way to learn about the research activities of the Department is to consult this publication, it is probably useful here to summarize these activities briefly.

The Department has maintained its traditional interest and strength in the molecular biology of nucleic acids. Work in this area continues in the laboratories of Professors Gobind Khorana, Maurice Fox, Paul Schimmel, Malcolm Gefter, Alexander Rich, Uttam L. RajBhandary, and Phillip Sharp. The recent work of Professor Sharp on "gene-splicing" is of particular interest since it has made such an impact in the area of the mechanism of gene expression.

Microbiology continues to be a very active area of research in the Department. Professors Boris Magasanik, Ethan Signer, and Bonnie Tyler are investigating various aspects of the control of nitrogen assimilation in bacterial systems; Professor Annamaria Torriani is studying sporulation in bacteria; Professor Jonathan King's interests are in the area of the morphogenesis of the bacterial viruses T2 and P22; Professor David Botstein is continuing his work on gene expression and regulation in microorganisms; Professor Salvador Luria is investigating the effects of colicins on bacterial processes; and Professor Graham Walker's studies are concerned with the mechanism of chromosome repair in bacteria.
Developmental and cell biology is well represented in the Department through the efforts of Professors Housman, Mary Lou Pardue, Harvey Lodish, Charles Holt, Vernon Ingram, Howard Green, Sheldon Penman, Richard Hynes, Raymond Baker, Linda Hall, Eugene Bell, Frank Solomon, Robert Horvitz, and Alexander Varshavsky.

An important area of research, particularly in the Center for Cancer Research, continues to be the molecular biology of tumor viruses. This general subject is well represented by the work of Professors David Baltimore, Robert Weinberg, Nancy Hopkins, and Phillip Sharp.

Many members of the Department use genetics and genetic techniques in their research programs. This is particularly true for Professors Baker, Botstein, Fox, Hall, Holt, Tyler, and Robert Horvitz.

The biochemistry of transformed animal cells, with a particular emphasis on cell surfaces and cell membranes, is being studied in the laboratories of Professors Phillips W. Robbins, Richard Hynes, and Frank Solomon.

Enzymology, enzyme mechanisms, and biosynthesis are areas represented by the efforts of Professors John M. Buchanan, Christopher Walsh, and Gene Brown. Certain aspects of physical biochemistry of macromolecules are being investigated by Professors Rich, Schimmel, Varshavsky, Jonathan King, and David Waugh.

The field of neurobiology is represented by the interests of Professors Hall, Horvitz, and Jerome Lettvin.

One of the areas which we have strengthened considerably in the past few years is immunology. Professors Lisa Steiner, Herman Eisen, Paul Gottlieb, and Michael Bevan form the nucleus in this area, and recently Professors Baltimore and Gefter also have been developing interests in this subject.

**EDUCATIONAL ACTIVITIES**

No significant changes have been made in the undergraduate curriculum in the Department during the past year. The Department continues to feel that biochemistry and genetics are the two subjects that form the basis for a good understanding of the biological sciences. Advanced undergraduate subjects are then taken by students who have the advantage of having been introduced to the fundamentals of biology in biochemistry and genetics.

We continue to recognize the importance of introducing undergraduate students to research. The students are encouraged to take one of our research-oriented project laboratories or to become involved in research activities in the laboratories of faculty members.

In the past year we added a new seminar course on Cell Surfaces to our offerings for graduate students. This subject was taught by Professor Hynes and was well received by the 30 students who enrolled. We have organized a new subject in Cell Biology for entering graduate students to be given for the first time during the fall term of the 1978-79 academic year. This subject will be given by Professors Pardue and Lodish and is designed to introduce the fundamentals of cell biology to graduate students to prepare them for advanced subjects in this area.
In the past year we have added two new faculty members to our staff. Dr. Varshavsky was appointed as Assistant Professor in September 1977. Professor Varshavsky received the S.B. from Moscow State University in 1970, and in 1973 he received the Ph.D. from the Institute of Molecular Biology, USSR Academy of Science, Moscow. He continued his work at the Institute of Molecular Biology as a Junior Scientist until 1977 when he joined our Department. Professor Varshavsky's research interests are in the area of the structure and function of chromosomes.

Dr. Horvitz was appointed Assistant Professor effective January 1978. Professor Horvitz received the S.B. from M.I.T. in 1968 with a double major in mathematics and economics. He attended graduate school at Harvard University where he received the Ph.D. in molecular biology in 1973. Professor Horvitz was on a postdoctoral appointment at the Medical Research Council, Laboratory of Molecular Biology, in Cambridge, England, until January 1978. His research interests are in the developmental and behavioral genetics of soil nematodes.

In addition to these two new appointments, Dr. Robert Sauer will be joining the Department in September 1978, as Assistant Professor of Biochemistry. Dr. Sauer's research interests are in the area of protein chemistry.

Professor Luria reached retirement age during the year but he will continue, as Institute Professor Emeritus, to maintain an active research program and to participate in the teaching activities of the Department and as Director of the Center for Cancer Research. Professor Luria has been a valuable member of the Department for the past 19 years and it is gratifying to know that the Department and the Institute will continue to benefit from his services.

Professors Botstein and Walsh were promoted to full Professor effective July 1, 1978. Associate Professor Sharp was awarded tenure to become effective July 1, 1979. Assistant Professors Hynes and Housman were promoted to Associate Professors effective July 1, 1978.

Three faculty members were honored by receiving special professorships during the past year. Professor Boris Magasanik, who served as Head of the Department from 1967 until 1977, was named the Jacques Monod Professor of Microbiology; Professor Irving London was named the Grover M. Hermann Professor of Biology; and Professor Robbins was awarded an American Cancer Society Professorship of Biochemistry.

Professor Hall won an award from the McKnight Foundation which generously supports her research program in neurobiology, and Professor Walker competed successfully for an award from the Rita Allen Foundation. This award is given to support the research of outstanding young scientists in the area of cancer research.

Professor Schimmel is the recipient of the Pfizer Award in Enzyme Chemistry for 1978. This prize is given by the American Chemical Society to a scientist under the age of 40 who has done outstanding work in the field of enzymology. Professor Botstein received the 1978 Eli Lilly Award in Microbiology. This award is made to a scientist under the age of 40 for
outstanding research contributions to the field of microbiology or immunology. Professor Green was doubly honored in the past year. He was elected to the National Academy of Sciences and he was the recipient of the Selman Waksman Prize for outstanding contributions in the area of Cell Biology.

GENE M. BROWN

Department of Chemistry

Bachelor of Science degrees in chemistry this year were awarded to 55 undergraduates: five in February and 50 in June. Most of the graduates will be attending graduate school in chemistry, medicine, or related areas, or have been employed by industry. The degree of Master of Science was awarded to five candidates: three in September and two in June. A total of 32 Ph.D.s were awarded to 12 candidates in September, nine in February, and 11 in June. To date, 1,529 Ph.D.s and 373 Master's degrees have been awarded by the Department.

RESEARCH

A vigorous research program encompassing many areas within chemistry and related disciplines continues in the Department. A few representative research activities which are in progress in the Department of Chemistry are described below.

Research in Professor George Büchi's laboratory on the synthesis of natural products is being pursued along several lines. In the past year Professor Büchi and his associates have developed biomimetic syntheses of neolignans, a group of secondary plant metabolites structurally characterized by the presence of two arylpropanoid units. Novel cycloadditions of properly substituted p-quinone ketals to either cis- or trans-isosafrole give, depending on conditions and acid catalysts used, either bicyclo[1,2,3]octane, hydrobenzofuran, or spiro[5,5]undecane type neolignans. The naturally occurring neolignans guianin, burchellin, and futoenone were prepared in a stereospecific manner by such cycloadditions, and it seems likely that Nature uses the same principle to elaborate these metabolites.

Interest in non-toxic, naturally occurring pigments with potential use in the beverage, food, and cosmetic industries has led to a study of the synthesis of the betalains. Contrary to the carotenoids, these red-violet and yellow pigments are water soluble. Total syntheses of betanidin, the red pigment of the beet and of indicaxanthin responsible for the yellow color of cacti have been completed. Neither is practicable as of now, and both need to be shortened.

Within the past decade it has become apparent that the majority of human cancers are caused by environmental contaminants. Some of these toxic agents are the result of modern technology, but others are natural metabolites of bacterial, viral, and fungal growth. Work on substances in the latter category has been performed in collaboration with Professors Gerald N. Wogan and Arnold L. Demain of the Department of Nutrition and Food Science. Continuing their work on food-borne mycotoxins, this group is now studying the mode of action of the aflatoxins, a group of mold metabolites known to be exceedingly carcinogenic in many animal species and suspected of being responsible for the high incidence of human liver cancer in tropical regions. Chemical carcinogens seem to interact with cellular
macromolecules and cause qualitative changes in the informational DNA and RNA molecules. Such lesions could alter gene expression and cause neoplastic transformation. Aflatoxin B₁ binds covalently to DNA in vivo and in vitro after metabolic activation. Indirect evidence has suggested the formation of an epoxide as an activated metabolite responsible for binding to nucleic acids, but the structures of such adducts have not been determined.

It has now been shown how aflatoxin B₁ activated metabolically in vitro binds to DNA. Approximately 90 percent of the binding is between aflatoxin B₁ epoxide and guanine residues in DNA. The adduct liberated by formic acid catalyzed hydrolysis was demonstrated to be 2,3-dihydro-2-(N⁷-guanyl)-3-hydroxy aflatoxin B₁, by a comparison of its spectral properties with those of a model compound and by chemical synthesis.

The research of Professor John S. Waugh's group for the past 10 years has been largely devoted to the physics of systems of nuclear spins and the applications to experimental chemistry, biology, and engineering which an understanding of this subject makes possible. The most conspicuous result has been the development of a family of techniques by which the resolving power of nuclear magnetic resonance (NMR) in solids can be improved by several orders of magnitude. In this way it is possible to uncover fine structure similar to that which is familiar and widely exploited in the liquid state. The most recent experiments in Professor Waugh's laboratory involve a combination of various radio frequency perturbations with a physical rotation of the solid specimen about an axis making the "magic angle" 54.7° with the external magnetic field. In this way one recovers not only a highly resolved spectrum similar to that obtained in liquids, but also accurate information concerning the direction dependences of spin interactions which is lost in liquids and which illuminates the geometric and electronic structure of molecules. In addition, these experiments have led to a promising new technique for the direct study of ultra-slow molecular motions with characteristic times as long as one second.

The research interests of Professor John Ross are in the area of dynamics of chemical reactions, reaction rates, and instability phenomena in complex reaction mechanisms. He is studying the kinetics of first order phase transitions such as the transition from vapor to liquid or from solution to solid, that is colloidal or crystalline growth. The kinetics proceeds by a mechanism with autocatalysis, due to the fact that small crystalline particles are less stable than larger ones; the kinetics of this growth process coupled with diffusion leads to the formation of macroscopic spatial structures. He has confirmed these predictions with experiments and this research has led to a new interpretation of periodic processes such as Liesegang rings. The onset of the formation of macroscopic spatial structures is predicted to be accompanied by an increase in fluctuations, analogous to critical opalescence, and he is studying these processes experimentally and theoretically.

Reactions of photo-excited species have been studied for a long time; however, the availability of intense light sources provided by lasers permits the study of a much larger class of reactions. Professor Ross has investigated the reactions of photo-excited NO₂ with itself and a number of other chemical compounds. Photo-excited NO₂ is an effective oxidizing agent as for instance in the reaction with cyclopropane to form NO, ethylene, and formaldehyde. The purpose of this study is to determine the dynamics and mechanisms of such reactions as well as the possible variation of types of products obtained with frequency of excitation.

Another area of research interest is concerned with issues of efficiency of rate processes. A reversible heat engine, such as run in a Carnot cycle, is one of maximum efficiency in regard to the second law of limitation of the conversion of heat to work. However, since the engine must be run reversibly in order to obtain this maximum efficiency, the power output of the engine is zero. It is important to inquire about the efficiency of engines, or chemical reactions, for processes run at non-zero rates. In such cases there will, of course, be an entropy production which reduces the work of the engine but the engine produces a non-zero.
power output. Professor Ross's research has led to the formulation of upper limits of efficiency, and efficiency at maximum power output, for engines operated with simple rate processes; the work is continuing on the study of the efficiency of chemical reaction rates.

Almost all controlled chemical changes which occur in living organisms are effected by enzymes, proteins with specific catalytic activities. To understand what patterns of chemical reactions occur as normal or abnormal components of metabolism, one must understand the nature and scope of enzymatic catalysis. Professor Christopher Walsh studies enzymatic reaction mechanisms both from a kinetic and chemical point of view. He is particularly interested in the molecular action of antimetabolites and in the rational design of new drugs and therapeutic agents based on knowledge of the specific enzyme targets in cells.

For some years Professor Walsh's group has been investigating several enzymes which use the coenzyme forms of vitamin B₂, riboflavin, as cofactors required in oxidative metabolism. The heterocyclic ring system can serve as a temporary storage bin for electrons removed from reduced organic substrates during enzymatic oxidations. The reduced riboflavin derivatives can subsequently give up electrons to various acceptors, such as O₂, one at a time or two at a time to regenerate on oxidized cofactor ready for another catalytic cycle. Thus flavin coenzymes sit at the crossroads of two-electron and one-electron transfer pathways in cellular energy metabolism, occupying this key role because the semiquinone radical is sufficiently stable chemically to be a biologically accessible intermediate. The second key feature of these coenzymes is that flavins, in serving as rapid, low energy conduits for transfer of electrons to O₂ in metabolism, enable reductive metabolism of oxygen, a highly useful and thermodynamically favorable set of chemical reactions in cells.

The biological utility of flavin analogues, particularly 5-carba(5-deaza) and 1-carba(1-deaza) riboflavins derivatives, has been studied as well. The 5-deaza analogue is chemically restricted to two-electron transfer only (nitrogen at position 5 is required to stabilize the radical form) and is inert in reaction with molecular oxygen. It is a powerful riboflavin antagonist against parasitic worms which infest chickens. The 1-deazaflavins are kinetically competent for both one-electron and two-electron enzyme chemistry but are thermodynamically more difficult to reduce than the normal cofactor. Thus in any flavin-linked enzyme where oxidations and reductions are rate-limiting in catalysis, reconstitution with 1-deazaflavins may selectively lower rates by about 100-fold. The ability of 1-deazaflavin-enzymes to carry out oxygen insertion reactions on aromatic rings of substrates, an ecologically important and little understood reaction, is currently under examination.

Another theme in Professor Walsh's laboratory has been the design and testing of analogues of physiological metabolites, analogues which incorporate latently reactive functional groups. These analogues are termed mechanism-based enzyme inactivators or suicide substrates because they are designed to inactivate a target enzyme in vivo by a specific irreversible covalent modification. The premise is that the enzyme will mistake the analogue for a substrate, initiate chemical catalysis on it in the normal fashion, and thereby chemically uncover a reactive electrophile which now alkylates or acylates a neighboring nucleophile on the protein. These reagents promise great specificity: they are activated only by the target enzyme which unmasks the latent group only in the precise local microenvironment of its own active site. Since the group should be activable only by a certain type of chemical reaction, only the intended enzyme should be induced to commit suicide.

Three natural products appear to act as toxins because of such mechanisms. Propargylglycine, a natural antibacterial agent produced by streptomyces strains, inactivates a vitamin B₆-dependent enzyme, cystathionine-γ-synthase, involved in bacterial biosynthesis of the amino acid methionine.

Vinylglycine is found in mushrooms reportedly as both D- and L-forms. On enzymatic oxidation by a bacterial D-amino acid transaminase the isolated olefin becomes a conjugated
Ketimine which alkylates the enzyme. Since this enzyme may be involved in supplying D-amino acids for bacterial cell wall formation and has no animal cell counterpart, it is a likely target for antibiotics.

The third naturally elaborated amino acid, o-carbamyl-D-serine, has recently been found to be a suicide substrate for E. coli alanine racemase, again a key enzyme in provision of D-alanine for bacterial cell walls but an enzyme completely absent in higher organisms.

Illumination of an n-type semiconductor as an electrode in an electrochemical cell results in the non-spontaneous flow of electric current in the external circuit. This photovoltaic-like effect can, in principle, be exploited to convert sunlight to electrical and stored chemical energy. In practice, n-type semiconductor surfaces degrade under illumination in the electrolyte solution, and this surface photocorrosion reaction is regarded as one major problem in the practical deployment of semiconductor/liquid junction solar cells. The research group of Professor Mark Wrighton has been engaged in a fundamental research effort to stabilize n-type semiconductors to the photocorrosion reaction in order to develop their use in energy conversion and electrosynthesis applications.

Early in 1976, they reported on the suppression of the photocorrosion problem associated with n-type CdSe and CdS. The stabilization technique involves the addition of electroactive substances to the aqueous electrolyte solution such that the oxidation of the additive occurs at a rate which is significantly faster than the electrochemical corrosion reaction of the photoelectrode surface. Photoexcitation of the electrode thus yields one of two possible reactions: 1) oxidation (corrosion) of the electrode surface or 2) interfacial oxidation of the dissolved additive (reductant). The objective is to completely efficiently oxidize the reductant while excluding the corrosion of photoelectrode. The original discovery led to the ability to stabilize n-type CdX (S, Se, Te); GaP, GaAs, and InP with at least one of the ionic additives X²⁻=S²⁻, Se²⁻, or Te²⁻. Semiconductor/liquid junction cells employing such additives have been shown to sustain the conversion of sunlight to electricity with > 5 percent efficiency.

Stabilization of an n-type semiconductor to photocorrosion by adding reductants to the electrolyte solution has been somewhat successful, but the success hinges on the choice of reductants. While some criteria to choose the reductant have been elucidated, the final selections must be made on the basis of experimental trials. Additionally, once a suitable reductant is found for a given electrode, the stabilization technique inherently precludes any other interfacial oxidation chemistry. The approach of simply adding specific reductants to the electrolyte solution does work, but the approach is not a general one.

Desiring photoelectrodes that are capable of effecting a large number of different oxidation reactions, Professor Wrighton and his co-workers embarked on a research effort to derivatize electrode surfaces with reductants, A, in order to passivate them with respect to corrosion. The ideal sequence of events would be light absorption in the semiconductor followed by oxidation of the surface-attached species A, A→A⁺, and then A⁺ oxidizes a solution species, say B, regenerating A on the surface. The aim is to take advantage of the light absorption and charge separating properties of the semiconductor, while exploiting the chemistry of the A/A⁺ system. With such an electrode one should be able to photochemically oxidize any B that is oxidizable with A⁺. This technique is clearly a broad approach aimed at being able to drive a large number of reactions photochemically.

Recent proof-of-concept experiments have been completed which show that a derivatized electrode can be used to effect interfacial photochemical oxidations under conditions where the "naked" electrode is incapable of doing so. Further, the findings indicate that derivatized electrodes will not necessarily result in losses in efficiency in energy conversion applications.

As a model system, n-type Si has been actively studied. Its photocorrosion reaction is oxidation of the surface to form an insulating oxide, Si→SiOx. Presumably, the source of
oxygen is $H_2O$ which is unavoidably present even in the non-aqueous electrolyte solutions used in our work. It has been discovered that a hydrolytically unstable ferrocene derivative will react with an appropriately pretreated Si surface to yield a derivatized surface which is durable; the anchored ferrocene can be photooxidized by illumination of the surface with wavelengths which excite electron-hole pairs in the n-type Si. Direct comparison of the naked Si and the derivatized Si in photoelectrochemical cells shows that the formation of $SiO_x$ on the naked electrode is so severe in the presence of $H_2O$ that the oxidation of solution species cannot be sustained, whereas the "dressed" electrode shows sustained oxidation of a solution species. In some cases the dressed electrodes have even been used in pure $H_2O$ electrolyte solutions. Oxidations which are simply not observable at naked surfaces are doable with the photogenerated molecular oxidants attached to the surface.

Electroanalytical experiments have given direct evidence for the mediation of electron transfer by the surface-bound $A/A^+$ system. That is, light creates electron-hole pairs in the semiconductor; $A$ is oxidized to $A^+$; and $A^+$ oxidizes the solution species $B$. This is the first direct proof of mediated electron transfer at any derivatized electrode surface. Importantly, this establishes the potential of being able to design lock-and-key interactions between $A/A^+$ and $B$ which would allow the specific oxidation of $B$ even in the presence of other oxidizable substrates! Professor Wrighton's research group is now attempting to establish criteria for a dress code so that the electrodes can be properly attired to match their end use.

The general theme of Professor Edward Solomon's research program in physical-inorganic chemistry is the application of spectroscopic techniques to problems of inorganic structure and bonding. Emphasis is placed both on the detailed study of chemically relevant excited states and in the determination of active sites in metalloproteins and heterogeneous catalysts. The general goals are to elucidate unique geometric and electronic structures and to correlate changes in structure with variations in function.

The strongest effort has been devoted toward the application of physical methods to problems in bioinorganic chemistry. In particular, a number of important proteins and enzymes contain a binuclear copper active site that interacts with $O_2$ as part of its biological function: the hemocyanins bind oxygen, the tyrosinases are mono-oxygenases and the laccases and ceruloplasmin (found in human blood plasma) are oxidases which catalyze the four-electron reduction of $O_2$ to water. Prior to these studies, little had been determined about the binuclear copper unit in any of these proteins due to the unique electronic structure properties exhibited by these active sites as compared to all known simple copper complexes, and the further complications associated with the presence of more than one metal center. This problem has been approached by preparing a variety of new derivatives which are well defined and can be chemically varied in a reasonably controlled way to provide perturbations for a variety of physical techniques. The techniques which have been emphasized include ground state magnetic methods (electron paramagnetic resonance and temperature dependent magnetic susceptibility), excited state spectroscopy (linearly polarized and low temperature absorption, circular dichroism, magnetic circular dichroism) and vibrational spectroscopy (resonance Raman, infrared). Thus far this research (which has emphasized hemocyanin and tyrosinase) has provided insight into the nature of each copper site, the interaction of the active site with the small molecule, the interaction between the two coppers, the variation in structure among the active sites, and the nature of their unique electronic structure properties.

Detailed studies of excited states in simpler, more symmetric transition metal systems have involved high resolution low temperature polarized single crystal spectroscopy, as well as the application of the more unconventional methods of magnetic circular dichroism, resonance Raman, and other tunable laser spectroscopic techniques. Three particular areas are presently of interest:
1) Spectroscopic studies on photochemically active transition metal excited states. This has involved the synthesis of a new class of transition metal molecular crystals which allowed the experimental determination of the geometries, Jahn-Teller effects, and interactions between potential surfaces of excited states involved in the photochemistry of octahedral complexes.

2) Excited states of binuclear complexes. In the limit of weak interaction between metals new transitions become allowed where one photon can excite two centers. When strong interactions become possible, metal-metal bonds form, resulting in unique structures which are being elucidated through detailed spectroscopic study.

3) Spectroscopic studies on organometallic compounds. The electronic spectra of even the simplest organometallic molecules are not well understood. Detailed spectroscopic studies are required for a definitive assignment of their optical spectra and a general understanding of the bonding and reactivity of these molecules.

In collaboration with the Electronic Materials Group at Lincoln Laboratory, Professor Solomon has also been interested in the related problems of active sites in heterogeneous catalysis. Here, primary emphasis is placed on the interaction of a number of chemically relevant small molecules with zinc oxide (the methanol catalyst), chromium oxide (specific dehydrogenation) and aluminum oxide (dehydration) single crystal surfaces and catalytic powders. To elucidate the nature of the small molecule-surface interactions, this group is utilizing surface-sensitive electron spectroscopic methods (UV photoelectron, ESCA, Auger, LEED), combined with controlled chemical perturbations. These studies to date have demonstrated that there are very specific surface geometric requirements for CO chemisorption and H₂O and NH₃ poisoning on ZnO, with large differences in reactivity between the different crystal faces. Through these studies, Professor Solomon and his co-workers hope to elucidate the nature of the surface geometric and electronic structural requirements for chemisorption on these materials, and thus to gain insight into the fundamental processes of oxide catalysis.

PERSONNEL

Professor John M. Deutch, Head of the Department of Chemistry since July 1, 1976, is on leave of absence from October 1, 1977 to September 30, 1979, to be Director of Energy Research in the Department of Energy in Washington, DC.

Professor James L. Kinsey, a physical chemist and member of the M.I.T. faculty since 1962, has been appointed Head of the Department for the duration of Dr. Deutch's absence.

Professor Walsh will be promoted to the rank of Full Professor in the fall of 1978. Professor Robert W. Field will be promoted to Associate Professor. Professor Richard R. Schrock will be promoted to Associate Professor.

Dr. Satoru Masamune will join the staff as Professor in Organic Chemistry in the fall.
Dr. Gregory A. Petsko will join the staff as Associate Professor in Biochemistry.
Dr. Mary F. Roberts will join the staff as Assistant Professor in Biochemistry.
Dr. William R. Roush will join the staff as Assistant Professor in Organic Chemistry.
Professor Jack E. Baldwin was elected a fellow of the Royal Society of London. Professor Deutch was elected a fellow of the American Academy of Arts and Sciences and was awarded an honorary Doctor of Science degree by Amherst College.

Professor H. Gobind Khorana was appointed by Pope Paul VI to the Pontifical Academy of Sciences and was elected a foreign member of the Royal Society of London. Professor George M. Whitesides has been appointed Arthur Clay Cope Professor. The chair is named in honor of the late Dr. Arthur C. Cope, Professor and Head of the Department of Chemistry. Dr. Whitesides has also been elected a member of the National Academy of Sciences.

Professor John W. Irvine, Jr., was on sabbatical leave from January 15, 1978 to May 30, 1978.

Professor James L. Gole left the Department to accept a position at Georgia Institute of Technology. Professor Carol D. Meyer will leave the Department to accept a position at Northeastern University.

Visiting faculty and scientists were as follows: Noam Agmon and Yoram Alhassid, Hebrew University, Jerusalem, Israel; Didier Astruc, Université de Rennes, France; James C. Baird, Brown University; Pierre Bourget, Laval University, Canada; Derek R. Boyd, Queen's University, Belfast, Ireland; John H. Brophy, University of Leeds, England; Itamar Burak, Tel Aviv University, Israel; Gregory M. Dobbs, Princeton University; Moshe Gitterman, University, Sverdlovsk, USSR; E. David Green, M.I.T.; William D. Honnick, State University of New York; Michael A. Johnston, College of Holy Cross; Edgar F. Kiefer, University of Hawaii; Marianne J. Moore, Pharmacy University, Paris, France; Raphael D. Levine, Hebrew University; Louis Nadjo, University of Paris, France; Arnet L. Powell, US Office of Naval Research; Vernon N. Reinhold, University of Vermont; Vladislav Ivanovich Shcherbakov, Institute of Chemistry of the Academy of Sciences of the USSR, Gorky, USSR; Miriam Sohn, Princeton University; Peter J. Stang, University of Utah; Bruce J. West, University of Rochester.

The Department was privileged to sponsor a series of lectures provided by the Arthur D. Little and T.Y. Shen Professorships. Arthur D. Little Visiting Professor Raphael D. Levine of Hebrew University lectured on the following topics: "Structure-Reactivity Correlations," "A Thermodynamic-Like Framework," "Energy-Reactivity Correlations." Dr. Roger Guillemin of the Salk Institute, San Diego, was the T.Y. Shen Visiting Professor. His lecture was "Biochemical and Physiological Studies on the Endorphins."

JAMES L. KINSEY

Department of Earth and Planetary Sciences

During 1977-78, the Department had 89 graduate students enrolled in Course XII, and 37 enrolled in Course XII-W, which is the joint program in oceanography with the Woods Hole Oceanographic Institution (W.H.O.I.). The undergraduate population was 64 with a larger than normal number in the class of 1978. We conferred 27 B.S., five M.S., six Ph.D.s, plus four Ph.D.s jointly with W.H.O.I. Of the graduate students, 75 percent of those enrolled in the Department were supported either with assistantships or fellowships. All joint program students were fully supported. Seventy-two undergraduate students were on the payroll this year.
Honors and Awards

Professor John Edmond received the James Macelwane Award from the American Geophysical Union. This award, for the outstanding young geophysicist in the world, has been received by members of the Department three times in the past seven years. An Alfred P. Sloan Research Fellowship was awarded to Professor Sean Solomon for 1977-79. Professor William F. Brace was the recipient of the Rock Mechanics Award in 1978 for the best basic science paper in that subject. Professor Carl Wunsch, the Department Head, was elected to the National Academy of Sciences. Professor Tanya Atwater received the unusual honor of being asked to give the keynote address in Spanish of the very first Iberian-Latin American Geophysical Union Congress in Caracas in November.

Curriculum

The past year was a quiet one for curriculum changes in our Department, evidently in anticipation of some major changes to take place in the near future. A new series of mini-courses was introduced by John Southard in the area of sedimentary processes. The courses were very well attended. Our Crosby Visiting Professor, Hugh Davies, taught a graduate level course in mineral deposits in which he discussed the problems of location and ore extraction, and the genesis of ore and petroleum deposits. Because the Crosby Professors are chosen especially for their expertise in these areas the course was well received by both the undergraduate and the graduate students who took it.

RESEARCH

The Department of Earth and Planetary Sciences covers diverse fields in the study of the earth and planets. Many of these fields are highly overlapping and interactive. But for purposes of this report I will divide the Department's research work over the past year into a number of broad areas.

Planetary Science

Professor Irwin Shapiro and his colleagues have discovered that the spin vector of the planet Venus is not controlled by the earth as had been thought. Its 243-day retrograde spin period deviates enough from the theoretical value that they have been able to rule out control by the earth. Furthermore, they found that the spin vector is aligned with the angular momentum vector of the solar system rather than normal to the orbital plane. This suggests the possibility that an accurate determination of the spin vector will determine the unknown mass of the planet Pluto because the solar system angular momentum is strongly affected by Pluto due to the high inclination of its orbital plane. In other work Professor Shapiro has been able to very greatly reduce the scatter in very long base line interferometry (VLBI) systems. Scatter is now three centimeters on a baseline of 3900 kilometers between Massachusetts and California. With a deployment next year of the full Mark III VLBI, the group will begin to monitor movements of the earth's crust. Professor Gordon Pettingill's research group has been continuing its ground-based radar observations of the planets. They obtained the first detection of radar echoes from the asteroid Ceres and the measurement and polarization of radar echoes from the rings of Saturn and the Galilean satellites of Jupiter, which evidently possess unanticipated physical properties. The chemistry of the accretion histories of the terrestrial planets is being studied by Professor John Lewis's group who have worked out a very efficient scheme of calculation. They can place limits on the amount of mixing of pre-planetary material which attended the accretion.
Seismology and Geophysics

Professor Keiiti Aki and his colleagues have made a breakthrough in calculating seismic motion from a propagating rupture in a layered medium. Synthetic records for realistic layer parameters and rupture models give excellent agreement with those observed for actual earthquakes. Their method will be very useful for prediction of earthquake strong motion. Data from the northeast seismic network which covers New England (its center at the George R. Wallace, Jr. Geophysical Observatory) is being used to study the seismicity of New England. Professor M. Nafi Toksöz and his group have been using the array to study crust and mantle structure under New England. For the first time they have been able to determine the three-dimensional structure of the area. Crust and mantle properties reflect the geologic history of the region dating back hundreds of millions of years. Professor Peter Molnar has been continuing his studies with Paul Tapponnier of the large-scale tectonics of Asia, including Tibet, Mongolia, and the Baikal region. They have found that Tibet seems to be deforming by east-west extension in spite of the northward motion of India towards it. India seems responsible for earthquakes and tectonic activity 3000 kilometers north of it as it transmits the pressure which has given rise to the Tibetan high. Professor Solomon has been working on the tectonic and volcanic history of the terrestrial planets. On the moon he has demonstrated a correlation between surface elevation and bulk density calculated from the surface chemistry of the lunar highlands. He suggests that there must be a Pratt type compensation mechanism as the dominant contributor to lunar isostasy which acted early in the moon's history.

Rock Mechanics

Professor Gene Simmons and his group have been continuing their development of methods for characterizing microcracks in rocks. They have developed a new technique to measure crack volume, orientation, and pressures at which individual sets of cracks close. Professor William F. Brace managed to measure accurately for the first time thermal expansion of rocks under pressure. Measured values were found to be in close agreement with theoretical calculations of Dr. Joseph Walsh, working from single crystal properties. Walsh is now examining transport properties of a new model in which cracks are assumed to be rough surfaces in contact. This is part of a general study of the properties of porous rocks which characterize the first few tens of kilometers of the earth.

Geology and Geochemistry

Professor Roger Burns and Virginia M. Burns, using scanner electron microscopy, found that nickel and copper become concentrated inside seafloor manganese nodules as a result of recrystallization of biogenic silica and amorphous manganese oxides after deposition takes place. The work was filmed for the BBC "Horizon" scientific documentary program. They also have begun a three-year mineral exposure experiment on the seafloor of the equatorial Pacific aimed at measuring the rate at which metals are moved into synthetic manganese nodules.

Professor John Dickey and his students completed a geological map of the ronda ultramafic complex in southern Spain. This map incorporates the results of a 10-year field study and will be the most complete description extant of a high temperature peridotite intrusion now in existence. Professor Clark Burchfiel, along with his colleagues, has been continuing his research on the structural evolution of the Cordilleran mountain system. They have developed a new, testable, synthesis for the structural evolution of the southern part of this mountain system. Future work will be aimed at testing the synthetic scheme. Their hope is that the method will provide insight into Cordilleran tectonics and also into other types of mountain belts as well.
Professor Frederick Frey, working with Icelandic and M.I.T. colleagues, has been studying a small region of the Reykjanes peninsula in Iceland. They have discovered basalts whose range of chemical compositions is normally to be found over a much wider area. These variations will provide information on the extent and geographical distribution of compositional heterogeneities in the earth's mantle. The results are particularly surprising because of the previously assumed uniform nature of Icelandic volcanism.

Professor Stanley Hart and his students have been studying the major chemical effects related to circulation of ocean water through oceanic crust and have found that these effects take place within 10 million years after crustal formation. In collaboration with Professor Frey on the Icelandic basalts, Professor Hart has found that the mantle source must have undergone mixing or establishment of heterogeneous chemical characteristics within the last 250 million years.

Oceanography

Professor John Sclater and members of his group participated in five deep sea cruises in the past year, including two in Antarctic waters, one in the equatorial Pacific, and two in the North Atlantic. Aside from this observational work, he has been continuing his collaboration with colleagues on demonstrating and explaining the remarkable correlation between heat flow and the age of the oceanic crust. Professor Atwater has been preparing for the operation of a major expedition under her direction to work with submersibles and ships on the mid-Atlantic ridge region in the so-called Famous area. They will be using techniques of paleomagnetism, geochemistry, and geophysics to study the fine details of the ridge. This work is part of a continuing study which also includes detailed work on the Galapagos hydrothermal cell area in the eastern Pacific Ocean. Professor Edward Boyle has been studying titanium-aluminum ratios in sediments which he has demonstrated to be governed by the dynamics of wind-blown material from the continents. He has found that the ratio has undergone significant changes during glacial-interglacial climatic transitions in the past 130,000 years. The work will provide a method for studying previous climatic states in some detail. Professor Wunsch and his group have been continuing their application of inverse methods to the study of the general circulation of the ocean and to acoustic techniques for making large-scale monitoring measurements of the ocean. The work so far has culminated in a circulation scheme for the entire western North Atlantic and in the outlining of a complete acoustic monitoring system for a substantial fraction of an ocean basin.

Personnel Changes

Dr. Wunsch, who is the Cecil and Ida Green Professor of Physical Oceanography, became Head of the Department on April 1, 1978, after having held the post of acting Head since the departure of Professor Frank Press to Washington, DC one year before. The Department suffered a tragic loss in the death of Professor Christopher Goetze, age 38. Professor Goetze was a source of strength in the area of rock physics and is badly missed.

Two new assistant professors joined us in July 1977. Both were recent graduates of the M.I.T.-W.H.O.I. joint degree program. Dr. Edward A. Boyle, who received his degree in 1976, came to us after a year spent as NATO postdoctoral fellow at the University of Edinburgh. Professor Boyle is a chemical oceanographer with special interests in the
interactive chemistry of seawater and sediments. Dr. Charles Eriksen is Assistant Professor of Physical Oceanography. He returned to M.I.T. after a year spent at the Woods Hole Oceanographic Institution as a postdoctoral investigator. Professor Eriksen's special interests are in internal waves and equatorial flows.

CARL WUNSCH

Department of Mathematics

Last year's report on the Department of Mathematics started with the statement "1976-77 was a banner year for honors and awards..." We have to report that this year has been almost as much of a banner year, in that Professors Bertram Kostant and Daniel Quillen were elected members of the National Academy of Sciences. It is rare for a mathematics department to have two of its faculty elected members of the NAS in one year, but to have two elected in each of two consecutive years may be a unique occurrence, and one of which we are justly proud.

This year has seen the installation and start-up of an HP 3000 Model 8 computing system in the Department, which was generously donated by Hewlett-Packard. This is the first major computing system to be installed in Mathematics, and it is to be used for both research and teaching. Various departmental subjects, like numerical analysis and statistics, will use the new facility for term projects and homework exercises, in order to maintain close contact between mathematical theory and practical applications. In addition, the facility will be available to faculty and graduate students for their research projects. We will not be surprised if this new research capability leads to important new mathematical results.

The system consists of a central processing unit with 320K bytes of memory, a large fast disk for secondary memory storage, and other peripheral devices like a tape unit, line printer, and five display terminals. Future plans call for expansion of the system to about a dozen terminals, including graphic display terminals and plotters. The new computing lab will be connected to the Applied Mathematics Computing Laboratory by a number of data lines, in order to encourage maximum use of both facilities. The HP 3000 system normally runs in a time-sharing mode, using either FORTRAN or BASIC programming languages. We will also be adding another language, APL.

For some years the Department has been giving two large lecture subjects primarily for electrical engineers: 18.031 Linear Algebra and Differential Equations -- which attracts about 180 students -- and 18.04 Complex Variables -- with 160 students. A third was added last fall when we took over from Course VI-3 the subject 18.061 Introduction to Algebraic Structures -- with 130 students -- given primarily for students in computer science. Although it was fairly well received, more experimentation with subject matter will be needed to find material which is both mathematically significant and which is perceived by the students as interesting and relevant to their studies.

The Department's experiments with videotaping of recitations continued, using our own equipment. Over 20 classes were taped and discussed in seminars. Most of the teachers were teaching assistants or two-year instructors, but there were also several professors hardy enough to subject themselves to this experience. We hope during the summer to put together a composite tape showing common errors made in pedagogy, as well as one showing some scenes where everything went well -- both for the edification of fledgling teachers.
During the January Independent Activities Period, under the direction of Moore Instructor John D'Angelo, the Department fielded an unusual variety of activities. One of them, a "Soap Bubble Carnival," run by Dr. Frank Morgan (Moore Instructor and ex-M.I.T. undergraduate), received a great deal of publicity. It featured costumes, juggling acts, blowing of soap bubbles inside other soap bubbles, and an appearance by Professor Harold "Doc" Edgerton -- all of these surrounding some serious audience participation in resolving classical questions and paradoxes in the mathematical theory of minimal surfaces.

Applicants for fall 1977 admission to the Mathematics graduate program numbered just over 300, as they have for several years. Of this group, 35 were admitted and enrolled, seven with National Science Foundation Fellowships. The number of women applying and being admitted to our program continues to increase. Fifty-four women applied and six of the 35 enrolled students are women.

Twenty-four Ph.D.'s were awarded: two in algebra, one in algebraic geometry, one in algebraic topology, two in analysis and functional analysis, one in artificial intelligence, four in combinatorics, one in computational fluid dynamics, one in geometry, three in logic, one in nonlinear wave propagation, two in number theory, one in numerical analysis, one in operations research, one in optimization, one in partial differential equations, and one in theoretical physics. Five Master of Science degrees were also awarded.

FACULTY

We are proud and pleased to report some new faculty appointments. Professor George Lusztig, one of the outstanding algebraists of our time, has accepted a professorship, moving here from Warwick University, England, where he has held a personal chair for the past four years. Drs. Victor Kač and Michèle Vergne (both in the field of group representation theory) have been appointed Associate Professors with tenure. Professor Kač comes to M.I.T. from Moscow University, and Professor Vergne from the Centre National de la Recherche Scientifique in France. At the Assistant Professor level, Dr. Gary Miller (computer science) was appointed in January 1978, and effective July 1978 Dr. Sy Friedman (logic) and Dr. David Vogan (group representations) will be joining our faculty.

In the area of promotions, Professors Richard Melrose (partial differential equations) and Edward Miller (topology) have been promoted to Associate Professors, and Drs. William Dunsmuir (statistics) and Adi Shamir (computer science) have been promoted to Assistant Professors.

Faculty members visiting the Department during the past year have been: Dr. Igor Dolgachev (formerly of Moscow University), Professors Kač, Lusztig, Vergne, Felix Browder (University of Chicago), Moshe Israeli (Technion, Israel), Michael Rabin (Hebrew University of Jerusalem), and Louise Raphael (Clark College, Atlanta).

Faculty members on leave during 1977-78 were: Professors Warren Ambrose, Michael Artin, David Benney, Hung Cheng, Victor Guillemin, Isadore M. Singer, Harold Stark, David Schaeffer, Dorian Goldfeld, and Richard Melrose.

We would like, here, to make special mention of the retirement (one year early) of Professor George Thomas, Jr., after 38 years at M.I.T. Professor Thomas has been one of the great teachers at M.I.T., and his book Calculus and Analytic Geometry -- known to all as "Thomas's Calculus" and which has been translated into at least five languages and has exceeded 2.5 million copies sold to date -- has been used by vast numbers of calculus students in colleges and high schools across the country in the 27 years since it was first published.
George Thomas came to M.I.T. in 1940 as an Instructor, having completed his Ph. D. at Cornell in that year. He was promoted to Assistant Professor in 1944, to Associate Professor in 1950, and to Professor in 1960. His service to the Department has included being Executive Officer from 1950-59 and Registration Officer for the Graduate Program from 1962-67. He has served the Department in so many other ways as well that it is impossible to describe them all.

During World War II, George worked part-time in the Center of Analysis of the Department of Electrical Engineering while continuing his teaching duties in Mathematics. The object of interest in the Center of Analysis was the electronic computing machine, M.I.T.'s Differential Analyzer. Later, George was in charge of the operation of an installation of IBM punch card machines, working mostly on weather prediction problems for the Air Force. After the war, George continued his interests in probability and number theory, and taught a wide variety of mathematics subjects.

One very significant contribution which George Thomas has made to M.I.T. as a whole in recent years has been in his capacity as member, co-chairman (for one year), and trustee of the M.I.T. Community Service Fund. His dedication to this worthwhile task has been remarkable.

Over the years, George has been very active nationally in matters of mathematics teaching and curricula. He was on the Board of Governors of the Mathematical Association of America (MAA) from 1955-57 and was First Vice President of the organization in 1958-59. For five years he was editor of the Classroom Notes Section of the American Mathematical Monthly. From 1956-59 he served on the Executive Committee of the Mathematics Division of the American Society for Engineering Education. George also worked on the School and College Study of Admission with Advanced Standing, as well as the 12th-grade writing panel of the School Mathematics Study Group. From 1955-58, George worked for the Commission on Mathematics of the College Entrance Examination Board, devoting full time to the effort for about two years. This pioneering study of secondary school mathematics curricula was headed by Albert Tucker of Princeton. In 1959, George was chairman of the MAA Committee to Conduct Regional Conferences for National Science Foundation Summer Institute Lectures, and himself lectured at these institutes for secondary school teachers in the summers of 1956, 1957, and 1959. He has served as consultant to such diverse educational entities as the Brookline Public Schools and the Birla Institute of Technology and Science in Pilani, India.

But surely George's greatest impact on mathematics education has been because of his textbooks. His books on probability and statistics, written with F. Mosteller and R.E.K. Rourke, have been widely used, and we, his colleagues, are keenly aware that nearly all the current successful texts in calculus are amazingly similar to the "Thomas's Calculus" that came out in 1951 and is about to appear in its fifth edition. With the writing of this book, George continued a tradition of outstanding calculus texts at M.I.T. going back nearly to the turn of the century.

At George Thomas's last lecture on May 16, he was serenaded, toasted, and treated to a standing ovation by his students, representatives in a long line who owe much to George's inspiring and dedicated teaching during his years at M.I.T. It was a fitting tribute.

KENNETH HOFFMAN
This year marks the 50th anniversary of the founding of our Department. The oldest department of meteorology in the United States, it was originally conceived and organized by the late Professor Carl-Gustaf Rossby, regarded by many as the outstanding meteorologist of the 20th century. The Department will formally celebrate its anniversary at the end of October 1978, when our former students will be invited back to hear non-technical talks by their former professors. The first Victor Paul Starr Memorial Lecture will also be delivered on this occasion.

**Enrollment**

The student enrollment continued its slow increase, reaching 63. Of these, 44 pursued curricula primarily in meteorology, and 19 in physical oceanography. Five were women. Three Ph.D.s, one Sc.D., and 14 S.M.s were granted.

**Awards**

The American Meteorological Society's annual Award for Outstanding Services to Meteorology by a Corporation was given to M.I.T., "for its leadership in meteorological education since the founding in 1928 of the first academic meteorology department in the United States."

Professor Emeritus Henry G. Houghton, who was Head of the Department for 29 of its 50 years, and who was marking his own 50th year of service to M.I.T., accepted the award on behalf of the Department and the Institute.

For the second successive year, Professor Henry Stommel received a major award. This year it was the Rosenstiel Award in Oceanographic Science of the American Association for the Advancement of Science. Professor Frederick Sanders received an award from the National Weather Association for his "outstanding contributions in applied meteorology."

The Carl-Gustaf Rossby Award, offered annually for the most outstanding thesis submitted to the Department, was given to Kerry Emanuel for his doctoral thesis entitled "Inertial Stability and Mesoscale Convective Systems." Incidentally, Dr. Emanuel had entered M.I.T. as a freshman in 1973, and, after graduating in three years, fulfilled the doctoral requirements in another two.

**RESEARCH**

The Weather Radar Project directed by Senior Research Associate Pauline M. Austin has been accumulating digital data for New England storms. These data are being analyzed to provide quantitative descriptions of storm precipitation patterns and to determine their relationship to the larger-scale circulations. Data obtained from one of our shipborne radars during the GARP (Global Atmospheric Research Program) Atlantic Tropical Experiment (GATE), an international meteorological experiment conducted during the summer of 1974, are also being included in analytical studies of convective precipitation patterns. Of
particularly interest is the effect of cumulus convection on the vertical transport of heat and momentum. The project has developed numerical models of convective cells to help in interpreting the observed distribution of radar reflectivity in terms of up- and down-draft characteristics.

Professor Jule G. Charney together with Professor Eugenia Kalnay de Rivas and Visiting Professor Jagadish Shukla has been developing coupled axisymmetric models of atmospheres and oceans. A combined ocean-atmosphere numerical experiment with the sun at the equator has produced a double intertropical convergence zone, as is observed during equinoctial months in the Pacific.

Professors Charney and Shukla also have investigated the predictability of monthly and seasonal mean temperatures. Their results suggest that a large part of the low-latitude variability is due to anomalies in such boundary quantities as sea-surface temperature, albedo, and soil moisture. Since these anomalies have longer time constants than the flow instabilities which limit middle-latitude predictability, there may be greater predictability in low latitudes, especially over the monsoon regions. More recently Professors Charney and Shukla have extended this work by examining the rate of error growth as a function of latitude, horizontal scale, and time scale, using a global circulation model (GCM).

Professor Glenn R. Flierl has conducted research on the theory of oceanic motions of horizontal scales extending from the mesoscale (around 100 kilometers) to entire ocean basins. Theoretical models describing the structure and motion of isolated intense eddies have been constructed, partly in collaboration with scientists from the Institute of Oceanology (USSR) and the National Center for Atmospheric Research; existing oceanic (and atmospheric) data are being examined to see whether such models can profitably explain some of the properties of observed eddies. Studies of particle trajectories in translating eddies show that water is entrained and detrained from certain regions of these vortices. Data from various sources are being examined to estimate the rates at which these processes occur. Other aspects of Professor Flierl's research have been the study of topographical interactions of internal and external Rossby waves, the examination of particle trajectories in large-amplitude Rossby waves, and a study of the initial evolution of a large-amplitude baroclinic vortex.

Research Associate Claude Frankignoul has been investigating the low-frequency response of the upper ocean and the ocean interior to stochastic forcing by the atmosphere. Such forcing may play a part in generating sea-surface temperature anomalies and quasi-geostrophic oceanic eddies.

Professor Rivas 1) has worked on the improvement of the fourth-order version of the Goddard GCM; 2) in cooperation with Professor Charney has adopted a zonally symmetric Boussinesq model originally designed for Venus to compute the axisymmetric circulation of an ocean driven by surface heat flux and wind stress; the model has also been coupled with an axisymmetric version of the Goddard GCM; 3) directed thesis research on the three-dimensional moving-flame effects and their relevance to the circulation of Venus; 4) directed thesis research on the effects and improvements of top boundary conditions in primitive-equation models; 5) developed a system of "baroclinic shallow-water equations," in which the usual shallow-water equations are coupled with a "temperature equation" in such a way that the system is energy conserving and can develop an instability similar to baroclinic instability; 6) developed a modified version of the Matsuno time scheme which is 60 percent faster and has been tested in the coarse-grid Goddard GCM.
Professor Edward N. Lorenz has developed a numerical procedure for evaluating the amount of moist available energy in the atmosphere from standard meteorological data. This quantity, which is an extension of the previously defined available potential energy to the case where water in the atmosphere plays a crucial role, has so far been evaluated only by graphical methods. Professor Lorenz has also been using simple but representative systems of difference and differential equations to examine the arrangements of the numerous transitions from periodic to aperiodic behavior, or vice versa, as critical parameters are varied.

Professor Erik L. Mollo-Christensen has been studying nonlinear wave processes in the atmosphere and the ocean. Among his recent results are exact solutions of equations for geostrophic billows in the ocean and the atmosphere, and for edge waves in a rotating stratified fluid. The former solution represents finite-amplitude disturbances on a front, and may model observed cusped deflections of fronts in the equatorial Pacific Ocean, while the latter may model satellite observations of disturbances on the continental-shelf waters in the Gulf of Mexico. This work is in part a result of attempts to interpret satellite data, especially those patterns visible in infrared images.

Further work deals with the consequences of modeling the presence of wave groups in a random wave field, taking advantage of recent work by many others that demonstrates the possibility of envelope solitons in surface wave fields. A random-field model can be constructed from envelope solitons that behave nearly independently of one another, and the field statistics can be described in terms of an ensemble of wave-packet-like particles. This viewpoint is also pursued in a joint investigation of wave generation by wind, by Professor Mollo-Christensen and Research Associate Alfred Ramamonjinarisa at M.I.T. and also at Dr. Ramamonjinarisa's home institution, the Institute Mécanique Statistique de la Turbulence in Marseilles, France.

Professor Reginald E. Newell and his collaborators have completed an empirical-orthogonal-function analysis of sea-surface temperature in the Indian Ocean for the 1949-1972 period. It has been found that the Indian Ocean temperature pattern like that of the Pacific Ocean is a major factor in governing subsequent temperature changes in the tropical troposphere. By contrast only the Pacific Ocean pattern is a significant factor in controlling the rate of accumulation of fossil-fuel carbon dioxide in the atmosphere. A statistical method, based on the prediction of the time series of the most important empirical orthogonal functions, has been used to forecast Atlantic sea-surface temperatures one month in advance, and has yielded a definite improvement over the use of climatological mean values. The empirical-orthogonal-function analysis has also been used to study the three-dimensional field of temperature changes over Africa, with the hope of understanding the physics of seasonal and year-to-year circulation changes.

Professor Ronald G. Prinn and Research Associates Derek M. Cunnold and Fred N. Alyea have continued work with their three-dimensional dynamical-chemical model of the upper atmosphere. An expanded version of this quasi-geostrophic model with increased horizontal resolution and containing some 40 chemical reactions is nearing completion. An older version of this model is presently being used to study the dynamics of sudden stratospheric warmings. Research Associate Tsing-Chang Chen has developed programs for computing energy cycles in these three-dimensional models. Recent accomplishments of the group have included the first complete explanation for the observed ozone distribution at levels between 30 and 50 kilometers, the definition of the scales and phase relationships involved in eddy transport of ozone, and the possible role of deserts as sinks for fluorocarbons. Visiting their project this year were Research Associates John Barnett, who successfully compared model runs with observed satellite radiances, and Guido Visconti, who worked on improvements to the treatment of radiative transfer in the three-dimensional model and on the chemistry in a related two-dimensional model.
Drs. Alyea, Cunnold, and Prinn have also proposed and established a measurement program comprising four globally distributed ground stations (in Ireland, Barbados, Samoa, and Tasmania) which will take roughly hourly measurements of CFCl₃, CF₂Cl₂, CF₃CCl₃, CH₃CCl₃, CCl₄, and N₂. All these species decompose in the stratosphere, leading to ozone destruction. Measurements will proceed for at least three years with the principal aim of determining the atmospheric lifetimes of CFCl₃ and CF₂Cl₂, using the measured concentration trends. Dr. Cunnold is also involved in two satellite measurement programs, one involving ultraviolet measurements for ozone on Nimbus G and the other involving ozone and NO₂ measurements on the SAGE satellite. Dr. Alyea has been studying tropospheric-stratospheric exchange processes and the problems associated with interpretation of minor-species measurements from U-2 aircraft.

In work on planetary atmospheres, Professor Prinn has shown that the recently observed carbon monoxide on Jupiter can be used to deduce the vertical mixing rate in the deep atmosphere. In collaboration with Dr. Robert Huguenin of the University of Massachusetts at Amherst, he also demonstrated the role of the Martian surface in stabilizing the carbon dioxide atmosphere of Mars. In work on radiative transfer, he has demonstrated the important roles played by both atmospheric inhomogeneities and surface properties in the damping of temperature perturbations. In particular, radiative damping rates are much greater over oceans than over land surfaces.

Professor David Randall has continued the development and testing of a theory of entrainment into the planetary boundary layer, applied a higher-order closure model of turbulence to the study of turbulent transfer at the earth’s surface, continued studies of radiative-convective feedback loops, and suggested an approach to the problem of separating an ensemble of cumulus clouds into subensembles.

Professor Frederick Sanders and his students have studied major thunderstorm systems of the central United States and obtained a self-consistent picture of the transports of heat, moisture, and momentum by the cumulus clouds within the mesoscale circulations of these systems. A doctoral dissertation in progress is aimed at simulating the major features of this type of system in a dynamical model. In a study of oceanic storms of middle and high latitudes it was found from a dynamical model that air-mass contrasts are insufficient to account for their occasional great intensity, indicating that organized cumulus convection may play an important role in these as well as in tropical storms.

Professor Shukla has conducted numerical experiments with the GCM of the Goddard Laboratory of Atmospheric Simulations to examine the effects of sea-surface temperature anomalies in the Pacific on the atmospheric circulation over North America. These experiments support the hypothesis that the cold winter of 1976-77 over the eastern United States was in part due to the most anomalous sea temperatures ever observed over most of the North Pacific Ocean.

Professor Henry M. Stommel is continuing to conduct a field program, using a vessel locally chartered at the Seychelles Islands, for monitoring changes in the Equatorial Indian Ocean Current System during the onset of the Southwest Monsoon. This is one component of a cooperative program involving Professor Carl I. Wunsch of the Department of Earth and Planetary Sciences and investigators from other American institutions and the National Institute of Oceanography of India. The western tropical Indian Ocean exhibits the most extreme variability of current regimes of any ocean because of seasonally shifting wind systems. It is a very favorable part of the ocean, therefore, for testing the dynamical theories that are being constructed to explain the response of the ocean to variable forcing, and hence is an important test area for developing ideas eventually to be applied to joint atmospheric-oceanic climate models.
Professor Peter H. Stone and the staff of the Goddard Institute for Space Studies (GISS) have continued to collaborate on the development of simplified general-circulation models, and on the photo-polarimeter experiment for the Pioneer Venus mission, which was successfully launched on May 20, 1978. In connection with the latter project, they have been using theoretical models to study the stability of the atmospheric flows observed on Venus by previous missions. Professor Stone is also a co-investigator on the GISS photo-polarimeter/radiometer experiment that was selected recently for Project Galileo, the Jupiter-orbiter-probe mission to be launched in 1982.

In his individual work Professor Stone has continued with the parameterization of atmospheric-eddy heat transport, using both theoretical models and observational results to extend earlier results to include the effect of the curvature of the earth's surface. He also has directed student research on the sensitivity of transient-eddy heat fluxes to the vertical structure of the atmosphere, the development of simple two-dimensional heat-balance climate models, the role of stationary eddies in atmospheric heat transports, the extension of conventional terrestrial dynamical models to conditions appropriate for Jupiter, and the diagnostic calculations of atmospheric-eddy heat fluxes.

EDWARD N. LORENZ

Department of Nutrition and Food Science

During the past year the research and educational activities of the Department have shown continued growth. The number of postdoctoral associates and graduate students increased again. The number of undergraduates decreased slightly, primarily because of a lower enrollment of the Class of 1979 in the Applied Biology option. Since the Class of 1980 enrollment increased substantially over that of 1979, this decrease appears transitory. The faculty continued to be active in various national and international advisory bodies, and the level of research activity remains high with 370 research papers published or accepted for publication during the past year. The research of the Department's faculty is described in a publication entitled Faculty Research Summaries. It is available at departmental headquarters.

Undergraduate Education

Enrollment in the undergraduate curriculum in Applied Biology, Course VII-B, is remaining relatively constant. In the spring of 1978 the enrollment was 113, distributed as 52 seniors, 28 juniors, and 33 sophomores. Since the establishment of the program in 1971, 163 students have graduated as of June 1978. The faculty has continued to be active in the Undergraduate Research Opportunities Program (UROP) and in other modes of interaction with undergraduates as shown in the following table.
### Undergraduate Student-Faculty Interactions Outside of Course Work

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of UROP Students</th>
<th>Number of Undergraduate Seminars</th>
<th>Number of Freshman Advisors</th>
<th>Pre-Med Students Advised</th>
<th>VII-B Students Advised</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-71</td>
<td>7</td>
<td>14</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1971-72</td>
<td>34</td>
<td>56</td>
<td>2</td>
<td>12</td>
<td>65</td>
</tr>
<tr>
<td>1972-73</td>
<td>60</td>
<td>86</td>
<td>8</td>
<td>9</td>
<td>39</td>
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<tr>
<td>1973-74</td>
<td>103</td>
<td>102</td>
<td>6</td>
<td>6</td>
<td>42</td>
</tr>
<tr>
<td>1974-75</td>
<td>103</td>
<td>118</td>
<td>11</td>
<td>10</td>
<td>45</td>
</tr>
<tr>
<td>1975-76</td>
<td>102</td>
<td>112</td>
<td>9</td>
<td>12</td>
<td>49</td>
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<td>1977-78</td>
<td>79</td>
<td>98</td>
<td>9</td>
<td>13</td>
<td>48</td>
</tr>
</tbody>
</table>

This summer a number of undergraduates will be doing research full time. They are being supported as follows:

- UROP and faculty funds: 30
- National Science Foundation/Undergraduate Research Participation Grant (NSF/URP): 12
- Other: 5
- TOTAL: 47

Summer and I.A.P. both continue to be opportune times for undergraduates to do full-time research without the competition of course work.

### Graduate Education

The enrollment of 191 regular graduate students as degree candidates beginning in September 1978 was an increase of 10 from the previous September total. During the year 29 students received the S.M. and 10 were awarded the Ph.D.
Foreign students constitute 38 percent of our total student body, a slight increase from last year. Two students are from Canada, 11 from Europe, 20 from Central and South America, six from the Middle East, 28 from Asia, and five from Africa. Women constitute approximately one-third of the graduate students in the Department.

Recruitment of minority students is being pursued actively, and a brochure has been prepared for distribution to potential minority applicants and to minority schools with curricula which prepare their graduates for graduate programs such as ours.

Conferences and Summer Courses

The Fifteenth Annual Underwood Prescott Memorial Symposium was held on September 27, 1977. Peter Barton Hutt, Esq., attorney-at-law and partner at Covington and Burling, Washington, DC, delivered the memorial lecture on "The Basis and Purpose of Government Regulation of Adulteration and Misbranding of Food." On November 3, 1977 the Department hosted a symposium on "Dietary Choline Sources and Brain Function," coordinated by Professor Richard J. Wurtman and funded by a grant from the Ford Foundation. Professor Daniel I. C. Wang hosted an NSF-sponsored workshop on the Fundamentals of Biochemical Engineering which was held in College Park, Maryland, during December 12-14, 1977. On April 19-21, 1978, Professor Nicholas Catsimpoolas hosted an International Conference and poster presentation entitled: "Electrophoresis '78," which was jointly sponsored by the Department of Nutrition and Food Science and the Industrial Liaison Program. The Department of Nutrition and Food Science sponsored a mini-symposium on "Oxidative Enzymes and Molecular Toxicology" on May 18, 1978.

Five one-week summer programs were given in 1977 and were attended by industry, government, and university scientists. A listing of subjects and their attendance follows:

- **Enzymes and Their Uses in Analysis and Clinical Diagnosis**
  Director: Professor George Wolf
  June 27 through July 1, Attendance: 16.

- **Advances in Food Science and Technology**
  Director: Professor Marcus Karel
  July 25 through July 29, Attendance: 33.

- **Advances in Human Nutrition Knowledge**
  Director: Professor Vernon R. Young
  July 25 through July 29, Attendance: 23.

- **Fermentation Technology**
  Director: Professor Daniel I. C. Wang
  August 8 through August 12, Attendance: 55, and

- **International Nutrition: Problems, Policies, and Strategies**
  Director: Dr. Max Milner
  July 18 through July 22, Attendance: 15.
This summer (1978) five courses will be given: International Nutrition: Problems, Policies, and Strategies, Director: Professor Max Milner, July 17 through July 21; Advances in Food and Applied Microbiology, Director: Professor Anthony J. Sinskey, July 17 through July 21; Advances in Food Science and Technology, Director: Professor Marcus Karel, July 24 through July 28; Fermentation Technology, Director: Professor Daniel I. C. Wang, August 7 through August 11; and Concepts and Techniques in Experimental Pathology and Toxicology of Natural and Man-made Agents, Director: Professor Paul M. Newberne, August 14 through August 18.

Clinical Research Center

During the past year, 22 active projects have been carried on at the M.I.T. Clinical Research Center (C.R.C.); 147 admissions were made, and over 2,800 patient days of care were rendered. The studies under the direction of Professors Nevin S. Scrimshaw and Vernon Young and their postdoctoral fellows and graduate students were devoted to such matters as amino acid and protein, the energy requirements of humans, and the nutrition of children with thermal burns in collaboration with the Shriners Burns Institute of the Massachusetts General Hospital. Professor Robert M. Suskind and members of the clinical nutrition fellowship program have been studying a variety of nutritional disorders in disease states. These include cystic fibrosis, congenital heart disease, renal disease, obesity, and thermal burns.

The Department of Psychology continued to make important contributions to and to use the Center, particularly under the direction of the late Professor Hans-Lukas Teuber in collaboration with Drs. Thomas Twitchell and Suzanne Corkin. Other members of this Department including Professor Richard Held (Head) and Professors Emilio Bizzi and Alan Hein have also begin research in the Center.

Professor Wurtman and his colleagues have been studying the role of dietary precursors of neurotransmitters in studying neurological diseases, particularly Huntington's disease and tardive dyskinesia. Their group has shown that the administration of choline causes a substantial improvement in patients with tardive dyskinesia.

Dr. Robley Evans and Dr. Melvin Chalfen of the Argonne National Laboratory, Center for Human Radiobiology in Phoenix, Arizona, and here at M.I.T. have continued their studies of bone-seeking radioisotopes in humans.

Professor Ronald Arky (Harvard Medical School) has continued his studies of obesity and the effects of starvation and refeeding.

Dr. George L. Blackburn and his colleagues have added to their data on obesity and, in collaboration with Professor Suskind, on the effect of malnutrition on immunity.

International Nutrition Policy and Planning Program (I.N.P.)

This program, now five years old, was established in cooperation with the Center for International Studies and with the collaboration of the Departments of Economics and Political Science and now also involves the Departments of Urban Studies and Planning and Humanities and the Harvard School of Public Health. Professor Barbara Underwood, a well-known nutritionist, recently joined the staff. At this time, 30 graduate students are enrolled whose major studies represent various disciplines in the Departments indicated. The Advanced Study Program has been broadened recently in the cooperative effort with Harvard to include fellows assigned through the United Nations University. The first group (six to eight individuals) will start their work in fall 1978. Staff and students continue to be involved in research in a number of developing countries. A summer session program started last year will be continued in 1978.
Faculty Changes

New appointments in the Department include Dr. Michael J. Baum as Associate Professor of Behavioral Endocrinology, Dr. Henri Brunengraber as Associate Professor of Physiological Chemistry, Dr. John F. Burke as Visiting Professor of Experimental Surgery and Director of the Clinical Research Center, Dr. Robert S. Langer, Jr. as Assistant Professor of Nutritional Biochemistry, Dr. Michael Moscovitz as Visiting Assistant Professor of Neurosciences, and Dr. Barbara Ann Underwood as Associate Professor of Nutrition.

Professor James M. Flink accepted a position at The Royal Veterinary and Agricultural College in Denmark. Professor Sanford A. Miller accepted the assignment as Head of the Bureau of Foods of the Food and Drug Administration and will be on leave from the Department for three years.

Faculty Awards

Dr. Brunengraber, Associate Professor of Physiological Chemistry, will become the Established Investigator of the American Heart Association in July 1978. Professor Arnold L. Demain received three awards -- the 1977 Labatt Lectureship Award from the University of Western Ontario, the 1978 Hotpack Lectureship Award from the Canadian Society of Microbiology, and the 1979 Rubio Oratory Award from the Australian Society of Microbiology. Professor Scrimshaw presented the ninth W. O. Atwater Memorial Lecture, "Through a Glass Darkly: Discerning the Practical Significance of Human Dietary Protein-Energy Interrelationships," on August 15, 1977 in Quebec, Canada. The Atwater lecture, sponsored by USDA's Agricultural Research Service, honors Dr. Wilbur Olin Atwater (1844-1907), USDA's first chief of nutritional investigations. On November 14, 1977, Professor Scrimshaw presented the first Ellen Swallow Richards Memorial Lecture, "Nutrition and the Health of Nations," at the Institute of Nutrition of the University of North Carolina, Greensboro.

Department of Physics

The Department has had another productive year with respect to the instructional and research programs (described in detail in later sections). The size of the Department remained essentially constant, with a total of 87 faculty members, 269 graduate students, and 281 undergraduate physics majors. Degrees awarded during the year numbered 36 Ph.D.s, nine S.M.s, and 89 S.B.s.

The following faculty members received promotions during the year: Associate Professors June Matthews and Saul A. Rappaport were granted tenure. Drs. George Brandenburg, Claude Canizares, Robert Jaffe, John Ioannopoulos, Paul Joss, Susan G. Kleimann, and Charles Thorn were promoted to Associate Professor; Dr. Elizabeth Hafen was promoted to Assistant Professor.
School of Science

Visiting faculty included Professors Hans A. Bethe, Keith Boyer, Robert B. Raphael, Glen A. Rebka, Jr., and Gordon L. Squires, and Visiting Associate Professor Harold J. Metcalf.

Professor Roman Jackiw was on leave during the academic year; Professors George B. Benedek and Lawrence W. Rosenson were on leave for the spring term. Resigning were Assistant Professors Donald Barton and Carleton De Tar, and Instructor Carroll Creswell.

New appointments included John S. Whitaker as Assistant Professor and Joseph D. Burger as Senior Research Scientist.

Professor Ali Javan was appointed as the first Francis W. Davis Professor of Physics.

ASTROPHYSICS

The Department research program in astrophysics spans the entire range of astrophysical scales including fundamental studies of the primeval cosmic explosion and the epoch of the earliest galaxy formation, the quasars and distant galaxies, the intergalactic medium, the dynamics of, and objects in, our own galaxy, the interstellar medium and research of the solar system. The observational part of the program extends over nine decades of the electromagnetic spectrum, from hard X rays, through the visible and infrared, into the microwave radio region using space, near space, and ground-based observing platforms.

The X-ray astronomy program is carried out primarily from satellites. The M.I.T. satellite SAS-3, launched in 1975, is still functioning and has been joined by HEAO-A which is carrying out an unprejudiced survey of the X-ray sky. Later this year HEAO-B will be launched; it has the capability of X-ray imaging and spectroscopy in the 1/10 to 4 KeV band. Among the most interesting results during the year have been the discovery and precise location of two faint extragalactic X-ray sources which were subsequently identified as quasars through observations with optical telescopes. This suggests that future X-ray observations with more sensitive detectors will prove to be the most effective means for the discovery of these most luminous and distant of all celestial objects. SAS-3 also detected two new highly luminous and variable X-ray stars in the Small Cloud of Magellan. A study of the properties of these and the other Magellanic X-ray sources has led to the conclusion that they are much more luminous than similar X-ray stars in our galaxy and that the reason for the difference is probably the much lower abundance of heavy elements in the Magellanic Clouds.

On a subject much closer to Earth, new light was thrown on the nature of the transient X-ray sources in our own galaxy with the discovery by SAS-3 of a 3.6-second pulsation in one such transient called 3U0115+63. Doppler analysis of the variations in pulse period demonstrated that this object is a neutron star in the widest and most eccentric binary system so far measured among X-ray sources. Systematic study of the X-ray burst sources with SAS-3 has shown that their properties agree in several important respects with the calculated properties of a nuclear flash burning model in which helium in a layer on the surface of an accreting neutron star undergoes a sudden explosive episode of nuclear fusion into carbon and heavier elements. These episodes recur at intervals of several hours, and after each episode the fusion energy, equivalent to the energy radiated by the sun in one week, is emitted as blackbody radiation in the X-ray region of the spectrum.
The optical observing program, using primarily the McGraw-Hill and Cerro Tololo Inter-American Observatories, has become an important link in the X-ray observing program as it relates the more developed astronomy with its elaborate classifications and rich observational base to the X-ray sky. Observations of the optical counterparts to X-ray sources may be able to establish the true nature of the sources, in particular if they are black holes.

In the infrared program, observations of the Becklin-Neugebauer source, an intense infrared object in the Orion Nebula, have shown that it is a very young star, possibly less than 1,500 years old, still embedded in the dust cocoon and gas from which the star was formed.

The COBE (Cosmic Background Explorer Satellite) project has moved into a phase B study and a prospective launch in 1983. The project, a joint effort of the Goddard Institute for Space Studies, Princeton University, the University of California at Berkeley, the Jet Propulsion Laboratory, and M.I.T., will make the definitive measurements of the spectrum and isotropy of the primeval cosmic radiation and will search for the radiation of the earliest galaxy production in the 300 to 2 micron region.

The radio astronomy program uses the Haystack Radio Observatory plus other radio observatories throughout the world as a very long baseline network of interferometers. This year an interesting event was discovered in the water maser source W30H. The complete sequence of turning on and decay was observed for an interstellar maser and a theoretical explanation was developed. An enormous amount of energy, of the order of $10^{40}$ ergs, appears to have been released in a very small volume of space. It is conjectured that in the process of star formation, magnetic field line recombination can occur resulting in a solar flare-like phenomenon but with an energy release several million times greater.

A coordinated set of observations, involving X-ray, optical, and radio investigations, was carried out on the X-ray galaxy NGC 2110. The radio group, using the Very Large Array (VLA) of the NRAO were able to measure the radio characteristics of the radio galaxy, showing that the position coincided accurately with the X-ray and optical positions and, further, that the source showed a slight extension of a few arc seconds. The galaxy appears to be an active galaxy of a new type, and further investigations are proceeding.

Radio observations of dark interstellar cloud complexes have revealed that the mean temperature and density are correlated: molecular clouds are hotter when they are denser. This trend is consistent with equilibrium between cooling by molecular line emission and heating by a combination of gravitational collapse, collisions with warm grains, and the slip of ions past the cloud magnetic field.

Research in solar system plasma physics has advanced with the successful launch of Voyager 1 and 2. These spacecraft will fly past Jupiter in 1979, Saturn in 1981, and possibly Uranus in 1986. The Voyagers carry space plasma probes which, for the first time, will be able to measure the three-dimensional velocity distribution of the solar wind and, with the use of on-board magnetometers, determine these distribution functions relative to the direction of the interplanetary magnetic field.

In experimental relativity and gravitation this year, an interesting limit on the amount by which a source motion can affect the speed of light was determined by using data of the well-timed signals of X-ray binary stars. The special theory of relativity assumes no effect and the data indicate that it is less than one part in $10^{10}$ of $c/v$.

Long baseline gravitational wave antennas have been studied this year. Several systems appear promising to detect the gravitational radiation by stellar binary systems.
One of the last frontiers in solid-state physics is the understanding of the properties of disordered solids (glasses). Since these possess no crystal structure, the motion of electrons in glasses cannot be predicted by conventional solid-state theory. On the other hand, the local order (chemical bonding) in the glasses is nearly perfect. That is, the atoms in the glass have the same number and variety of nearest neighbors as in the crystal.

It is now known that many properties of solids (both amorphous and crystalline) are determined by this nearly perfect local order rather than by long-range order. However, some of the most unusual properties of glasses are the result of a small proportion of defects: deviations from the perfect local order. It appears that, in chalcogenide glasses (containing O, S, Se, or Te), electrons residing on such defects attract rather than repel each other. This attraction between electrons explains a wide variety of observed electronic and optical phenomena.

The first detailed model of the structure and behavior of defects in chalcogenide glasses has been constructed. The explanation rests on an understanding of the unusual chemical bonding in these systems. The model predicts similar defects in chalcogenide crystals and these have recently been observed.

A dramatic phase transition in gels has been observed and explained by mean field theory. The volume of a polyacrylamide gel has been observed to decrease by a factor as great as 10 as the temperature is lowered or the acetone concentration of the acetone-water gel fluid is increased. It has been found that there are essential differences between phase separations of gels and those of binary fluid mixtures due to the covalent cross links in the gel polymer network. Theory predicts, and the experiments verify, that there is a critical endpoint in the phase equilibria.

Interband and intraband absorption and reflection experiments have been carried out, in magnetic fields up to 18.5T, on three small-gap semiconductor systems: InSb, Hg$_{1-x}$Cd$_x$Te, and Hg$_{1-x}$Mn$_x$Te. For InSb, interband transitions were resolved between several heavy-hole levels to one of two conduction-band levels, providing new results for the heavy-hole cyclotron frequencies and the conduction-electron spin-flip frequencies. For the alloy systems Hg$_{1-x}$Cd$_x$Te and Hg$_{1-x}$Mn$_x$Te both cyclotron and combined resonance, and phonon-assisted resonances, were observed. For Hg$_{1-x}$Cd$_x$Te the results differed from predictions based on earlier interband measurements on the same samples; the same discrepancy has been noted for InSb. For Hg$_{1-x}$Mn$_x$Te the observed conduction-electron spin resonance frequency for $x=0.10$ was significantly smaller than that extrapolated from the "giant spin splitting" observed in alloys of smaller Mn composition.

High temperature superconductivity in the various symmetry classes of d-band metals is usually accompanied by lattice softening or structural transformations; in extreme cases the crystal structure itself is thermodynamically unstable. The relationship between these instabilities and high critical temperature $T_c$, which is a necessary ingredient in any predictive theory for the occurrence of superconductivity, has not been determined in even a general way despite extensive research. It has been difficult previously to produce samples with well-controlled or sufficiently characterized microstructure. The first experimental verification of the role of microstructure in the observed lattice transitions has been achieved this past year with ZrV$_2$, one of the two high $T_c$ members of the C15 crystal class. Using neutron diffraction, resistivity, ultrasonic velocity and $T_c$ measurements, it has been shown that perfect single crystal samples do not undergo a lattice transformation but twinned
single crystals do. However, both types of crystal exhibit an electronic instability. Having identified local stress as the key to the structural transformation and other anomalous normal state transport properties, efforts to determine the static or dynamic character of these forces and their effects on the superconducting state are now under way.

The study of polymers of helium has been extended. It has been found that there is a notable difference, depending on whether He³ or He⁴ is used, in the appearance curve of helium dimers and higher polymers as a function of pressure (p) in the source which generates a supersonic beam in which the polymers condense. For He⁴, dimers appear in proportion to p³ starting at 10 Torr, and higher polymers in proportion to p⁴ starting at 150 Torr. For He³, dimers and higher polymers appear together in proportion to p⁶ starting at about 450 Torr. This is evidence that He dimer exist in the beam and play a role in the formation of higher polymers, whereas the lighter He dimer does not bind at all on account of its greater zero-point energy.

Activities in the Neutron Diffraction Laboratory during the past year have centered on the development of a new type of neutron interferometer which utilizes two crystals for coherent splitting and recombination rather than the usual three-crystal system. With different performance characteristics, the two-crystal system may well offer advantage in certain types of application and these are being explored. Other activities in the laboratory include continuing studies on the paramagnetic scattering of neutrons by very weakly magnetic alloys and diamagnetic scattering by the classic diamagnetic material, bismuth.

A study of optical pumping in barium has been carried out using narrow-band laser light. The results of laser saturation experiments turned out to be radically different from simple predictions. A theoretical analysis has been carried out. The work is part of a larger project to study nuclear properties by the technique of laser spectroscopy.

The structure of atoms in very high magnetic fields has been of interest since it was realized that fields on white dwarf stars and neutron stars could be thousands or millions of times larger than the strongest man-made fields. The binding forces on such atoms are dominantly magnetic and the properties of the atoms are very different from those of conventional atoms. Such magnetic atoms have now been observed in the laboratory. Rather than attempting to create super high field, the experiment employs highly excited atoms in which the electric forces are very weak. This allows achievement of the high field regime with a conventional superconducting solenoid. The experiments are important in testing the theory that has been developed, and is stimulating the creation of a comprehensive theory for atoms in magnetic fields. The experimental techniques, which involve lasers and an atomic beam, have been developed during the past year, and a study has been carried out in the "low field" regime where the diamagnetic interaction is larger than the term separation of the coulombic states, though still small compared to the total electrostatic energy of the atom.

The study of weakly bound diatomic molecules has been advanced by the application of supersonic molecular beam and tunable dye laser techniques to measure the molecular absorption spectrum of NaNe. The molecules are created by free expansion of a high pressure gas (>150 atmospheres) into a vacuum, which results in cooling the gas to temperatures on the order of one degree Kelvin, low enough to result in the formation of weakly bound NaNe molecules. The approximately 300 spectral lines observed have been used to find the three lowest potential curves of NaNe.

Alkali/rare-gas molecules are the prototype of weakly bound one-electron molecules, and the NaNe potential curves have been the focus of numerous theoretical investigations using both pseudo-potential and ab initio techniques, partly because of our experimental work. The progress of the pseudo-potential calculations has been dramatic: all calculations prior to 1975 gave potential well depths too low by factors of 10 or so; the latest pseudo-potential calculations show less than 10 percent error.
Other potentials for NaNe have been determined from scattering experiments and from spectral line-broadening experiments -- they all disagree with the present results in some important respect. Reconciliation of these differences should lead to better theoretical understanding of those processes, and may have important implications for line-broadening diagnostics of plasmas and stellar atmospheres.

The Versator II research tokamak constructed by the Plasma Dynamics Group was originally designed to operate at a peak magnetic field of 8kG. The machine is being used primarily for the purpose of investigating various radio-frequency heating schemes of the tokamak discharge. To make these studies as versatile as possible, the machine was upgraded to allow operation at 15kG magnetic field levels. The upgrading has now been completed and rf heating studies are about to begin. The first year will be spent exclusively on lower hybrid heating at a frequency of 800 MHz and at a power level of 200 kW. In the spring of 1979 a series of experiments will be initiated on electron-cyclotron heating at a frequency of 36 GHz and at a power level of 200kW. The lower hybrid experiments are being carried out with Princeton Plasma Physics Laboratory which is supplying the high power klystron. The electron-cyclotron heating experiments will be made in cooperation with the Naval Research Laboratory which will be providing a novel 200kW gyrotron.

**CENTER FOR THEORETICAL PHYSICS**

**Elementary Particle Theory**

The basic structure of matter is now coming into focus. The fundamental particles are quarks and leptons, interacting through exchange of the various vector mesons: eight colored vector gluons give rise to quark binding and are responsible for the strong interactions; four intermediate vector bosons generate the weak and electromagnetic interactions of quarks and leptons.

Intense efforts by the particle physics group go into mathematical studies of these vector interactions, whose novel and often startling features may be responsible for the phenomena of quark confinement, of "scaling," and of CP violations.

On a phenomenological level, much work is being done on what is now generally called the "M.I.T. bag model" of hadrons. It has not only yielded a quantitative understanding of hadronic spectroscopy but also has furnished an intuitive picture of how hadrons are made from quarks pulled together by "color" flux lines.

Ordinary hadrons are made up of either three quarks (baryons) or a quark and antiquark (mesons). We have been systematically considering the properties of hadrons made of more than three quarks. The properties of these "multiquark hadrons" promise to provide sensitive tests of quark dynamics, especially regarding "color." We have made an exhaustive study of the two-quark/two-antiquark hadrons which may be seen as prominent resonances in the scattering of baryons and antibaryons. We are now studying the effect of multiquark hadrons on the spherically symmetric scattering of ordinary mesons and baryons. This promises to lead to a rather novel interpretation of low energy scattering processes in which color plays an essential role.

Another topic of immediate interest is the possibility of "color-isomers," multiquark hadrons which are long lived because the internal structure of the quark's color couplings inhibits decays into ordinary mesons and baryons.
Heavy quarks and antiquarks move non-relativistically in a central potential, which gives a constant force at long distances. This potential has been very successful in giving the structure of the charmonium spectrum. We have more closely investigated this and have shown, using a variational method, that this phenomenon can be derived from the M.I.T. bag model and very accurately represents the force even at intermediate distances. The first order relativistic corrections which yield spin dependent forces between the quarks also have been derived and have been shown to give a reasonably accurate representation of the position of the triplet P states. This work is being extended to the upsilon region which is conjectured to correspond to a still heavier quark-antiquark system.

We have refined some ideas on the grouping of mesons into Regge trajectories. The slight deviations from linearity of the trajectories with strange quarks are predicted accurately by a formula which arises naturally in a semi-classical approximation to the M.I.T. bag model.

We have carried out a study of the two-nucleon interaction (nuclear force) at low energies viewed from the standpoint of the quark model of the neutron and proton. At short range, when the nucleons overlap, the M.I.T. bag model yields a soft repulsive core, and at intermediate range an attractive minimum; both features correspond qualitatively to what is known from the low energy scattering data.

We continue the intense effort we have devoted to the study of non-Abelian gauge field theories. From all indications, they are fundamental to an understanding of quark dynamics (quantum chromodynamics), and the unification of weak and electromagnetic interactions.

On the classical level, non-Abelian gauge theories possess soliton solutions, such as the monopole in Minkowski space-time, and the instanton in Euclidean space-time. The former leads to the possibility of making spin one-half particles from boson fields, and the latter represents a tunneling motion between classical configurations of different topological structures. Much work remains to be done in the classification of these solutions in terms of group theoretic parameters, and in understanding their role in the corresponding quantum theory.

The quantization of these theories remains a difficult and delicate problem, and is made more so by the discovery of the classical soliton solutions. The general problem is to find an appropriate gauge in which the quantization prescription can be formulated unambiguously and consistently, and can be used as a starting point for calculating physical quantities.

We have demonstrated a precise connection between two alternative approaches to particle theory, namely Dual Resonance Models (Interacting String Theory) and Perturbative Field Theory. Our work has shown that these two approaches are respectively strong coupling and weak coupling expansions of the continuum limit of a model lattice theory. We have applied this work to a calculation of the spectrum in the "Dual Resonance" limit of Quantum Chromodynamics, with very promising results. In particular, we have insight into the mechanism by which chiral symmetry is spontaneously broken.

Some of the problems encountered in the connection between dual resonance models and field theories are closely related to properties of some unusual one-dimensional many-body systems. We studied the collective modes of these systems using the random phase approximation. The relevant boundary effects are rather delicate, but we were able to establish some definite results by using the constraints imposed by duality on two-dimensional lattice systems. We will continue the study of the consequences of these very powerful constraints.
We have conducted research in relativistic many-body theory. Using graphical techniques and the renormalization group, the equations of state for quark matter were calculated. These thermodynamic relations were used to investigate the properties of quark stars. The formation of a super-conducting ground state in quark matter was also studied.

The gluon exchange model of the pomeron suggested several years ago was first evaluated using quark wave functions suggested by the M.I.T. bag model. A more general covariant treatment of the problem is still in progress, leading to fewer detailed results, but still allowing restrictions to be placed on the spin dependence of the eikonal.

We have shown that the observed rapidity dependence of high energy production amplitudes implies a classical picture of the trajectories of the produced particles. This picture is the corresponding "outside" picture to Gottfried's "inside" picture, and is consistent with it, but on a firmer basis. A great deal of effort was devoted to studying the possibility of "seeing" this very large space-time structure by anomalies in the single and double bremsstrahlung in high energy hadron-hadron collisions. It turns out that although the effect is in principle there, it is in practice so small that it is totally unobservable.

We have studied spin correlation tests for gluon-induced processes. These are based on the helicity conservation of vector interactions, and should characterize high $p_T$ jets.

In collaboration with high energy experimentalists in the Accelerator Particle Collaboration group at M.I.T., we are helping with the theoretical questions encountered in an analysis of the average multiplicity of particles produced in association with the production of a particular particle.

Nuclear Theory

Finite nuclei and their interactions with hadronic, mesonic, and electromagnetic probes provide one of the richest and most challenging many-body systems presently amenable to quantitative experimental investigation. Many facets of nuclear theory are presently being addressed by nuclear theorists at the Center.

Formulation of the microscopic theory of nuclear structure is a continuing interest. Recent advances in understanding the properties of infinite nuclear matter have provided strong support for the validity of perturbation theory techniques, indicated significant shortcomings in our understanding of nuclear forces, and given insight into the behavior of matter at high densities in the interior of neutron stars. Progress in understanding the effective interactions between nucleons with a nucleus and in extending the mean-field approximation have provided a detailed understanding of the shapes, density distributions, and energies of many nuclei.

Because the electromagnetic interaction is both weak and well understood, the scattering of electrons provides the most precise probe available of the nuclear wave function. Comparison with experiment of the theoretically predicted scattering for closed shell spherical nuclei and well-deformed rotational nuclei has provided quantitative corroboration of our understanding of the shapes of these nuclei. Recent investigations into the role of meson exchange currents and magnetic scattering from nuclear spin and current densities offer the hope of even more detailed understanding of the electromagnetic structure of the nucleus.

Significant progress has been achieved in formulating a general time-dependent theory of nuclear dynamics. A systematic hierarchy of successive approximations has been developed and shown to converge adequately in selected exactly solvable models. The lowest order approximation, the time-dependent mean field approximation, has been successfully applied to a variety of nuclear processes, yielding a quantitative understanding of the fusion cross sections of light nuclei, the deep-inelastic scattering of heavy nuclei, and a qualitative description of fission.
Since the nuclear force is generated in part by the exchange of pions, it is clear that the interactions of pions with nuclei offers a wealth of valuable information concerning both nuclear structure and strong interactions. In the energy region of the lowest pion-nucleon resonance, considerable success has been achieved in the description of pion-nucleus scattering in terms of a model in which a pion and nucleon interact only through the formation of an isobar. In addition to scattering in the resonance region, pion photo-production, pionic atoms, pion absorption, and pion condensation have also been investigated.

Additional topics of current interest in the Center include a unified theory of direct reactions and statistical processes, the theory of nucleon-nucleon forces, relativistic heavy ion collisions, nuclear collective motion and the scattering of high energy protons from nuclei.

**EXPERIMENTAL NUCLEAR AND PARTICLE PHYSICS**

Our experimental nuclear physics groups have continued their work in nuclear structure physics, using a variety of probes -- from electrons to heavy ions -- on a variety of nuclei at a variety of energies. Much of the work has been carried out at the Bates Linear Accelerator, but our groups have also utilized accelerators at Brookhaven, the University of Indiana, Los Alamos, the University of California at Berkeley, and Stanford.

Thus, the group working on heavy ion interactions continues its investigations on the nature of the energy dissipation mechanism in heavy ion collisions. The study of the $^{12}_C - ^{12}_C$ system has been further advanced through observation of the reaction $^{12}_C + ^{16}_O \rightarrow ^{24}_Mg$, into two $^{12}_C$ nuclei. In addition, the search for ultra-heavy nuclei continues.

At the Bates Linac, precision studies of electron scattering from heavy nuclei (in particular, lead) have probed the magnetic structures of states excited by as much as 14 units of angular momentum -- an unprecedentedly huge span of excitation. Systematic studies of nuclear rotational band structure are being carried out over a wide range of nuclear mass values, from uranium down to the oxygen isotopes. More disruptive photon-induced reactions (including proton knockout and pion production) are being used to probe those features of the nuclear forces that affect the higher-momentum components of nuclear wave functions.

At high energies, our groups are actively involved in the preparation and carrying out of large experimental programs at the Fermi National Accelerator in Batavia, Illinois, the European Center for Nuclear Research (CERN) in Geneva, Switzerland, and the German Electron Synchrotron Laboratory (DESY) in Hamburg, Germany. The Accelerator Particle Collaboration (APC) group has demonstrated the validity of a unified approach to the interpretation of strong hadronic interactions in the ultra-high energy range available at the Fermi Accelerator. In anticipation of a major experimental study of strong hadronic interactions, using a "hybrid" -- bubble chamber plus electronic detection devices -- system, they have developed new devices for the precision identification and momentum measurement of both charged particles and gamma rays.

Having completed data taking on a major spectrum study of the products of high-energy hadron scattering (and being well along in the analysis of the data, and their interpretation in terms of the quark structure of the hadrons), the Counter, Spark-Chamber (CSC) group has now embarked on the preparation of an apparatus -- involving a 400-ton combined target and electronic detection system -- for a study of the properties of neutral weak currents in neutrino interactions.
The Electro-Magnetic Interaction (EMI) group has been extending its studies of the spectrum of mu-pair production into proton-proton reactions with center-of-mass energies in excess of 20 GeV, a heretofore unexplored energy range. These experiments are being performed at the intersecting storage ring (ISR) facility at CERN. When the newest and highest-energy electron-positron colliding beam (PETRA) comes into operation at the DESY laboratory in Hamburg in the summer of 1978, the group's detection system will be prepared for the first observations in this new range of energies. Among many exciting prospects is the possibility of observing, for the first time, the simultaneous manifestation of the weak and electromagnetic forces in $e^+e^-$ interactions in which each particle can carry energy of up to 20 GeV.

HERMAN FESHBACH

Interdisciplinary Science Program

The Interdisciplinary Science Program (Course XXV) sponsored by the School of Science is intended to provide special opportunities for undergraduate and graduate students interested in science programs that differ significantly from established departmental offerings. For example, students may concentrate in fields such as astronomy, meteorology, oceanography, environmental sciences, neurosciences and behavior, perceptual systems, human cognition and artificial intelligence, medical science, and nutrition and food science. Students in the Program arrange their own curricula in consultation with faculty advisors, subject to the approval of a faculty committee consisting of representatives from the Department of Psychology and all departments in the School of Science.

In addition to the Bachelor of Science, the degree of Master of Science in Interdisciplinary Science is offered under the auspices of the Interdisciplinary Science Program. The objective of this Program is to provide an opportunity for graduate study in an interdisciplinary area with a strong science core, and to prepare students for positions in industry, government, education, or medicine where training beyond a Bachelor's degree is required. Students entering the Program may elect either a specified or the unspecified degree option. The requirements for each specified program are predetermined by a special faculty committee whose members have expertise in that area.

Currently, specified Master's Programs are being offered in the areas of Animal Cell and Tissue Culture Science, Science Education, and Environmental Chemistry. In addition, a new specified two-year Master's Program in Science Communication is being offered beginning in 1978-79 for students interested in science writing for the print medium, or in reporting and education through the audiovisual medium of films, television, and radio. A selection of subjects will be made to develop an integrated curriculum encompassing the technical aspects of science communication, policy issues involved in science and its public understanding, and a broadened comprehension of various aspects of science at an advanced level. Course options will be selected principally from offerings listed in the School of Science, the School of Humanities and Social Science (Course XVII and XXI), and the School of Architecture and Planning (Course IV). A graduate subject in science writing 21.742, taught by Professor Rae Goodell, will also be available in September 1978.
Requirements for the degree of Master of Science in Interdisciplinary Science with specialization in Science Communication are: 1) 42 graduate (A) units, of which 36 are to be in science subjects; 2) 48 units in subjects related to science writing, the audiovisual media, or the political, social, or legal aspects of science communication; 24 of these units must be listed for graduate (G) or (A) credit; 3) a minimum of 24 units of thesis in science communication.

Students will be allowed to specialize in either the science writing or audiovisual tracks but will be expected to obtain some training (at least one course) in the alternate track.

An internship at the graduate level will also be possible as part of both tracks to provide practical experience in a specific area of training.

In addition to the existing specified Master's programs, provision is made as in the undergraduate program for individual proposals, which are approved in detail by the Course XXV admissions committee. The criteria for acceptance are that there must be a worthwhile focus to the program that cannot be adequately served by an existing departmental program, and that the program contain a significant number of graduate "A" courses in science among the usual course and thesis requirements.

The Interdisciplinary Science Master's Program received initial approval in the spring of 1975 as a three-year experiment. Subsequently, in the spring of 1977 upon the recommendation of the Course XXV faculty committee, approval was given to extend the experiment an additional three years. The statistics summarized below are an indication of the numbers of students in the program, the concentrations they have chosen, the distribution of advisors among M.I.T. departments, and the students' academic records during the first three years.

Twenty students have graduated from the Program since its inception in 1975. Eight are presently enrolled in Course XXV, and we expect at least six to begin in September 1978.

In the designated programs, five students have chosen the option in Science Education, five in Animal Cell Science, and four in Environmental Chemistry. The individually designated courses fall into the following categories: five in Biomedical Science, one in Analytical Chemistry, two in Biomedicine and Neurology, two in Biomedicine, one in Astro Science, one in Life Science and Nutrition, one in Management and Nutrition, one in Biological Oceanography, one in Physical Oceanography, one in Psychology and Management, two in Science and Public Policy, one in Artificial Intelligence, and one in Theories of Intelligence.

The distribution of advisors among departments is as follows: four in Chemistry, four in Biology, two in Physics, three in Psychology, eight in Nutrition and Food Science, four in the Division for Study and Research in Education, two in Management, one in Meteorology, one in the Harvard Medical School, one in the Sea Grant Program, and four Undesignated.

Students' cumulative grades have been as follows: the range was 3.6 - 5.0; the median was 4.7; and one student is still in the Program with less than a 4.0 average.

During the academic year 1977-78, Bachelor of Science degrees in interdisciplinary science were awarded to five undergraduates: one in neuroscience and behavior, one in psychology and education, one in science education, one in medical sciences, and one in environmental sciences. The degree of Master of Science was awarded to seven candidates: five in animal cell and tissue culture science, one in biomedical sciences, and one in science education. There were 18 undergraduate and 13 graduate students in the Department during 1977-78. To date, we have admitted six new graduate students for the academic year 1978-79.
PERSONNEL

The 1978-79 Interdisciplinary Science Committee consists of the following individuals: Dean Robert A. Alberty, School of Science; Professor John M. Buchanan, Department of Biology; Professor David N. Hume, Chemistry; Professor Charles C. Counselman, Earth and Planetary Sciences; Professor Louis N. Howard, Mathematics; Professor James M. Austin, Meteorology; Professor Vernon R. Young, Nutrition and Food Science; Professor Earle L. Lomon, Physics; and Professor Gerald E. Schneider, Psychology.

We will miss Professor Sanford A. Miller, our representative from Nutrition and Food Science for the past three years, who leaves for Washington, DC to assume the position of Director of Foods in the Food and Drug Administration. Professor Vernon Young has accepted the invitation to replace Professor Miller on the Committee.

Professor Buchanan has agreed to continue in his capacity as committee chairman and registration officer for 1978-79.

JOHN M. BUCHANAN

Spectroscopy Laboratory

The Spectroscopy Laboratory is dedicated to advancing our knowledge of the structure and dynamics of atoms and molecules and the properties of liquids and solids, utilizing the techniques of modern spectroscopy. These techniques include the use of lasers and high resolution spectrometers. As an interdepartmental laboratory, the Spectroscopy Laboratory encourages participation and collaboration among staff members in various disciplines of science and engineering. This past year there has been participation from the Departments of Biology, Chemistry, Physics, Aeronautics and Astronautics, and Chemical Engineering, and the Energy Laboratory. Outside collaborations with Harvard Medical School, Boston University, and Wellesley College have also begun.

The Laboratory has had a long and distinguished career and has played an important role in areas of classical spectroscopy, including the detailed studies of atomic spectroscopy which led to the M.I.T. Wavelength Tables, and the development of techniques for making optical diffraction gratings of unequaled size and resolution. There has been a new challenge to redirect the efforts of the Laboratory and bring it into the era of modern spectroscopy, especially utilizing the powerful techniques made possible by intense, coherent laser sources. Notable achievements in this area include the initial observations of Lamb dip and superradiance phenomena. The progress made during the past year reflects these goals.

Professor Alexander Rich, in collaboration with Drs. Andrew H. J. Wang and Frances Jurnak, all of the Department of Biology, and Dr. Alex McPherson of Hershey Medical Center, has continued his X-ray diffraction mapping studies of the gene 5 protein, a protein molecule which comes from the bacteriophage fd and functions to unwind the double helix of DNA. For several heavy atom and iodination derivatives 2.3 Å resolution data have been collected. The electron density map, based on the phases computed from the data, clearly reveals the overall shape of the molecule and some of the major features. More precise data, collected at 1.5 Å resolution, will be used to refine the molecular structure and obtain accurate information of the arrangement of every individual atom of this protein.
Another study, in collaboration with Drs. Wang and Francis J. Kolpak, also of the Department of Biology, and Dr. Jacques van Bloom of Leiden University, has been initiated to study the structure of a series of deoxy-tetranucleotide triphosphates at atomic resolution by X-ray crystallographic analysis. Four self-complementary tetramers are under investigation: \( \text{dCpGpCpG} \), \( \text{dGpGpCpC} \), \( \text{dGpCpGpC} \), and \( \text{dCpCpGpG} \). For the first of these an accurate set of native intensity data has been collected, from which the overall structure of the unit cell has been established. Work is under way to solve the detailed structure of this and the remaining three tetramers. In addition, co-crystallization with intercalators, peptides, and other molecules which interact with the deoxynucleotides is under way. Such studies will provide a detailed look at the specific interaction of these molecules with DNA.

Professor Richard C. Lord (Department of Chemistry), in collaboration with Professor Rich and Drs. Michael C. Chen and Richard Giegi, has completed a comparative study of the conformations of 10 transfer RNA molecules using Raman spectroscopy. This study examines the structures of these molecules by comparing their spectra with that of phenylalamine tRNA from yeast, whose structure was determined crystallographically by Professor Rich. A similar comparison was made for 35 ribosomal RNA from \( \text{E. coli} \).

The Tunable Laser Facility became fully operational during the past year, largely through the efforts of Professor Robert W. Field and Dr. Phillip G. Cummins. Professors Field, Jeffrey I. Steinfeld, Edward I. Solomon, and James L. Kinsey (all of the Department of Chemistry) have been the major users.

Professor Field and his colleagues have progressed in their studies of diatomic molecules using fluorescence, Lamb dip, optical double resonance, optical pumping, and other laser spectroscopy techniques. New results in \( \text{CaF} \) include measurements of spin rotation constants and magnetic hyperfine structure, and the discovery of two new electronic states. Electronic states and structure have been studied in \( \text{CaS, SrO, SrS, and BaS} \). Molecular iodine has also been studied via optical pumping. Participants in this research include Drs. Cummins, Ingemar Renhorn (Chemistry); and Drs. Joel Schamps, University of Lille; Roger Bacis, University of Lyon; Frank Wodarczyk, Rome Air Development Center; and Stuart Silvers of Virginia Commonwealth University.

Professor Steinfeld's group has been active in several areas. Multiple infrared photon excitation of a series of chlorine-substituted ethylenes was studied, and the mechanism of the isomerization and \( \text{HCl} \) elimination reactions was established. Multiple photon excitation of the triplet state of \( \text{biacetyl} \) was also studied.

Preliminary experiments have begun on laser-induced fluorescence spectroscopy of transient species in hydrocarbon flames. These studies, directed at reducing the output of nitrogen oxides and polynuclear aromatic hydrocarbons from combustion sources, are being carried out in collaboration with Dr. Donald Coe and Professor Adel Sarofim, both of the Department of Chemical Engineering, and Dr. Joel M. Levy of the Energy Laboratory.

Working in collaboration, Professors Steinfeld and Field have reanalyzed the \( \text{A}^2\Pi - \text{X}^2\Sigma^- \) system of the CN radical and obtained accurate spectroscopic constants. These are of value to astrophysicists searching for CN transitions in stellar atmospheres, and for calculating quenching rates of the \( \text{A} \) state.

Professor Kinsey and Dr. William Dimpfl (Chemistry) have set up a UV-pumped molecular sulfur laser and a tunable CW dye laser probe to investigate the preparation of highly vibrationally excited diatomic molecules for collisional studies.
During the past year Professor Solomon has begun a spectroscopic study of transition metal excited states in the Laboratory, the overall goal being to correlate changes in geometric and electronic structure with biochemical changes and biophysical parameters. Two important techniques are employed: high resolution studies of laser-induced polarized fluorescence, and laser Raman spectroscopy. For the latter the tuning range of the Raman spectrometer has been greatly augmented by interfacing a tunable dye laser with it.

Both simple highly symmetric transition metal complexes and more complicated biological systems such as metalloenzymes have been under study. The former studies, which focused on photochemically active inorganic complexes in systems that exhibit low photoactivity, reveal that the accepted spectral assignment of the low energy spin forbidden region is incorrect. Proper interpretation of the potential surfaces associated with this region is vital to an understanding of the details of the emission processes. The initial metalloenzyme studies compared oxyhemocyanin and oxytyrosinase and show that oxygen is very similarly bound in both active sites, strongly suggesting that the enzymatic activity of the tyrosinase is due to the details of the substrate-active site interactions, rather than the relative activation of the oxygen.

Professor Ali Javan (Department of Physics) and his co-workers have made progress in several areas of laser spectroscopy. Relaxation processes in water vapor have been studied by probing a D$_2$O transition collisionally coupled to a second transition saturated by an intense, short CO$_2$ laser pulse. In this way the relaxation of the 010 vibrational state due to self and buffer gas broadening was measured, as well as relaxation from several rotational levels within the 010 manifold. One of these levels is found to relax several orders of magnitude more slowly than the others. This dramatic difference is attributed to the high J and placement of this level, which collisionally isolate it from the rest of the manifold.

A precision twin laser spectrometer, consisting of two highly stable N$_2$O lasers servo-locked in frequency offset, has been developed to study three-level crossing resonances in N$_2$O. The goal is to establish the nuclear electric quadrupole hyperfine structure of the N$_2$O molecule. Vibrational changes in the quadrupole coupling constant have been observed for a number of lines. Analysis of the data is in progress.

Another project, undertaken in collaboration with Dr. Keith Boyer of Los Alamos Scientific Laboratory, seeks to develop a CW fast-flow TEA CO$_2$ laser utilizing an electron beam to preionize the moving gases. The e-beam characteristics of the prototype system are currently being investigated. Once completed, the device should have the capability of continuous tunability over the entire CO$_2$ 9 and 10 micron bands. This device, whose ultimate stability is expected to be excellent, is being developed in support of the laser spectroscopy program of the Laboratory.

Professor Michael Feld's research has advanced along several lines. The laser-induced nuclear orientation experiments, described in last year's Report, have progressed during the past year. These experiments study the gamma ray angular distribution from an atom, optically pumped by a monochromatic laser field, whose nucleus is in an excited isomeric state. The initial experiments are being done on the 661 keV metastable level of the barium 137 nucleus, with the electronic states pumped at 553 nm by a single mode tunable dye laser. During the past year detailed studies to produce microscopic quantities of barium atoms in the vapor phase have been performed and sensitive fluorescence detection techniques have been developed. In addition, a Lamb dip-optical pumping technique has been developed for studying the hyperfine structure and isotope shifts in ground state barium, and the extent of laser optical pumping. One interesting feature of this new technique is that it can yield Lamb dips opposite in sign to those usually expected. Related studies in sodium isomers have also begun. Others participating in this project are Professor Martin Deutsch of the Department of Physics and Dr. Dan Murnick of Bell Laboratories.
Research on superradiant emission in an extended, optically thick sample continues. Detailed analyses have shown that free induction decay and adiabatic inversion are potential new ways to achieve strong superradiant emission. Based on the calculations, a set of molecules and atoms has been selected for study in the 10 micron region and in the visible. Preparations for the experiments are under way.

Other areas being pursued include time-delayed laser saturation spectroscopy, a novel technique developed in the Laboratory over the past two years, studies of the fine structure of molecular helium, development of a highly stable, tunable CW CO\textsubscript{2} waveguide laser, and studies of the excited vibrational structure of methyl alcohol using optical pumping techniques.

During the past year Professors Feld and Javan have embarked on a collaborative study of the dynamical processes and laser kinetics occurring in the xenon fluoride molecule. In the experiments a tunable pulsed UV dye laser is used to probe specific vibronic transitions. Two techniques are used, direct measurements of probe absorption when XeF is produced in a laser discharge, and measurement of fluorescence induced by the probe when XeF is produced by photodissociation of XeF\textsubscript{2}. The experiments are measuring the rates of dissociation and vibrational equilibration in ground state XeF under various conditions, information important in modeling XeF excimer laser systems.

Over the past year, two important collaborative efforts with outside universities have begun. Professor Feld and Professor Samuel A. Latt and Dr. Eli Sahar of Harvard Medical School are studying the induction of sister chromatid exchanges (SCE) in Chinese hamster ovary cells by 8-methoxypsoralen and 10-15 nsec. pulses of 350 nm XeF laser light. SCEs have been shown to be very sensitive indices of the impact of mutagen-carcinogens on mammalian chromosomes. Thus far the conditions for effective SCE induction have been established, and preliminary data showing the dependence of SCE induction on the number of laser pulses have been obtained. Additional experiments of psoralen-DNA mono- and bi-adducts in inducing SCEs are planned to further characterize the formation mechanism.

In another collaboration, Professor Theodore Ducas of Wellesley College, working with the Spectroscopy Laboratory staff, has constructed a laser photoacoustic spectrometer to study photoacoustic signatures of different types of living tissue. The aim of these studies is to develop spectral indications of tissue pathology -- in particular, carcinoma -- in tissue samples. Preliminary absorption data from cholesterol and other systems has been obtained. In addition, collaborative efforts with Dr. Geza Jako of the Boston University Medical School have shown that studies of this type provide important information essential for direct clinical applications in surgery.

Viewed in perspective, the past year saw a significant continued increase in the interactions among members of the Laboratory, other departments, and outside universities. Of particular significance was the development of a major proposal to house a regional facility for laser spectroscopy and dynamics in the Spectroscopy Laboratory, submitted to the National Science Foundation. This facility would serve scientists in the industrial and university communities throughout the Northeast. A funding decision should be forthcoming in the early fall.
George R. Wallace, Jr. Astrophysical Observatory

The George R. Wallace, Jr. Astrophysical Observatory contains two telescopes, one 16-inch and one 24-inch, and serves as an active teaching and research facility. It is located near Westford, Massachusetts.

During the past year, major problems were experienced with the electrical control and mechanical drive of the 24-inch telescope. As a consequence, the telescope has been disassembled and the drive system has been redesigned. The overall result will be a more precise drive system and one which is more useful to a larger group of astronomers who do not always need the present computer-controlled automated telescope steering and data collection facility. To minimize the inevitable disruption in the use of the Observatory, the work has been planned in three phases, the first of which has been partially completed and will be finished during the summer academic recess.

During this first phase, new motors and gear trains will be installed in the telescope to improve the steering precision and to provide faster slewing and guiding rates. The electronic circuits that actuate the drive motors have been redesigned so that the steering controls and position displays required by the observer can be located in the telescope dome. This arrangement will provide maximum operational convenience for manual control of the telescope. Also during the initial phase, certain structural members of the dome which support the hoist used to assemble and disassemble the telescope will be reinforced to provide a larger margin of safety for heavy loads.

The second and third phases of the redesign will be carried out and implemented as time and funds permit. In the second phase microprocessor-based computing facilities will be added to the equipment in the telescope dome. These facilities will be used to perform corrections for gear nonlinearity and for air mass and will remove these calculations from the central computer.

In the third phase the computing facilities in the dome will be expanded to allow the observer to specify a list of targets which are to be scanned sequentially. At this point, it will be possible to operate the telescope in an automated mode without involving the central computer which will be used exclusively for data reduction and analysis. The second and third phases will be scheduled during slack periods when the telescope is not being used for research purposes.

Because of the problems experienced with the 24-inch telescope drive, most of the research program planned for this instrument in 1977-78 was not accomplished, although one project was essentially completed.

During the fall term of 1977 and spring term of 1978, the 16-inch telescope was used regularly by students enrolled in the sequence of courses 12.111 - 12.114 taught by Professor William H. Pinson. Approximately 50 students used the facility.

HERBERT S. BRIDGE
Vice President and Dean of the Graduate School

The annual reports for the Medical Department -- including those for the Environmental Medical Service, Radioactivity Center, and Division of Laboratory Animal Medicine -- and for the Registrar follow my own reports on the Graduate School and the Institute's student housing programs.

DEAN OF THE GRADUATE SCHOOL

I have not attempted to count the number of regional educational associations which in some way or other address matters of graduate education. I know the number is certainly well over 10 and I suspect it may approach 100. Thus, we at M.I.T. cannot hope to relate effectively to even a bare majority of these groups.

Prominent among the associations with whom we do relate are the Council of Graduate Schools (the CGS), the Association of Graduate Schools (the AGS), and the DWA (a small sub-set of the AGS). My associates in these organizations are typically graduate deans of faculties of arts and sciences; some are responsible also for the engineering disciplines, but few are concerned with architecture or management education. Thus, the agendas for our meetings tend to be dominated by matters of particular concern to arts and sciences -- which, for M.I.T., would translate principally to the Schools of Science and of Humanities and Social Science. Over the past few years discussions focusing on these agenda items have become increasingly pessimistic, if not downright gloomy. The simple fact is that most graduate programs in the arts and some in the social sciences are in serious trouble. Projections of the nation's future needs for persons holding doctoral degrees in these disciplines are dismal indeed. In many institutions, administrations and faculties are struggling with major issues concerning their futures; morale is seriously impaired; and these conditions often seem to impact negatively on related undergraduate programs.

I sometimes find myself having to exercise considerable restraint to overcome a feeling of complacency or smugness during these discussions. While M.I.T. has severe problems in graduate education -- particularly in providing graduate student financial support -- we do find ourselves in a world in which graduates from essentially all of the disciplines represented in our graduate programs are in considerable current demand, and future projections are relatively promising. While it is true that graduates in certain disciplines (physics or mathematics, for example) are not subject to the very intense placement recruiting they enjoyed a few years ago, no one at M.I.T. seriously questions the need to provide long-term continued support to the faculties and students of the departments affected -- a difference in kind from the situations faced by many disciplines and therefore many departments at other universities.

We cannot be complacent about our own future, nor can we be complacent about the long-range impact upon the intellectual life and fabric of our society which current disaffection with many areas of graduate education may portend. Certainly in our maturing society, "more" is not necessarily "better," but too little is clearly bad. Thus, it is incumbent upon us to work
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closely within M.I.T. and with our colleagues at other institutions to find ways in which to maintain health and vitality in programs of quality across all disciplines.

Evidence of the Institute's continuing strength is set forth in the traditional Graduate School statistics which are set out in Tables I, II, and III.

**Graduate Student Financial Support**

In my report for last year, I explored the generally pessimistic projections of our ability to meet the financial needs of individual graduate students. There have been no major changes in this situation over the intervening year. An overview of these problems is set forth in Table IV. The trends are best observed through the numbers in parenthesis, which are constructed in such a way as to take approximate account both of the growth in the total graduate student body and of inflation.

The figures in the first column are the annual totals of awards made by M.I.T. to M.I.T. students (from internally controlled funds or funds provided to M.I.T. from outside sponsors for support of M.I.T. students) and those made directly by outside sponsors to M.I.T. students. The drastic reduction over the decade is primarily the result of the decline of support through various Federal programs.

The figures in the second column are a measure of the relative level of support through appointments to teaching assistantships since each teaching assistant receives a tuition award plus a stipend toward living expenses. While relatively constant over most of the past decade, the modest decline in this form of support over the past few years is a reflection of more stringency in departmental teaching budgets.

The third column reports the total annual salaries paid to teaching assistants and research assistants. Unlike teaching assistants, research assistants receive a salary from which they are required to pay their tuition charges. The relative stability in this column reflects the Institute's heavy dependence on sponsored research for graduate student support. The recent downturn is a reflection of the decline in the number of teaching assistant appointments (the number of research assistant appointments has increased slightly) and of stringency in granting annual stipend increases. (R.A. and T.A. stipends are no longer established with the intent of necessarily meeting the full living cost of the recipients. Unfortunately, it has not been possible to provide increments to keep pace with inflation over the past few years).

Finally, the data in the column headed loans shows evidence of the increasing tendency of graduate students to borrow in order to cope both with declining scholarship and fellowship support and with increasingly stringent stipends. In fact, the impact of the combined demands of undergraduate and graduate students for loan support together with worrisome repayment statistics for some foreign students provided the stimulus for a major re-study of our student loan policy over this past year. The modifications to our policy which resulted are reported in more detail in the Report of the Vice President for Administration and Personnel. The changes at the graduate level will impact primarily upon foreign students since they must now show evidence upon admission of not requiring M.I.T. loan support for their first year of study and must have a credit-worthy cosponsor should they wish to draw upon M.I.T. loan support following their first year.

Given these trends, we have been particularly anxious to utilize College Work Study Program (CWSP) funds more effectively at the graduate level, and a new program toward this goal was initiated this year. Under this new program, eligible teaching assistants were supported by CWSP, and it was possible to augment departmental budgets for T.A. support, thereby partially counteracting the impact of budget stringency on the number of T.A. appointments. The new
program is not without drawbacks, however. In order to establish each student’s eligibility
to be supported by CWSP, it is necessary that the student complete a financial need analysis
form. In addition, CWSP regulations require that students be compensated on an hourly basis
and, hence, that time cards be maintained. Some graduate students and faculty understandably
react negatively to one or both of these requirements.

With considerable faculty assistance, the staff of the Student Financial Aid Office, which is
responsible for implementing both undergraduate and graduate CWS programs, has developed
a need analysis which provides the required financial information with minimal intrusion.
We have also found that the CWSP provision that students be paid on an hourly basis is a
regulatory and not a statutory requirement. Accordingly, together with several other
institutions we are seeking to have those regulations modified to permit compensation for
certain graduate work -- such as teaching assistants -- on a "usual and customary" basis
(which is a monthly salaried basis).

Another governmental ruling has consumed considerable time over this past year. In late
December 1975, the Internal Revenue Service issued a letter to the National Institutes of
Health (NIH) stating that the IRS would tax the support received by graduate students through
the National Research Service Award program effective with the beginning of the program in
calendar 1974, and extending through the life of the program to calendar 1979. Since the NIH,
the cooperating institutions, and the students supported had been treating these awards as
scholarships or fellowships and hence not subject to tax, considerable confusion and protest
followed. Despite our efforts to the contrary, the IRS stated its position as a formal ruling
in September 1976. During the intervening period and extending through to this time, we have
worked toward achieving legislative relief from what we believe to be an unfair retroactive --
if not illegal -- move by the IRS. At this writing, I can report that the Senate has passed
HR 9251 which includes a moratorium on the taxation of these NRSA awards for the period
1974 to 1979. Conference on the bill has been delayed, but we do anticipate a favorable action
in the very near future.

During the course of these efforts, we have learned more of the considerations which may
influence a report on taxation of scholarships and fellowships to go to the House Ways and
Means Committee early in 1978. The following is quoted from a report from a Washington-
based observer to several educational institutions:

The General Accounting Office is expected to provide the Staff of the Joint
Committee on Taxation with a survey on the present tax status of scholarships
and fellowships in January. The Staff, in response to the requests included
in the legislative history with respect to the Tax Reform Act of 1976 will
utilize this as a basis for making an analysis of the tax status of scholarships
and fellowships for the benefit of the Ways and Means Committee and Finance
Committee. There are two approaches under consideration. First, the
present scholarship programs, public and private, are being examined to
determine what "strings" are attached to them by the donor with the thought
that certain categories of required consideration would cause a scholarship
to be taxable. The second is to differentiate grants for tuition and fees from
grants for cost of living. Under this approach, it is expected that the living
expense portion of scholarships and fellowships would be treated as taxable.
The effect of this on grantees would depend in part upon the effect of the reduced
tax on low-income individuals. Equally important is the extent to which Congress
can be persuaded to liberalize the exclusion of tuition and fees as broadly defined.

In any event, we must anticipate that the issue of statutory changes with respect
tax status of scholarships and fellowships may be considered by the Ways and
Means Committee in 1978.
In addition, some "usually reliable sources" report that another approach under consideration is to continue to exempt from taxation those awards which are made on the basis of the student's financial need but to tax those awards which are made solely on the basis of merit. While the financial support processes and policies at the undergraduate level have been developed over many years so that there is a reasonably uniform acceptance of financial need as a necessary criterion for financial support, there is currently a wide disparity in points of view at the graduate level. In some disciplines, an approach very much like the undergraduate approach is utilized. Many other disciplines are at the other end of the spectrum and support is awarded to graduate students purely on the basis of merit without regard to financial need. And still other disciplines are "somewhere in the middle."

Finally, further to compound the dilemma -- again unlike the undergraduate situation -- there is no generally accepted basis for establishing the financial need of graduate students even if support is to be awarded on a need basis. Questions of whether and how to evaluate parental resources are probably the most difficult ones upon which to get general acceptance by students, parents, and faculties.

I believe that, in addition to problems posed by having increasingly scarce resources available to support graduate students in the future -- and probably resulting from this scarcity -- we will have even greater difficulties in achieving agreement or acceptance of the bases on which we allocate these resources.

On a closely related topic, I should like to be able to report that we have been able to formulate new graduate tuition policies which reflect, on the one hand, the need of the Institute to maximize tuition income and, on the other hand, are responsive to the competitive pressures many of our departments experience, particularly in the School of Architecture and Planning and the School of Humanities and Social Science. In their relationships with their counterparts at other prestigious private universities, faculties in these schools find our current policy of charging full tuition during the entire period a student is making progress toward his/her degree to be uncompetitive. Most other universities charge reduced tuition levels as the student progresses through successive stages of his/her degree candidacy. (Most also have relatively more institutionally controlled funds available for scholarship and fellowship support.) Unfortunately, we have not been able to find a solution to this dilemma, so we intend to continue to address this problem over the coming year.

I close this section of my report on a bright note. In keeping with our past record, M.I.T. continues to enjoy high popularity among the winners of the prestigious National Science Foundation fellowships. In September 1978, we expect to register 55 new NSF fellows (about 11 percent of the national total) to bring the total number of NSF fellows in residence next year to 153.

Committee on Graduate School Policy

In addition to participating in discussion of matters relating to the financial support of graduate students discussed in the preceding section, the Committee on Graduate School Policy addressed a number of matters of academic policy. These discussions will continue through to next year.

A subcommittee chaired by Professor David J. Epstein of the Department of Electrical Engineering and Computer Science is concerned with limitations on numbers of authors of graduate theses and with clarification of policies with respect to acceptance of one thesis for more than one degree. In addition, the Committee is reviewing the proliferation of fields of graduate study which has evolved over the years with the view that simplification may be in order.
Another subcommittee chaired by Professor Warren M. Rohsenow of the Department of Mechanical Engineering is reviewing our several existing interdepartmental graduate programs. While M.I.T.'s academic structure is of remarkable flexibility and encourages interdepartmental and interdisciplinary efforts, it is important that guidance and evaluation be provided for those programs which are not parts of regular academic departments. By working with the faculty responsible for several interdepartmental programs, this subcommittee intends to provide such guidance and review.

Professor Gordon H. Pettingill of the Department of Earth and Planetary Sciences chairs a subcommittee whose concern is the evaluation of student performance and the validity of the processes employed in the various departments to make certain that students are fairly evaluated and informed of their progress.

The C.G.S.P. subcommittee on subjects of instruction is chaired by Professor Zenon S. Zannetos of the Sloan School of Management. This subcommittee acts on behalf of the entire C.G.S.P. in approving new graduate subjects of instruction submitted by the academic departments. Such matters as level ("graduate" or "graduate A") and departures from the standard ABCDF grading system are of concern to this subcommittee.

An ad hoc subcommittee on admissions, chaired by Associate Dean John B. Turner, has worked with the Admissions Office in revising new admissions forms and a new scheme for acquiring and processing the data on these forms. The new approach was first utilized for candidates for admission in September 1978. An evaluation of the changes is now under way.

The C.G.S.P. also sponsored a graduate admissions cancellation study carried out by the Admissions Office for the first time with candidates for admission in September 1977. Each candidate to whom admission was offered was asked whether or not he or she accepted the offer and why. Although this format was "open-ended," the Admissions staff was able to classify several categories into which the responses fell. For both candidates who accepted our offers and those who did not, the most attractive characteristics of M.I.T. reported are the perceived quality of the institution, its faculty, and its programs. The most unattractive are high cost (both tuition and Boston-area cost of living) and low level of financial support. Such considerations as geographical location, size, urban-bucolic environment, etc. seemed to be attractive to about as many as they were unattractive. Our primary "competitors," as identified by these candidates, varied considerably from discipline to discipline. However, across the board, Stanford seemed to emerge as a stronger competitor than others, perhaps reflecting our two prestigious Schools of Engineering. Individual departments have been asked to assist in formulating improvements for a similar study which will be performed for those offered admission for September 1978.

The effect of the new copyright law on graduate theses was a matter of some concern over the year. M.I.T.'s long-standing policy had been "theses are the permanent property of the Institute." Thus, the new law has a major impact in that it provides that the thesis copyright rest with the individual student unless his/her thesis resulted from "work for hire." Not only is it necessary to define carefully what is "work for hire," it is also important to make certain that theses continue to be available through normal library distribution mechanisms. At this writing, the major issues have been resolved but there remain several matters to be clarified.

Finally, after study of recommendations brought to it -- sometimes of a protracted nature -- the C.G.S.P. recommended to the faculty: the establishment of the new degree, Master of Science in Visual Studies; the establishment of the new degree, Master of Science in Architecture Studies; and the discontinuation of the existing degree (after the class admitted in September 1978), Master of Architecture in Advanced Studies; all in the Department of Architecture.
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The C. G. S. P. also approved and reported to the faculty: the establishment of a new program in the Department of Nutrition and Food Science leading to the degree, Doctor of Philosophy in Human and Clinical Nutrition; and the establishment of a new track in Science Communication in Course XXV leading to the existing degree, Master of Science in Interdisciplinary Science.

Graduate Women

From 1971 to 1976 the percentage of women enrolled in M. I. T.'s Graduate School increased from 8% to 14.5%. However, as is shown by the data in Table V, although enrollment of women reached an all-time high of 559 during the fall of 1977, this total represented only 14.6% of all graduate enrollment and only a small increase in the number of individuals from the fall of 1976. Our enrollment of women does not parallel the national picture. Nationally, there has been an overall leveling-off in total graduate enrollments from 1976 to 1977. But within this total, there is an increase of 5% in enrollment of women in graduate programs in all areas and an 11% increase in science and engineering.

Comparison of the data in Table I with that in Table V reveals interesting information on the concentration of M. I. T.'s graduate women enrollment within Schools. For fall 1977, only 6% of M. I. T.'s total male graduate enrollment was in the School of Architecture and Planning while 19% of our total female enrollment was in that School. Some 52% of M. I. T.'s total male graduate enrollment was in the largest School, the School of Engineering, while only 21% of the total graduate women are enrolled in Engineering. Although a marked increase in numbers of women enrolled in Engineering has taken place during recent years, there remains a challenge to attract more women in this area.

The number of graduate women applicants to the entire Institute increased by 6% (1,170 to 1,240) from 1976 to 1977, while the number of male applicants increased by 2%. It is heartening but not surprising to note from the data in Table VI that the greatest increase in female applicants was in the School of Engineering(+34%) with corresponding decreases in Architecture and Planning (-17%) and Humanities and Social Science (-17%), trends which probably reflect the influence of the national job market.

Data showing the pattern of degrees awarded to women by School, compared with degrees awarded to men, are set out in Tables VII and VIII. Women received 13% of all of the graduate degrees awarded by M. I. T. during 1977-78. They received 11% of the doctoral degrees and 14% of the master's degrees. The total of 182 degrees represents a slight decrease from last year's all-time high of 196 degrees won by women. Worthy of particular note, however, is the increase from 28 to 42 Master of Science degrees awarded to women by the departments in the School of Engineering. In addition, two women received doctoral degrees from the Sloan School for the first time, and -- as nearly as can be ascertained from our records -- one of the first two doctoral degrees won by a Native American was awarded to a woman by the Department of Linguistics and Philosophy. The large increase in master's degrees received by women may reflect the growing job opportunities and rising salary levels for those individuals who have some advanced training but have not undertaken research concentrations typified by doctoral degrees. There is, of course, a shortage of women with graduate degrees in technical fields.

A decrease (34 to 23) in the women receiving master's degrees from the School of Architecture and Planning may also reflect the less favorable job market in this area. While data for the School of Science shows a drop in women receiving both master's degrees (25 vs. 32) and doctoral degrees (25 vs. 28), the most disappointing data shows that, whereas eight women received doctorates in Engineering last year, this number was halved as only four women received their doctorates this year. Although the totals indicated an overall increase from
6 percent in 1971-72, when women received 73 of the 1,186 degrees awarded, to 13 percent (182 of 1,359) in 1977, it is important to note that the increases are modest when expressed as total numbers.

The impact of continuing decline in financial support for graduate students is reviewed in an earlier section of this report. While these facts influence enrollment of all graduate students, they also affect, perhaps disproportionately, enrollment of women. At M.I.T., the largest number of women continue to be enrolled in those programs whose financial resources are most limited.

This year we completed our fifth annual competition for the Ida M. Green fellowships, one of only two endowed funds at M.I.T. currently earmarked for support of women. This year six such awards were made, bringing the grand total for five years to 31 women so honored. In addition, this year one woman was designated as an Honorary Ida M. Green Scholar, since she will receive financial support from an NSF fellowship. Four honorary awards have been made previously. A cross section of M.I.T.'s departments is represented by these women scholars and such funds are important in attracting and increasing qualified women in M.I.T.'s graduate programs.

Two continuing women graduate students were awarded Collamore-Rogers fellowships. Although the income from the endowment given to M.I.T. to help women in their graduate studies is not adequate to cover these fellowships, we were able to use several small accumulated resources in other funds as supplements in order to be able to give two awards. We took this action because both women were outstandingly qualified and deserving of this honor.

Women at M.I.T. have also been recipients of awards from IBM and Xerox Special Opportunity Programs for minorities and women pursuing graduate study in specific areas of interest to these companies.

At least two M.I.T. graduate women received dissertation fellowships from the American Association of University Women and four women received awards from the Danforth Foundation. Minority women at M.I.T. continue to be successful in obtaining fellowships from the National Fellowships Fund; there were seven (out of 13) such recipients this year. Two of the five recipients of fellowships from the Graduate Fellowship Fund for Mexican Americans, Puerto Ricans, and Native Americans were women. Other women students received fellowships in national competitions from the National Science Foundation, the Hertz Foundation, the National Institutes of Health, and Bell Laboratories for their graduate studies at M.I.T.

Graduate Minorities

As this academic year came to a close, many of us were preparing ourselves for still another period of anxious uncertainty because we had no measure of the time scale or of the probable direction of the Supreme Court's decision on the Bakke case. At the very end of the year, the Court issued its findings and, although it is far too early to comprehend the full impact, we do feel we will be able to continue and strengthen our current policies and practices in our affirmative action programs for admission and support of minority students. The following simple statement released by our President and Chancellor on June 28, 1978 speaks for us all:

On the basis of our present understanding of the Supreme Court's decision, we do not believe that M.I.T.'s admissions procedures are at variance with those sanctioned by the Court. M.I.T. has no quotas nor a fixed number of places
in the class "set aside" for minority students, the particular feature of the
University of California Medical School admissions procedure to which the
Supreme Court took exception.

A complete assessment of the decision will have to wait on a full and careful
reading of the opinions in the case; however, M.I.T. is strongly committed
to providing the opportunity for an M.I.T. education for members of racial
minority groups, and, consistent with the Court's decision, we will continue
to make a determined effort to increase their number among the M.I.T.
student body.

We hope that the decision will not be misread as a signal to lessen efforts to
increase opportunities for minorities in our society.

For the first time in five years our minority graduate student enrollment has decreased from
the previous year, from 178 minority graduate students in 1976-77 to 157 in 1977-78. The
decline was most keenly felt in three departments: Architecture, Urban Studies and Planning,
and Economics. We believe the primary reason for the decrease in minority applicants and
corresponding decrease in minority admissions to these departments was our inability to
provide full financial support to entering students in these departments. Although the Graduate
School Office is able to provide a number of tuition awards for entering minority graduate
students, we do not have funds to provide stipends nor do these departments have funds to
complement our tuition awards. Most minority students cannot consider enrolling in graduate
programs if they do not receive full or nearly full financial support. Many of them come from
low-income families where an additional financial burden for graduate study would be
catastrophic.

We are working with these three departments to try to develop strategies to cope with the
problem, including writing proposals for outside fellowship assistance (i.e., HUD, Ford
Foundation, etc.). Minority graduate students should also benefit from our new CWS Program
and the possible development of a more equitable tuition policy for graduate students who are
writing their theses away from campus and are not using the Institute's facilities or a major
portion of faculty time.

Minority enrollment this year in the Schools of Engineering, Science, Humanities and Social
Science, and the Sloan School of Management is about equal to that of last year. If we continue
the programs we now have in place, we forecast an increase in enrollment in these Schools in
the coming years.

The National Consortium for Graduate Degrees for Minorities in Engineering, Inc., of which
M.I.T. is a founding member, is completing its second year of operation. This program
identifies minority undergraduates during their junior year and provides summer employment
for them at a research laboratory and subsequently underwrites their expenses through
graduate school for the master's degree. There will be 100 students in the program in the
steady state. We will have eight Consortium students enrolled in the School of Engineering
at M.I.T. for 1978-79. In two years this has become one of the most popular programs in the
country for minority youngsters interested in pursuing a career in engineering.

Lincoln Laboratory's Summer Work and Study Program for students from southern black
colleges will enter its fourth year of operation in the summer of 1978. Students who are
selected to be in the Program have successfully completed one year of undergraduate study
at a predominantly black institution and their major or intended major field is electrical
engineering or applied physics. Twenty-seven students arrived on campus in June 1978 and
were later assigned to positions in the Laboratory as technical assistants. Juniors and
seniors in the Program also attend classes at M.I.T. that are taught by M.I.T. professors
and laboratory instructors. The students live on the M.I.T. campus and commute to Lincoln Laboratory via the shuttle bus. The Lincoln Laboratory Program is unique in that it recruits students in their freshman year of school and provides summer employment for them until they receive an undergraduate degree. Students may then apply for admission to our Departments of Electrical Engineering and Computer Science or Physics.

The first Lincoln Laboratory Summer Work and Study Program students received their undergraduate degrees in May 1978. There were three graduates, and all three applied to the Department of Electrical Engineering and Computer Science for graduate study. Two were admitted, Sheila Rogers from Tennessee State University and Cedric Wooten from Southern University in Baton Rouge, Louisiana. Both students received staff associateships from Lincoln Laboratory to cover their expenses for graduate school at M.I.T. This program proved to be inspiring to these two students in more ways than one, for they also decided to get married the day after they received their bachelor's degrees. The program is very promising and there will be eight students graduating from it next year. M.I.T. hopes to attract a large percentage of these students for graduate study in the years to come.

Dean John B. Turner, Associate Dean of the Graduate School, prepared a proposal to the Office of Education in April 1978 for an institutional grant and fellowship program under a new Title IX program called "Graduate and Professional Opportunities Program." I am pleased to report that we were one of a small group of graduate institutions across the country to receive a grant. We will receive nine fellowships and an institutional grant of $20,000 for the academic year 1978-79. These will be used to support activities which help to increase access into graduate and professional education by making fellowships for graduate and professional study available to members of groups, particularly minorities, that have traditionally been underrepresented among recipients of graduate and professional degrees. The fellowships are restricted to underrepresented minority graduate students in the Schools of Engineering and Science and they cover tuition, fees, and a stipend of $325 per month for 12 months. These fellowships can be renewed for a period of up to 36 months. This is the first year the program has provided funds for graduate education and we are told that the program’s funding will be increased next year. Funded institutions should correspondingly receive more money for fiscal 1979.

This new program created by the Office of Education provides a tremendous boost to M.I.T.'s Minority Graduate Student Affairs Program, for it allows us to go out and recruit new students and back up our offers of admission with full fellowships for three years.

Increased minority participation in graduate education is an important goal for the Massachusetts Institute of Technology and for the nation. It is a goal that must be realized in order to assure social, economic, intellectual, and cultural well-being for all persons and for the collective benefit of society. If we are going to make any headway in enlarging the pool of minority persons in engineering, the biological and physical sciences, and management, then doctoral-granting institutions such as M.I.T. should and must provide the impetus and leadership in producing well-educated and trained persons with advanced degrees in these areas of study.

Toward these goals, we formed an Ad Hoc Advisory Committee for Recruitment and Support of Minority Graduate Students at M.I.T. in March 1978. We asked this group of distinguished scientists, business people, and educators drawn from several sectors of our society to give freely of their time to discuss ways of improving and maximizing current efforts at the Institute in minority graduate student affairs. There are three M.I.T. Corporation members on the Committee as well as several black alumni, a black college president, M.I.T. professors and administrators, and the Chancellor of the Board of Higher Education for the State of Massachusetts.
Our first meeting was held on April 14, 1978 and a follow-up meeting is planned for the fall term of 1978-79. The Committee's advice and guidance have been very helpful over the year and we look forward to working with them very closely in 1978-79.

Dean Emeritus Irwin Sizer and Donald Johnson in the Development Office have worked closely with Dean Turner in identifying and cultivating additional fellowship funds for minority graduate students in the life sciences. As a result of their efforts, M.I.T. was successful in receiving a grant from the Sandoz Foundation, establishing the Sandoz Fellowship for Minorities in the Life Sciences. Neal Scott, a black student who is working toward his Ph.D. in the Department of Nutrition and Food Science, was recently named the first recipient of the Sandoz Fellowship for 1978-79.

Over the past four years we have received fellowship grants for minority graduate students from a number of sources: IBM, Xerox, Bell Laboratories, the Danforth Foundation, the National Fellowship Fund, the Council for Opportunity in Graduate Management Education, the National Science Foundation, Draper Laboratory, Lincoln Laboratory, HUD, among others. As I observed earlier, we have not been able to provide stable financial support programs in those departments where we have the largest minority pool, i.e., Architecture, Urban Studies and Planning, Economics, and Political Science. The challenge before us in the next few years will be to develop strategies that will help us to maintain our minority numbers in those few departments that can offer adequate financial support, and at the same time to develop additional strategies to cope with the underrepresentation of minorities in the sciences, engineering, and management.

It will be a long and continuous struggle but we feel that M.I.T. has the will, vitality, and the wherewithal to meet the challenge. Given the Bakke decision by the United States Supreme Court, the grant from the Office of Education, the advantage of counsel from the Ad Hoc Advisory Committee for Recruitment and Support of Minority Graduate Students, the active participation of distinguished faculty members like Professor Ernest G. Cravalho in our minority recruitment program, strong administrative support, an expanded and more involved black alumni network, a workshop in the fall to bring faculty from black colleges to meet faculty at M.I.T. in order to establish better communications and faculty ties, and general support and cooperation from the departments, M.I.T. should have a bright future in minority graduate student affairs.

Graduate Study Abroad

The gradual increase in the number of applications received by the Foreign Scholarship Committee from our seniors and graduate students for grants for graduate study abroad continued this year. The Committee reviewed 22 applications for scholarships for graduate study abroad: eight for the Fulbright-Hays program, seven for the German Academic Exchange Service (DAAD) Scholarship Program, and seven for the Winston Churchill Foundation Scholarship Program. Of the eight applicants for the Fulbright-Hays grants, three passed the National Screening Committee's preliminary application stage; unfortunately, none were successful in the final competition.

The Committee submitted the nominations of two principal and two alternate candidates to the German Academic Exchange Service (DAAD) for their scholarship competition. Three of the four candidates were awarded grants for one year of graduate study in the Federal Republic of Germany. They are: Robert B. Doak, Department of Aeronautics and Astronautics; Leland M. George, and James D. Pustejovsky, both of the Department of Linguistics and Philosophy.
In the competition for the Winston Churchill Foundation Scholarships, two of the three candidates nominated by the Foreign Scholarship Committee won scholarships for a year of graduate study at Cambridge University. A total of only 10 Churchill Scholarships were awarded throughout the entire United States. The two Churchill Scholars from M.I.T. are Susan N. Coppersmith, Department of Physics, and Robert M. Zimmer, Department of Mathematics.

In an attempt to increase students' awareness of the scholarship opportunities for graduate study abroad, an I.A.P. activity was held in January on this topic. Representatives from the Fulbright-Hays, Churchill, DAAD, Marshall, Rhodes, and Luce Scholarship programs gave presentations on their respective programs. It is the Committee's hope that this activity, along with additional publicity efforts, will help enlarge the pool of applicants from M.I.T. for the 1979-80 scholarship competitions.

I would be remiss if I did not take this opportunity to thank Professor Martin A. Abkowitz, who has served as the chairman of the Foreign Scholarship Committee for the past three years. We acknowledge his generous gifts of time and leadership on behalf of the Committee. Professor Abkowitz completed his term in a very fitting way by winning a senior Fulbright-Hays grant to Israel.

HOUSING

Despite the fact that capital gifts for student housing have been considered of high priority in our current development efforts, we have continued during 1977-78 to be unsuccessful in soliciting large gifts for the funding of additional student housing. As a consequence, we have not felt it wise to initiate any planning for additional student housing on campus -- either for undergraduates or graduate students.

Given this austere framework, it is particularly heartening that we have been able to recognize the generosity of Jonathan Y., Class of 1923, and Blanche Ballard; William A. Coolidge; Thomas G. Desmond, Class of 1909; and Leonard D. Lawrence, Class of 1929, in the naming of four of the new West Campus houses in their honor. This highlight of the year is reported in some detail by the Dean for Student Affairs.

As I reported last year, we were faced in September 1977 with the need to find housing for approximately 100 more first-year students than we had anticipated in setting admissions targets. To meet this need, we utilized the last available housing resource near the campus by converting Random Hall to an Institute house. Although not of a quality we would wish to characterize as an undergraduate Institute house, Random Hall has proved to be an adequate solution during the intervening year and will be kept in operation for the foreseeable future.

For September 1978, we have set the first-year admissions target at 1,050 students, which we predict will result in an undesirable but tolerable overcrowding in the undergraduate houses of 100 to 110 over design capacity. This level of overcrowding does, of course, impact on many more students than the additional 100 housed in this manner. The total size of the undergraduate body during fall term 1978 is predicted to be in the range of 4,550 to 4,600.

If we choose to maintain this level of overcrowding over the next several years -- and if we continue generally to deny access to on-campus housing to incoming college transfer students and to undergraduates who have not been in residence in an Institute house continuously -- we will be able to admit about 1,075 new first-year students each year. We estimate that this rate of admission will result in relative stability of the undergraduate study body at about 4,500.
All of these estimates are made under the assumption that there will be no significant changes in the fraternities and other independent residences, in the nature of the free choices M.I.T. grants to upperclass students in selecting housing, or in the patterns of yearly registration leading to the Bachelor of Science.

Clearly, we very much need an additional undergraduate house of about 300 capacity to relieve the present overcrowding, provide on-campus housing for college transfer and returning upperclass students, and to provide permanent on-campus housing to replace the temporary off-campus housing in Random Hall.

I also reported last year on the conversion of an apartment building at 351-355 Massachusetts Avenue, Cambridge, to house two new independent residence groups -- one a cooperative for undergraduate women and one a fraternity for undergraduate men. This project was completed in time for fall occupancy and the undergraduates involved exhibit all of the characteristics of promising, healthy, independent resident groups. We had based the financial planning for this conversion on hoped-for future availability of funding from our Independent Residence Development Fund (the "IRDF"). However, the Federal government reopened the College Housing Program through HUD with priorities defined in such a way as to make this project appear of high priority. Accordingly, we applied for and received a Federal loan under terms of 3 percent-40 years to provide the required permanent financing. Thus, this project's demand for possible future IRDF funding has been withdrawn, and the resident students will occupy their new houses at rental rates which reflect these very favorable terms, and which are therefore in line with rental costs in other undergraduate facilities.

Although we do not see any near-term relief to the financial dilemma of constructing additional on-campus housing, my hope is that we can, over the coming year, undertake a modest review to update our understanding of the projected needs for both undergraduate and graduate students.

KENNETH R. WADLEYEIGH
For simple comparison with data for 1976-77, the statistical information on Tables I, II, and III for 1977-78 is presented in the same format. Numbers in parenthesis indicate the changes from 1976-77 to 1977-78.

Table I  REGULAR GRADUATE STUDENT ENROLLMENT, FALL TERM 1977

<table>
<thead>
<tr>
<th>School</th>
<th>Foreign*</th>
<th>Women**</th>
<th>Minority***</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>School of Architecture and Planning</td>
<td>76(+20)</td>
<td>104(+5)</td>
<td>44(-15)</td>
<td>293(+5)</td>
</tr>
<tr>
<td>School of Engineering</td>
<td>642(+38)</td>
<td>118(+8)</td>
<td>40(-4)</td>
<td>1,799(+25)</td>
</tr>
<tr>
<td>School of Humanities and Social Science</td>
<td>77(+5)</td>
<td>73(+4)</td>
<td>21(-6)</td>
<td>285(0)</td>
</tr>
<tr>
<td>Sloan School of Management</td>
<td>108(+12)</td>
<td>82(+3)</td>
<td>20(+3)</td>
<td>384(-12)</td>
</tr>
<tr>
<td>School of Science</td>
<td>248(+17)</td>
<td>182(-7)</td>
<td>32(+1)</td>
<td>1,063(+32)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,151(+92)</td>
<td>559(+13)</td>
<td>157(-21)</td>
<td>3,824(+50)</td>
</tr>
</tbody>
</table>

* Includes Canadians
** See also Table V
*** Includes Black Americans, Puerto Ricans, Mexican-Americans, and Native Americans

Table II  GRADUATE DEGREES AWARDED, 1977-78

<table>
<thead>
<tr>
<th>Advanced Degrees Conferred</th>
<th>M.C.P., M.Arch., M.Arch. A.S.</th>
<th>S.M.</th>
<th>Engineer</th>
<th>Sc.D.</th>
<th>Ph.D.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 1977</td>
<td>12(-2)</td>
<td>175(+3)</td>
<td>24(+8)</td>
<td>9(-4)</td>
<td>116(+7)</td>
<td>342(+12)</td>
</tr>
<tr>
<td></td>
<td>1(WH)*</td>
<td></td>
<td>1(WH)*</td>
<td></td>
<td>5(WH)*</td>
<td></td>
</tr>
<tr>
<td>February 1978</td>
<td>11(-4)</td>
<td>207(-13)</td>
<td>33(+6)</td>
<td>20(+1)</td>
<td>99(+13)</td>
<td>373(+3)</td>
</tr>
<tr>
<td></td>
<td>3(WH)*</td>
<td></td>
<td>3(WH)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 1978</td>
<td>53(-10)</td>
<td>476(-11)</td>
<td>51(+3)</td>
<td>16(-5)</td>
<td>154(+34)</td>
<td>752(+11)</td>
</tr>
<tr>
<td></td>
<td>2(WH)*</td>
<td></td>
<td>2(WH)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>76(-16)</td>
<td>858(-21)</td>
<td>108(+17)</td>
<td>46(-8)</td>
<td>379(+54)</td>
<td>1,467(+26)</td>
</tr>
</tbody>
</table>

* Woods Hole Oceanographic Institution
Table III
A "SNAPSHOT" OF GRADUATE STUDENT SUPPORT "FULL AWARDS"

The following sources provided at least full tuition support for graduate students during fall term, 1977. Total regular graduate student enrollment was 3,824.

<table>
<thead>
<tr>
<th>FELLOWSHIPS AND TRAINEESHIPS AWARDED BY M.I.T.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIH and NIMH Traineeships</td>
</tr>
<tr>
<td>NSF Energy and National Needs Traineeships</td>
</tr>
<tr>
<td>ERDA Traineeships</td>
</tr>
<tr>
<td>HUD Minority Intern Program</td>
</tr>
<tr>
<td>HEW Domestic Mining and Mineral Fuel Traineeships</td>
</tr>
<tr>
<td>HEW Public Service Education Traineeships</td>
</tr>
<tr>
<td>EPA Traineeships</td>
</tr>
<tr>
<td>M.I.T. Endowed and Other Fund Fellowships</td>
</tr>
<tr>
<td>Industrial and Foundation Fellowships</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FELLOWSHIPS AWARDED BY SPONSORS TO M.I.T. STUDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF Graduate Fellowships</td>
</tr>
<tr>
<td>NIH and NIMH Fellowships</td>
</tr>
<tr>
<td>Hertz Foundation Fellowships</td>
</tr>
<tr>
<td>EPA Fellowships</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STUDENT ASSISTANTSHIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
</tr>
<tr>
<td>Teaching</td>
</tr>
<tr>
<td>Instructor-G</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPONSORED STUDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many students receive support from employers and sponsors. The following reflect Student Accounts billings for tuition to employers and sponsors, who presumably provide stipends to students by private arrangements.</td>
</tr>
<tr>
<td>US Army and Related Programs</td>
</tr>
<tr>
<td>US Navy and Related Programs</td>
</tr>
<tr>
<td>Foreign Countries and International Programs</td>
</tr>
<tr>
<td>Industry and Foundation</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
</tr>
</tbody>
</table>

**SUMMARY BY SOURCES -- FULL AWARDS**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Fellowships and Traineeships</td>
<td>312</td>
</tr>
<tr>
<td>Graduate Student Staff</td>
<td>1,828</td>
</tr>
<tr>
<td>Industrial and Foundation Awards</td>
<td>137</td>
</tr>
<tr>
<td>M.I.T. Endowed and Budgeted Funds</td>
<td>227</td>
</tr>
<tr>
<td>Students Sponsored by External Sources</td>
<td>660</td>
</tr>
<tr>
<td><strong>TOTAL AWARDS</strong></td>
<td>3,164</td>
</tr>
</tbody>
</table>
Table IV
TRENDS IN GRADUATE STUDENT SUPPORT

The values reported are the annual sums in thousands of dollars. The numbers in parenthesis are "normalized values" to account for growth in the student body and inflation. To "normalize" these annual values, the total dollar values have been divided by the product (total regular graduate students registered fall term) (tuition for 9-month academic year).

<table>
<thead>
<tr>
<th></th>
<th>Fellowships</th>
<th>Traineeships</th>
<th>Scholarships</th>
<th>Staff Tuition Awards (TA)</th>
<th>Staff Salaries (RA &amp; TA)</th>
<th>M.L.T. Only</th>
<th>Loans</th>
<th>Total Including Outside Agencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968-69</td>
<td>4,994 (.710)</td>
<td>1,003 (.147)</td>
<td>6,015 (.855)</td>
<td>646 (.092)</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1969-70</td>
<td>5,197 (.712)</td>
<td>1,056 (.145)</td>
<td>6,815 (.934)</td>
<td>470 (.064)</td>
<td>643 (.088)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970-71</td>
<td>5,396 (.655)</td>
<td>1,182 (.143)</td>
<td>6,850 (.831)</td>
<td>483 (.059)</td>
<td>672 (.082)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1971-72</td>
<td>5,076 (.589)</td>
<td>1,294 (.150)</td>
<td>7,086 (.823)</td>
<td>696 (.080)</td>
<td>827 (.096)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1972-73</td>
<td>4,687 (.486)</td>
<td>1,432 (.150)</td>
<td>7,991 (.828)</td>
<td>754 (.078)</td>
<td>916 (.095)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973-74</td>
<td>3,930 (.378)</td>
<td>1,453 (.140)</td>
<td>8,781 (.844)</td>
<td>852 (.083)</td>
<td>1,014 (.097)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1974-75</td>
<td>3,693 (.318)</td>
<td>1,738 (.150)</td>
<td>9,760 (.840)</td>
<td>1,075 (.093)</td>
<td>1,293 (.111)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1975-76</td>
<td>3,447 (.259)</td>
<td>1,878 (.141)</td>
<td>10,878 (.816)</td>
<td>1,141 (.086)</td>
<td>1,407 (.106)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1976-77</td>
<td>3,454 (.229)</td>
<td>2,065 (.137)</td>
<td>11,654 (.772)</td>
<td>1,419 (.094)</td>
<td>2,013 (.133)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1977-78</td>
<td>3,418 (.205)</td>
<td>1,978 (.118)</td>
<td>12,479 (.750)</td>
<td>1,391 (.084)</td>
<td>2,201 (.132)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table V
WOMEN GRADUATE STUDENT ENROLLMENT
Comparison of Fall Term Enrollments -- 1976-77

<table>
<thead>
<tr>
<th>School of Architecture and Planning</th>
<th>1976</th>
<th>1977</th>
<th>% of Women in Total Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture IV</td>
<td>56</td>
<td>56</td>
<td>30</td>
</tr>
<tr>
<td>Urban Studies and Planning XI</td>
<td>43</td>
<td>48</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>99</td>
<td>104</td>
<td>34</td>
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<table>
<thead>
<tr>
<th>School of Engineering</th>
<th>1976</th>
<th>1977</th>
<th>% of Women in Total Enrollment</th>
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<tbody>
<tr>
<td>Aeronautics and Astronautics XVI</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Chemical Engineering X</td>
<td>22</td>
<td>28</td>
<td>12</td>
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<td>Civil Engineering I</td>
<td>15</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>Electrical Engineering and Computer Science VI, VI-A, VI-W</td>
<td>26</td>
<td>26</td>
<td>5</td>
</tr>
<tr>
<td>Materials Science III, III-B, III-W</td>
<td>20</td>
<td>18</td>
<td>13</td>
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<tr>
<td>Mechanical Engineering II, II-T, II-W</td>
<td>11</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
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<td>3</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>118</td>
<td>6.2</td>
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<table>
<thead>
<tr>
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<th>1977</th>
<th>% of Women in Total Enrollment</th>
</tr>
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<tbody>
<tr>
<td>Economics XIV</td>
<td>16</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Linguistics and Philosophy XXIV</td>
<td>20</td>
<td>16</td>
<td>38</td>
</tr>
<tr>
<td>Political Science XVII</td>
<td>23</td>
<td>31</td>
<td>26</td>
</tr>
<tr>
<td>Psychology IX</td>
<td>10</td>
<td>10</td>
<td>36</td>
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<tr>
<td></td>
<td>69</td>
<td>73</td>
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<table>
<thead>
<tr>
<th>Sloan School of Management</th>
<th>1976</th>
<th>1977</th>
<th>% of Women in Total Enrollment</th>
</tr>
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<tbody>
<tr>
<td>Management XV</td>
<td>72</td>
<td>75</td>
<td>24</td>
</tr>
<tr>
<td>XV-A (Fellows)</td>
<td>4</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>XV-B (Operations Research)</td>
<td>3</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>79</td>
<td>82</td>
<td>20</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>School of Science</th>
<th>1976</th>
<th>1977</th>
<th>% of Women in Total Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology VII</td>
<td>40</td>
<td>36</td>
<td>31</td>
</tr>
<tr>
<td>VII-W</td>
<td>4</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>Chemistry V</td>
<td>28</td>
<td>28</td>
<td>16</td>
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<tr>
<td>Earth and Planetary Sciences XII</td>
<td>23</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td>XII-W</td>
<td>8</td>
<td>8</td>
<td>23</td>
</tr>
<tr>
<td>Mathematics XVIII</td>
<td>13</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Meteorology XIX</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>XIX-W</td>
<td>2</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Nutrition and Food Science XX</td>
<td>52</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Physics VIII</td>
<td>23</td>
<td>22</td>
<td>9</td>
</tr>
<tr>
<td>Interdisciplinary Science XXV</td>
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<td>3</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>189</td>
<td>182</td>
<td>18</td>
</tr>
</tbody>
</table>

| TOTALS                                  | 546  | 559  | 14.5                         | 14.6|
Table VI
COMPARISON OF ADMISSIONS STATISTICS FOR GRADUATE WOMEN AND GRADUATE MEN
Number of Applicants 1976/Number of Applicants 1977
(Numbers in parenthesis indicate the % change in number of applicants from 1976 to 1977.)

<table>
<thead>
<tr>
<th>School of Architecture and Planning</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>286/238 (-17)</td>
<td>734/578 (-21)</td>
</tr>
<tr>
<td>School of Engineering</td>
<td>144/193 (+34)</td>
<td>2,365/2,317 (-2)</td>
</tr>
<tr>
<td>School of Humanities and Social Science</td>
<td>197/163 (-17)</td>
<td>489/517 (+6)</td>
</tr>
<tr>
<td>Sloan School of Management</td>
<td>176/243 (+38)</td>
<td>904/1,172 (+30)</td>
</tr>
<tr>
<td>School of Science</td>
<td>367/403 (+10)</td>
<td>1,397/1,446 (+4)</td>
</tr>
<tr>
<td></td>
<td>1,170/1,240 (+6)</td>
<td>5,889/6,030 (+2)</td>
</tr>
</tbody>
</table>

Table VII
DEGREES AWARDED TO WOMEN BY SCHOOL
1971-72 to 1977-78

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Master's</td>
<td>12</td>
<td>23</td>
<td>13</td>
<td>23</td>
<td>23</td>
<td>34</td>
<td>23</td>
</tr>
<tr>
<td>Doctor's</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Engineering</td>
<td>12</td>
<td>14</td>
<td>22</td>
<td>16</td>
<td>21</td>
<td>28</td>
<td>42</td>
</tr>
<tr>
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<td>2</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Doctor's</td>
<td>5</td>
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<td>10</td>
<td>8</td>
<td>10</td>
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<td>12</td>
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<tr>
<td>Humanities and Social Science</td>
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<td>3</td>
<td>4</td>
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<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Master's</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Doctor's</td>
<td>5</td>
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<td>10</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Sloan</td>
<td>10</td>
<td>3</td>
<td>11</td>
<td>21</td>
<td>26</td>
<td>46</td>
<td>40</td>
</tr>
<tr>
<td>Master's</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Doctor's</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Science</td>
<td>6</td>
<td>11</td>
<td>9</td>
<td>16</td>
<td>19</td>
<td>32</td>
<td>25</td>
</tr>
<tr>
<td>Master's</td>
<td>23</td>
<td>13</td>
<td>20</td>
<td>19</td>
<td>19</td>
<td>28</td>
<td>25*</td>
</tr>
<tr>
<td>Doctor's</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1(S.M.)</td>
<td>0</td>
<td>1(S.M.)</td>
</tr>
<tr>
<td>Operations Research</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1(S.M.)</td>
<td>0</td>
<td>1(Ph. D.)</td>
</tr>
<tr>
<td>WHOI</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1(Ph. D.)</td>
<td>2(Ph. D.)</td>
<td>2(Ph. D. included in VII &amp; XII)</td>
</tr>
</tbody>
</table>

* Includes 2 WHOI degrees
### Table VIII
**COMPARISON, IN NUMBERS, OF DEGREES AWARDED TO MEN AND WOMEN**

**1973-74 to 1977-78**

<table>
<thead>
<tr>
<th></th>
<th>Master's</th>
<th></th>
<th>Doctor's</th>
<th></th>
<th>Engineer's</th>
<th></th>
<th>Combined</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Total</td>
<td>% of Women</td>
<td>Women</td>
<td>Total</td>
<td>% of Women</td>
<td>Women</td>
<td>Total</td>
</tr>
<tr>
<td>1973-74</td>
<td>58</td>
<td>832</td>
<td>7%</td>
<td>34</td>
<td>378</td>
<td>9%</td>
<td>3</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td></td>
<td>58</td>
<td></td>
<td>34</td>
<td>378</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>92*</td>
<td>1,210*</td>
<td>7.6%</td>
<td>95</td>
<td>1,312</td>
<td>7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1974-75</td>
<td>80</td>
<td>856</td>
<td>9%</td>
<td>32</td>
<td>362</td>
<td>9%</td>
<td>0</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80</td>
<td></td>
<td>32</td>
<td>362</td>
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<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>112*</td>
<td>1,218*</td>
<td>9%</td>
<td>112</td>
<td>1,325</td>
<td>8.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1975-76</td>
<td>93</td>
<td>862</td>
<td>11%</td>
<td>32</td>
<td>320</td>
<td>10%</td>
<td>2</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td></td>
<td>93</td>
<td></td>
<td>32</td>
<td>320</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>125*</td>
<td>1,182*</td>
<td>13%</td>
<td>125</td>
<td>1,276</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1976-77</td>
<td>145</td>
<td>971</td>
<td>15%</td>
<td>51</td>
<td>379</td>
<td>13.4%</td>
<td>2</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>145</td>
<td></td>
<td>51</td>
<td>379</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>196*</td>
<td>1,350*</td>
<td>14.5%</td>
<td>196</td>
<td>1,441</td>
<td>13.7%</td>
<td></td>
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</tr>
<tr>
<td>1977-78</td>
<td>134</td>
<td>934</td>
<td>14%</td>
<td>48</td>
<td>425</td>
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<td></td>
<td>134</td>
<td></td>
<td>48</td>
<td>425</td>
<td></td>
<td></td>
<td>5</td>
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<tr>
<td></td>
<td>182*</td>
<td>1,359*</td>
<td>13.4%</td>
<td>182</td>
<td>1,467</td>
<td>12.7%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* without Engineer's degrees
Medical Department

The major preoccupation in the Department this past year has been the Determination of Need process. At the time of the last report, we were, with the help of the presidentially-appointed Long Range Planning Committee, engaging several program issues in anticipation of the new facility. With those issues resolved, we prepared our application for a Certificate of Need and submitted it on January 3, 1978. In the preparation, we learned a good deal about ourselves and were much encouraged by the expressions of support given by other health facilities in the area.

At this writing, our application has been reviewed by the staff, committees, and board of the Health Planning Council of Greater Boston. The recommendation of these bodies, without a dissenting vote, has been for approval. The final decision will be made by the Public Health Council; we hope to appear before the Council either in the late summer or early fall.

In addition to the intense concentration on the Determination of Need process, we have begun a careful exploration of the possible participation of the Medical Department in increasing degree in educational and research activities at the Institute. In the Environmental Medical Service and the Division of Laboratory Animal Medicine, great interest in the expansion of activities in these areas exists. Our participation in a program of training of residents in primary-care medicine is being actively planned. A pilot program has been established to introduce residents from this program into the Department. Three senior residents participated in a rheumatology elective this past year, and additional similar programs are planned in otolaryngology and dermatology. In addition, the contiguity of our new facility with the Whitaker College will afford opportunities for collaboration which we are beginning to explore.

We are very much concerned with the continuity of the care provided to our patients. They are urged to select an individual physician to provide primary care and to orchestrate the contributions of the several specialists available in the Department. An interruption in that continuity may occur when patients are admitted to hospitals, often under the care of physicians outside the Department. This past year, Pauline Jones, Director of Nursing, has begun to function in a role which we hope will maintain the linkage between our hospitalized patients and ourselves. She has begun to visit patients who are in outside hospitals, embodying our continued interest and concern for them. She also will be able to encourage early transfer of these patients to our Infirmary, when appropriate.

In addition, we plan to consolidate the several quality assurance programs which exist in the Department, and to focus these activities more sharply. Ms. Jones will provide the staff support for this integrated function which is now shared among the Utilization Review and Medical Records committees, the protocol system, and the Medical Records Service. We plan a series of record audits around clinical entities.

Level of Activity

The total number of visits to the Department this past year was 114,885, almost the same as during the preceding 12-month period (115,325). Although visits to the specialty clinics continued to increase (+4%), as did the off-hours clinic visits (+10%), there was a decline in primary care visits (-2%). An apparent decrease in Lincoln Laboratory visits (-9%) is partly artifactual since the 1976-77 statistics were kept differently and represented an estimate.
Visits by students increased slightly (0.7%), while M.I.T. Health Plan members made 5.8% more visits. The major decline was observed among employees who are not Health Plan members and among spouses and dependents of non-Health Plan members. In these categories, 2,444 fewer visits were made, representing a decrement of 12.5%.

The explanation for the lack of an increase in overall utilization probably includes several factors:

- Because of resignations from the staff, we have been one primary provider (an internist) short for six months of this past year.

- The general level of illness this past winter, although not as low as in the winter of 1976-77, was below that of many recent winters; there were no major epidemics.

- The blizzard of 1978 effectively closed the Department for a week. Although the Infirmary and off-hours clinic, staffed by truly dedicated people, remained open, very few patients could come for help.

- Finally, the health surveillance program has been further delayed, postponing an increment of visits to the Department for health surveys and screenings.

In interpreting the changes in utilization patterns, one must keep in mind that employees who are Health Plan members are counted as the latter. Their visits to the Department augment the total attributed to the Health Plan and not the "employee" category. This, doubtless, contributes to the apparent decrease in utilization of the Department by non-Health Plan employees as enrollment of employees in the Health Plan has continued to grow.

Our students continue to use the Department heavily (4.6 visits/student/year); our Health Plan patients take advantage of our service even more intensely (6 visits/member/year).

Utilization of the Infirmary decreased both in admissions (-3.7%) and in the observation unit (-3.2%). The usual peak of admissions during the winter did not occur. The average duration of Infirmary stay for all admissions was 4.45 days, compared with 4.86 days a year ago. This shortening of average hospital stay has been observed generally throughout the area. The Medical Department's Utilization Review Committee, chaired by Dr. Samuel W. Stein, monitors admissions in a continuing effort to assure efficient use of Infirmary facilities.

In predicting the future, always a hazardous enterprise, an increase in utilization of the Department can be anticipated. Further growth in our patient population will occur in that segment which uses our services most intensely -- the M.I.T. Health Plan. With a full complement of physicians for the first time in two years, more patients can be accommodated. New non-physician members of the staff will augment the capacity of the specialty clinics to care for patients. And, it is hoped, improved ongoing involvement with our patients hospitalized outside the Department will increase Infirmary utilization.
AMBULATORY SERVICES

Student Health

This heading does not usually appear as a separate item in these reports, since a major focus of all the Department's activities is our student patients. This past year, however, there have been some changes made which should be noted.

Under the leadership of Dr. Edward S. Rendall, a more comprehensive student entrance medical form has been devised. Our experience in the past with these forms has been dismaying in that the information supplied has often been quite incomplete. We have attempted formerly to shorten and simplify the form so as to entice the students' physicians into providing the basic information we need to care for the entering student. This has not been strikingly successful. We hope now with the new form to acquire information by asking for specific items. An anticipated use of this data is to identify those students with higher than normal risk factors, and to intervene in a way which will, if possible, lower the risk.

There has been a substantial change in the student hospital and accident insurance policy, with the provision of greatly increased benefits (hospital coverage to 120 days rather than 60, waiver of pre-existing illness exclusions).

Protocols and Checklists

The use of protocols and computer-audited checklists by non-physicians is now well established in the ambulatory services, off-hours clinic, and Lincoln Laboratory facility. Standards have been developed which reflect the pattern of good medical practice in our community. Computer audit allows rapid individual assessment of large numbers of patient visits. Records which reveal a departure from the norm are promptly reviewed by physician and non-physician members of the Protocol Committee. The protocols and standards have been modified by this on-going experience, and one protocol (upper respiratory infection) has undergone extensive revision. Additional protocols are being developed with the continued cooperation of Dr. Anthony Komaroff and his associates at the Beth Israel Hospital. The plan is to have protocols which will be appropriate for at least 80 percent of all visits to the "walk-in" facility. All patients whose problems are not covered by an appropriate protocol will be referred to physicians.

Teams

Recognizing that the use of protocols limits the initiative of the non-physician providers and creates a rather rigid structure within which they must work, we have arranged the schedule so that only one-half of their time is spent in that setting. The remainder is spent as a member of a health care team. Three such teams, each consisting of two internists and one or two non-physician providers, have now been in operation for over a year. The expected long evolutionary process has already led to a significant degree of interdigitation of the members' practices, with a resulting increased efficiency in the use of professional resources, better continuity, and more appropriate routing of patients within the system. It has also successfully provided a more stimulating and rewarding setting for the expression of the special role of the non-physician provider.
Non-Physician Specialists

The value of nurse-specialists has been abundantly demonstrated in the Department in the areas of pediatrics, midwifery, and most recently in dermatology. A physician assistant specializing in orthopedics and surgical trauma will soon join the Department. We anticipate more efficient utilization of the time of our orthopedists and surgeons with the addition of this new member of the Department.

Health Surveys -- Pre-Employment Screens

The planned initiation of the new system of health surveillance has been further delayed; it will go into effect this fall. Meanwhile, individual members of the faculty and staff and many other employees and Health Plan members have requested and been provided conventional health survey examinations.

The pre-employment health screenings also continued: over 1,100 were performed this past year. No applicant was refused employment because of findings of the screening procedure. Although this appears, at first glance, startling, it should be recalled that for about 15 years the number of applicants for employment who were turned down for medical reasons has not exceeded one-half of one percent. The medical decision has been based on the physical capability of the applicant to perform the specific physical demands of the job. Many handicapped people have been approved for employment and continue to be so.

Staff Changes

In the changes which have and will soon occur, we see the continuing influence of a long-standing policy to consolidate the specialist services in the Department. A smaller number of specialist consultants, each of whom gives a substantial portion of his or her time, has obvious advantages in continuity of care and commitment to the Institute. Unfortunately, it also means the loss of several valued and skillful "old friends" whose own schedules cannot accommodate a larger time commitment to the Department. In this uncomfortable trade-off, we are grateful for the superb level of services these people have provided our patients in the past.

The following also reflects a change in the status of several nurse practitioners and physician assistants to staff level on April 1, 1978.

The following appointments were made this year in the Department: Donald Bartlett, M.A., P.A., Physician Assistant; Cecilia Beaucage, M.Ed., Microbiologist; Janet Beyer, R.N.P., Nurse Practitioner; Bruce Biller, M.D., Physician; John Boyd, M.D., Neurologist; Monique Cantin, R.N.P., Supervisor of Nurses, Off-Hours Clinic; Eileen Cecca, R.N.P., Nurse Practitioner; Mitchell Galanek, B.S., Assistant Radiation Protection Officer, Environmental Medical Service; Richard Gardner, M.D., Physician; Matthew Garston, O.D., Optometrist; Mark Goldstein, M.D., Physician-Pediatrician; Lyle Jensen, B.S., Medical Technologist, Division of Laboratory Animal Medicine; Paul Kantrowitz, M.D., Physician; Joan Liem, Ph.D., Postdoctoral Fellow, Psychiatric Service; Joan Lippin, B.A., Technical Assistant (temporary); Howard Marton, M.D., Ophthalmologist; Barbara Merrifield, R.N., M.S., Nurse Midwife; Irene Merwin, M.S., Assistant Coordinator, Health/Information and Education; John Moses, M.D., Physician; Katherine Mulligan, R.N.P., Nurse Practitioner, Dermatology; Jean Prahl, R.N.P., Nurse Practitioner; Linda Rounds, M.B.A., Financial Manager; Richard Schwartz, Ph.D., Postdoctoral Fellow, Psychiatric Service; Elissa Sloan, R.N.P., M.S., Nurse Practitioner;
Medical Department

Howard Smith, M.D., Otolaryngologist; Arthur St. Andre, R.N., P.A., Physician Assistant; Maisi Tam, M.D., Dermatologist; Lorraine Toher, R.N.P., Nurse Practitioner; Marcia West, R.N.P., Nurse Practitioner; Susan Wicks, R.N.P., Nurse Practitioner; and Edward Wolpow, M.D., Neurologist.

Promotions this year included: Laurence Bishoff, S.B., Chief Administrative Officer, M.I.T. Health Plan, Associate Director for Administration; Murray Bolton, B.S., Associate Radiation Protection Officer, EMS; Edward Karaian, B.B.A., E.M., Associate Radiation Protection Officer, EMS; Deborah Leone, R.N., M.S., Associate Director of Nurses, Supervisor of Nurses, Infirmary; and Francis Masse, B.S., Radiation Protection Officer, Linear Accelerator.

The following resigned from the Medical Department staff: Alan Bennett, M.D., Urologist; Deborah Brandchaft, M.D., Postdoctoral Fellow, Psychiatric Service; Ann Marie Briley, M.D., Postdoctoral Fellow, Psychiatric Service; Gilbert Cherick, M.D., Physician; Elizabeth Cole, M.D., Dermatologist; David Friedman, O.D., Optometrist; Lawrence Greenberg, M.D., Ophthalmologist; Donald Keamy, M.D., Otolaryngologist; Jeltje Koumans, M.D., Dermatologist; Joan Lippin, B.A., Technical Assistant (temporary); Steven Locke, M.D., Postdoctoral Fellow, Psychiatric Service; Helena McDonough, R.N., M.S.N., Nurse Midwife; Carsten Mortensen, B.S., Systems Analyst; Howard Ramseur, Ph.D., Postdoctoral Fellow, Psychiatric Service; Francis Renia, M.D., Dermatologist; John Trakas, M.D., Otolaryngologist; Elizabeth Welch, R.N., Supervisor of Nurses, Off-Hours Clinic; and Mary Wheeler, R.N., M.S., P.A., Physician Assistant.

Dental Service

Activity in the Dental Service has continued at about the same level as formerly. In accordance with the recommendations of the Long Range Planning Committee, the program goals of the Service will be changed to center on students and their families. Starting in the fall of 1978, no new patients other than students and their families will be accepted into the Service.

Psychiatric Service

Dr. Merton Kahne, Psychiatrist-in-Chief, offers the following observations:

Conventional wisdom among media observers celebrates a "return to tradition" on the American college campus. A more apt description would stress the fearful conformity and anxious subordination of intellectual curiosity and moral concern among students, faculty, and staff in the interest of furthering their careers. It seems rather strange and disquieting that such an academic ambience should be reported approvingly as "traditional".

The number of visits to the psychiatric service increased slightly this past year, although the number of individuals was slightly smaller. This was, in part, a reflection of the greater variety of therapy groups conducted. In addition to continuing general treatment groups for individuals, couples, and families, Dr. Lois Eichler launched a support group for pregnant women, and Dr. Lora Tessman led a group for single parents, with assistance from Constance Bean and Irene Merwin of the Health Information and Education Office.

Other special projects included participation by Dr. Tessman in the organization of a new student-run community program -- MIT-NCAA Volunteers for Youth -- in which student athletes volunteer as "big brothers" and "big sisters" to local junior high school youth who are having problems. Several members of the staff assisted in the development of guidelines.
and procedures for a new student peer counseling service which is expected to go into effect
this fall. Assistance also was provided to residents of Eastgate and Westgate in the formation
of their own support groups. A series of discussion groups covering a wide range of social
issues was organized; meetings were held on consumer problems, self-protection (in
conjunction with Campus Patrol), and parenting, among others. Dr. Charlotte Schwartz
held a series of discussion groups which brought together various people who were involved
in providing important resource services to the M.I.T. community. These people, some of
whom had not known of the others’ existence, became aware of how they are regarded as
providers of information and help, and began to discover how to engage each others’ talents
and connections so as to facilitate their own work and enhance their effectiveness.

The Wives’ group continues to be a valuable resource and this year experienced a spin-off
with the formation of a Mother’s and Toddler’s discussion group.

The planning and preparation of the program for assistance of all M.I.T. employees whose
work effectiveness is declining because of personal problems has been the focus of the work
of an Institute-wide committee under the leadership of Dr. Alfred Koumans. This endeavor
was brought to a promising point with the selection of a staff member to initiate and coordinate
the program. He will join the Social Work Service this fall.

Other efforts which continue include the development of closer liaison with other services,
this year particularly with the primary-care physicians and their nurse associates engaged
in the care of Infirmary patients.

The data-collection system initiated a year ago has considerably improved the ability of the
Service to keep an accurate account of its work. The statistical report reveals that there
has been a substantial reduction in number of patient days in outside hospitals. Once again,
the critical importance of the Infirmary in providing care to students and others is demonstrated:
56 patients, of whom 35 were students, were cared for in the Infirmary, utilizing a total of
380 days; 25 patients (of whom 9 were students) were hospitalized at outside facilities, utilizing
983 days.

Social Work Service

Although the total number of visits to the Social Work Service increased this past year
(1,723/1,376), the increment reflects increased activity in group visits. Social worker
Myra Rodrigues conducted group meetings throughout the year with minority women students.
In addition, she was instrumental in the formation of a discussion group for black male
students and served as a resource for it. In recognition of her extraordinary service to the
black community at the Institute, the M.I.T. Office of Minority Education and Minority Affairs
conferred a Community Service Award on Ms. Rodrigues.

Both Ms. Rodrigues and Jacqueline Buck, Chief Social Worker, continue their work with the
Technology Children's Center, the Institute Committee on Privacy, and the Task Force for
the Handicapped. Ms. Rodrigues has joined the M.I.T. Women's Advisory Group and has,
in addition, participated in the state-wide Policy and Advisory Committee for Child Abuse.

The Service will be augmented this coming year with a new staff member who will launch a
program addressed to the troubled employee. The selection process which identified this
person was long and arduous, since 237 applications were received. The Institute-wide
committee which accomplished the planning for this new program shared in the final evaluation
of candidates and will continue to play a role in support of the program and its staff.
Surgical Service

The general level of activity in the surgical clinics remained about the same. Surgical admissions to the Infirmary declined in both the Observation Unit and the regular in-patient service.

During this past year, Dr. Robert Runyon, an Orthopedist who is particularly interested in athletic medicine, has been spending a portion of his time in the athletic facilities, working with the coaches and trainers in caring for athletes. His interest in the prevention of serious long-term effects of athletic injuries was demonstrated by a series of presentations on a Boston television station.

The list of sports injuries is again headed by the trio of basketball, soccer, and football. Baseball, bicycle injuries, and ice hockey followed.

Obstetrical and Gynecological Service

The continued growth of the M.I.T. Health Plan has a direct impact on this service. This past year there were 105 births, maintaining the high ratio of 71 births per thousand member-families, over twice the birth rate of employees who are not members of the Health Plan.

Although Helena McDonough, Nurse-Midwife, left the service to establish a private practice, we have been very fortunate in persuading Barbara Merrifield to join our staff. Ms. Merrifield, who received much of her training in Scotland, has most recently been working in the Nurse-Midwife training program at Meharry Medical College. With her presence, we intend to continue our exploration of alternative modes of delivery, under the guidance of Dr. Charles Eades, Chief of the OB/GYN Service. The criteria we will continue to use involve the safety of the mother and child, the legal constraints imposed by legislation and hospital rules, and good sense.

Environmental Medical Service (E. M. S.)

The routine activities of the Radiation Protection Office and the Industrial Hygiene Office continue to increase, while the Biohazards Assessment Office continues to grow.

The number of investigators using radioactive materials has increased as has the number of laboratories in which they are used. Volumes and concentrations of material have also increased, leading to more use of the Central Radioisotope Laboratory.

The problem of disposal of radioactive wastes has become disturbing. Although the increase in the amount of such material was predictable, the level of increase in the cost of disposal has been substantially higher than anticipated. Moreover, if the disposal site which is now being used becomes limited in burial volume, as it well may, the estimated costs to utilize more distant sites would be close to 200 percent more than we now pay.

During the year, the Radiation Protection Office has participated in the assessment of the radiation protection needs for the increased activities of the Plasma Fusion group at Alcator. The research nuclear reactor reached its full power potential after the reconstruction of the past two years. There was no radiation exposure beyond permissible limits. The Bates Linear Accelerator Radiation Protection Office has become a separate division of the Environmental Medical Service under the leadership of Francis X. Masse. Two- and three-week 24-hour shifts have become commonplace, personnel has increased, and planning and construction of a $5 million addition is in progress.
The Industrial Hygiene Office has been working with the newly formed Committee on Toxic Chemicals in considering optimal theories and structures for dealing with these materials. There is little feeling that solutions proposed at the Federal level are the final answer.

The Biohazards Assessment Office has increased in size and number of personnel. Laboratory activities now in temporary quarters will move into a new microbiology laboratory soon. In addition to his continuing activities on campus, Dr. Daniel Liberman has been working closely with the Cambridge Biohazards Committee in compliance with the City Ordinance on Recombinant DNA Technology, and has earned their thanks. His efforts in developing methods for monitoring biohazards in laboratories have become widely known and have stimulated requests for advice from many institutions.

It is increasingly clear that a large proportion of the service functions in the E. M. S. is linked to various regulations of governmental agencies and that the demands of these agencies will continue to increase. At the same time, there is increasing interest in the Service in research and educational activities. The latter have increased this past year with the initiation by the Biohazards Assessment Office of a series of lectures as well as the first Massachusetts Biological Safety Conference. A medical student from the University of Massachusetts Medical School spent a two-week elective with the E. M. S.; this coming year, two or three physician-students from the Harvard School of Public Health will spend several months in a tutorial program in the Service.

The Institute Council on Environmental Health and Safety has been formed and has begun to function. It is made up of the chairpersons of the various Institute health and safety committees, representatives of this Department, the E. M. S., and the Division of Laboratory Animal Medicine. Chaired by Dean Robert Alberty, the Council will consider issues of policy as well as problems which are not clearly appropriate to any of the specific committees. The Council, the new Committee on Toxic Chemicals and, most importantly, the Departmental Safety Committees are entities created or redefined as a result of the review of health and safety problems begun at the Institute three years ago, in which Dr. Melvin H. Chalfen has played a central role as Director of the Environmental Medical Service.

Division of Laboratory Animal Medicine (D. L. A. M.)

The program of renovation and construction of physical facilities for animals proceeded with the completion and occupation of the new Animal Care Facility on Vassar Street. The building provides for animal housing, animal care support, clinical services, clinical laboratories, and administration functions. Renovation of existing space, partially funded through an NIH grant, has been partially completed; further work on satellite facilities under the M.I.T. Animal Facilities Renovation Grant from the National Cancer Institute will soon begin.

Due in part to the construction and renovation plans, the Institute has been granted full accreditation by the American Association for Laboratory Animal Services.

The daily census of animals housed in the seven existing satellite facilities, involving 15 species, averages 13,000. The number has not changed in the past year because of space limitations.

The M.I.T. Animal Research Diagnostic Laboratory, having completed its second year of operation, has been the subject of a renewal-grant application for an additional three-year period. It provides diagnostic support for the M.I.T. animal medicine program as well as functioning as a referral resource in animal disease diagnosis for several research methodologies in the study of the pathogenesis of laboratory animal disease. Special emphasis is placed on those which may interfere with experiments or have a zoonotic impact. The laboratory currently
Medical Department

provides services in microbiology, hematology, parasitology, clinical chemistry, histology, and pathology.

The environmental survey program continues to monitor the several satellite facilities for level and type of bacterial contamination, allowing an appraisal of cleaning, cage washing, and autoclaving procedures. Because of a report of high lead levels in Boston water supplies, the water in the animal facilities was analyzed for levels of lead and cadmium. Acceptable levels were detected.

In addition, a study of possible lead contamination of dog and cat feeds was undertaken in collaboration with the Environmental Medical Service. Seventy-eight random samples of pet foods were purchased in local grocery stores and 25 different laboratory animal rations were taken from storage in laboratory animal facilities. Additional analyses for lead content were made of 124 specific feed ingredients from five major pet food companies. The results demonstrated a wide range of lead content. Of the feed ingredients, 48 (39 percent) had more than 1 ppm of lead, and one sample (mineral mix) had 3,600 ppm. Clearly, careful monitoring for lead in laboratory animal feeds is needed.

A study is currently under way to measure the cadmium level in feed. Cadmium can increase blood pressure in animals and is often associated with environmental lead contamination.

In addition to providing support for many investigators at the Institute, the laboratory is becoming an increasingly valuable reference source. This has stimulated the development of a library which will be readily available to researchers.

Among the interesting clinical cases this year have been two patients of the Medical Department with a dermatitis induced by an ectoparasite -- Cheyletiella -- which was identified by the Division of Laboratory Animal Medicine. A dormitory epidemic of rashes in students was discovered to be related to exposure to cats harboring mites and fleas; the Division established the diagnosis and formulated an eradication program for the parasites.

Teaching activities in the Division included the presentation of a course -- Laboratory Animal Usage in Biomedical Experimentation -- offered to graduate and undergraduate students. The summer internship for a veterinary student was continued. Informal instruction in necessary techniques, surgical procedures, methods of animal restraint, and specimen collection occurs frequently, and the Division is often asked for assistance in training and advising technicians.

Dr. James G. Fox, Director of the Division, was promoted this past year to the faculty rank of Associate Professor of Comparative Medicine with tenure.

Research activities have continued unabated, and have included collaboration with other investigators at the Institute. The staff this past year published 14 articles, has six more in press, and presented eight papers as invited speakers at various scientific symposia.

Health Information and Education

This office added an experienced health educator, Irene Merwin, M.S.P.H., to its staff to replace the former assistant coordinator who had resigned. Ms. Merwin came to us from the Peter Bent Brigham Hospital. She and Constance Bean continue to conduct the office's activities in providing information, offering health educational programs, and serving as patient advocates in responding to problems and questions about patient care.

Publications this past year included the quarterly Health Plan Newsletter, a new Patient Advocacy brochure, and, in response to requests, a list of services available of special interest to women.
Two Smoking Cessation programs were conducted, as well as three Weight Control programs. Both of these endeavors are very popular; a considerable waiting list for the Weight Control series has developed.

Following the first program offered in the spring of 1977, a second group of separated, divorced, and remarried parents was conducted by Dr. Lora Tessman and Constance Bean. Two meetings each month throughout the year have been held for expectant couples and recent parents. On one evening each month, a refresher class in Lamaze techniques is offered to six Health Plan couples.

In fulfilling their patient advocacy function, Ms. Bean and Ms. Merwin were consulted 180 times about medical, dental, or administrative questions. Problems are addressed promptly and are followed through to resolution. Six patients availed themselves of the opportunity to have an advocate accompany them back to the providers to discuss issues regarding their care.

The health educators gave six talks to groups including Lincoln Laboratory, Mount Auburn Hospital Patient Care Committee, M.I.T. Wives' Group, M.I.T. Minority Women Group, and the Wheelock Parent Education Program.

M.I.T. Health Plan

The Health Plan has now completed the first five years of its existence. Following the initial pilot-demonstration period, its growth has been steady and substantial. Membership now stands at 6,250. Its financial goals for the year have been met and the Plan continues as a major supporter of Department activities and programs.

In acknowledgement of his major responsibility for the continuing success of the Health Plan, Laurence H. Bishoff was promoted to Chief Administrative Officer, M.I.T. Health Plan, as well as continuing as Associate Director for Administration for the Department.

At this time, it appears that the decision to create the M.I.T. Health Plan has had very positive consequences. A review and summary of its first five years is being undertaken and will be published separately.

MELVIN H. RODMAN, M.D.
Registrar

All statistics on Registration and Staff in the following tables are given as of the fifth week of the Fall Term, except: 1943-44 as of August 2, 1943; 1944-45 as of November 27, 1944; and 1945-46 as of July 30, 1945.

Table I  Student Registration since the Founding of the Institute*

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<tr>
<th>Year</th>
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<th>Year</th>
<th>Number of students</th>
<th>Year</th>
<th>Number of students</th>
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<td>1944-45</td>
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<td>1867-68</td>
<td>167</td>
<td>1906-07</td>
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<td>1945-46</td>
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<td>1946-47</td>
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<td>1869-70</td>
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<td>1908-09</td>
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<td>1947-48</td>
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<td>1909-10</td>
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<td>1949-50</td>
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<td>1950-51</td>
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<td>1956-57</td>
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<td>1960-61</td>
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<td>1888-89</td>
<td>827</td>
<td>1927-28</td>
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<td>1928-29</td>
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<td>3,048</td>
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*From 1943 to 1946 Army and Navy students are omitted (see Table III-B in reports for 1943 to 1946).
### Table I-A  Student Registration in the Summer Session since 1948

<table>
<thead>
<tr>
<th>Year</th>
<th>*In Regular Subjects</th>
<th>+In Other Subjects</th>
<th>Year</th>
<th>*In Regular Subjects</th>
<th>+In Other Subjects</th>
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*Students attending regular subjects from M.I.T. curricula
+Students attending professional and technical subjects which are not part of M.I.T. curricula and in general carry no academic credit
Table II  Academic Staff Count

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|-------------------------------------------------------|----|---|---|----|---|---|---|---|---|---|---|---|---|---|----|---|---|---|---|---|-------|---|---|
| Biology                                               |    |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Chemistry                                             |    |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Earth and Planetary Sciences                          |    |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Mathematics                                           |    |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Meteorology                                           |    |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Nutrition and Food Science                            |    |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Physics                                               |    |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Total                                                 | 154| 18| - | 53 | 48| 6 | 5 | 14| 12| 24| 7 | 161| 59| 454| 155| - | 1,170| 20| 212|

| Administration                                        |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Aerospace Studies                                     |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Arterosclerosis                                       |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Artificial Intelligence Laboratory                   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Athletic                                              |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Center for Advanced Engineering Study               |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Center for Advanced Visual Study                    |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Center for Cancer Research                           |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Center for International Studies                    |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Center for Materials Science and Engineering         |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Center for Policy Alternatives                      |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Center for Space Research                           |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Division for Study and Research in Education         |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Energy Laboratory                                     |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Harvard-MIT Health Sciences and Technology          |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Joint Center for Urban Studies                       |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Laboratory of Architecture and Planning               |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Laboratory for Computer Science                     |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Laboratory for Nuclear Science                       |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Libraries                                             |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Medical                                               |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Military Science                                      |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| National Magnet Laboratory                            |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Naval Science                                         |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Neurosciences Research Program                       |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Nuclear Reactor Laboratory                            |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Operations Research Center                           |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Research Laboratory of Electronics                   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Sea Grant Program                                     |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Student Activities                                   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |       |   |   |
| Total                                                 | 2  | 4 | - | 11 | 4 | 1 | - | 3 | 2 | 11 | 20 | 36 | 5 | - | - | 99 | 4 | 409 |

Grand Total                                           | 456| 58| 3^2| 14^2| 209^2| 184^2| 21^2| 25^2| 102^2| 16| 58^2| 50^2| 322| 80| 1,373| 428^2| 17^2| 3,416| 61^3| 4 | 802^2|

Faculty Ex-Officio                                    | 24 |

Total Faculty 969

1Includes Guests, Research Affiliates, Technical Associates, Honorary Lecturer, Visiting Lecturers, Postdoctoral and Research Fellows, Visiting Scientists, visiting Engineers, visiting Scholars, Medical Doctors, Staff Librarian (Center for Policy Alternatives), Librarians, Coaches and Trainers, Administrative Officers, Administrative Assistants and House Person.

2Total Teaching Staff is 1,625.

3Not included in preceding total.

4Visiting Professors include 32 Professors, 18 Associate Professors, 9 Assistant Professors, 2 Institute Professors.
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1These totals include 3 students in third year, 1 student in fourth year on Foreign Study; 3 students in third year, 1 in fourth year on Domestic Study
2These totals include 7 students in third year, 3 students in fourth year on Foreign Study; 1 student in second year, 2 in third year on Domestic Study
3These totals include 8 students in third year, 1 student in fourth year on Foreign Study; 1 student in second year, 1 in third year and 1 in fourth year on Domestic Study.

(not included in above figures)

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1Also included in Table III
Total undergraduate women 749, 14 special undergraduate women are included.
### Table III-B Special Students by Schools, Courses and Years, 1977-78

<table>
<thead>
<tr>
<th>School of Architecture and Planning</th>
<th>Course</th>
<th>Year</th>
<th>Year</th>
<th>Year</th>
<th>Total</th>
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<td></td>
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<th>Year</th>
<th>Year</th>
<th>Total</th>
</tr>
</thead>
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<td></td>
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<th>Year</th>
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<td>Linguistics and Philosophy,XXIV</td>
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<td>Political Science,XVII</td>
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<td>11</td>
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<tr>
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<td>Psychology,IX</td>
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<th>Year</th>
<th>Year</th>
<th>Total</th>
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<table>
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<th>Year</th>
<th>Year</th>
<th>Total</th>
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<td>Chemistry,V</td>
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</tr>
<tr>
<td></td>
<td>Earth and Planetary Sciences,XII</td>
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<td>-</td>
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<tr>
<td></td>
<td>Interdisciplinary Science Program,XXV</td>
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<tr>
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<td>Mathematics,XVIII</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>Nutrition and Food Science,XX</td>
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<td></td>
<td>Physics,VIII</td>
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<td>Health Sciences and Technology,HST</td>
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<td>43</td>
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<td></td>
<td>Total</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>79</td>
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</tbody>
</table>

| Undesignated                          |                                 | 11   | 11   | 11   | 341   |

| Grand Total                            |                                 | 19   | 11   | 11   | 382   |

1 Included also in Table III
## Table IV  Continued, Former, and New Students

<table>
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<tr>
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<td><strong>Continued Students</strong></td>
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<td>5,513</td>
<td>5,747</td>
<td>5,980</td>
<td>6,055</td>
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<tr>
<td>graduate students</td>
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<tr>
<td>registered at the</td>
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<tr>
<td>end of the last academic</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>year (including special</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>students)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td><strong>Non-continued Students</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Former undergraduate and graduate students who previously attended the Institute but were not registered at the end of the last academic year (including special students)</td>
<td>306</td>
<td>249</td>
<td>227</td>
<td>272</td>
<td>271</td>
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<tr>
<td>Undergraduate students who enrolled for the first time since secondary school (excluding special students)</td>
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<td>1,033</td>
<td>1,156</td>
<td>1,042</td>
<td>1,073</td>
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<tr>
<td>Undergraduate students who enrolled for the first time at the Institute and who transferred from another collegiate institution (excluding special students)</td>
<td>85</td>
<td>99</td>
<td>130</td>
<td>134</td>
<td>124</td>
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<tr>
<td>Graduate students who enrolled for the first time at the Institute (excluding special students)</td>
<td>884</td>
<td>849</td>
<td>935</td>
<td>958</td>
<td>968</td>
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<tr>
<td>Special undergraduate and graduate students with no previous Institute registration</td>
<td>294</td>
<td>307</td>
<td>287</td>
<td>211</td>
<td>221</td>
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<td><strong>Total</strong></td>
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<td>8,050</td>
<td>8,482</td>
<td>8,597</td>
<td>8,712</td>
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<td>Entered with Bachelor's degree from other colleges</td>
<td>Entered Graduate Bachelor's degree from M.I.T.</td>
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<td>------------------------------------</td>
<td>-------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------</td>
<td></td>
<td></td>
</tr>
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<td>Architecture (IV,IV-B)</td>
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<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>21</td>
<td>257</td>
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<th>Entered with Bachelor's degree from other colleges</th>
<th>Entered Graduate Bachelor's degree from M.I.T.</th>
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</thead>
<tbody>
<tr>
<td>Aeronautics and Astronautics (XVI,XVI-B)</td>
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<td>29</td>
</tr>
<tr>
<td>Chemical Engineering (I,X-C)</td>
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<tr>
<td>Civil Engineering (I)</td>
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<td>48</td>
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<tr>
<td>Electrical Engineering and Computer Science (VI,VI-1,VI-3,VI-A,VI-W)</td>
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<td>255</td>
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<td>Materials Science and Engineering (III,III-A,III-B,III-W)</td>
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<td>Mechanical Engineering (II,II-A,II-B,II-T,II-W)</td>
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<td>Nuclear Engineering (XII)</td>
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<td>1,330</td>
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<th>Entered with Bachelor's degree from other colleges</th>
<th>Entered Graduate Bachelor's degree from M.I.T.</th>
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<tr>
<td>Linguistics and Philosophy (XXIV)</td>
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<td>Political Science (XVII)</td>
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<td>Psychology (IX)</td>
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<th>Entered with Bachelor's degree from other colleges</th>
<th>Entered Graduate Bachelor's degree from M.I.T.</th>
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</thead>
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<td>56</td>
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<table>
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<th>Entered with Bachelor's degree from other colleges</th>
<th>Entered Graduate Bachelor's degree from M.I.T.</th>
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<tbody>
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<td>Chemistry (V)</td>
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<td>Earth and Planetary Sciences (XII,XII-W)</td>
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<td>Interdisciplinary Science Program (XXV)</td>
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<tr>
<td>Mathematics (XVIII)</td>
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<td>13</td>
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<tr>
<td>Meteorology (XIX-XII-W)</td>
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<tr>
<td>Nutrition and Food Science (XX)</td>
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<tr>
<td>Total</td>
<td>91</td>
<td>865</td>
<td>198</td>
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</tbody>
</table>

| Undesignated         | 2                             | 2                                            | 2                              |
| First Year           | 1                             | 1                                            | 1                              |

<p>| Grand Total          | 353                           | 3,044                                         | 780                            |</p>
<table>
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<th>Table VI List of Colleges and Universities with Number of Graduates Entering the Institute as Regular Students</th>
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</thead>
<tbody>
<tr>
<td>Air Force Institute of Technology 1</td>
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<tr>
<td>Akron, University of 1</td>
</tr>
<tr>
<td>Alabama, University of 2</td>
</tr>
<tr>
<td>American University 1</td>
</tr>
<tr>
<td>Amherst College 2</td>
</tr>
<tr>
<td>Antioch College 1</td>
</tr>
<tr>
<td>Arizona, University of 1</td>
</tr>
<tr>
<td>Arkansas, University of, Fayetteville 1</td>
</tr>
<tr>
<td>Ball State University 1</td>
</tr>
<tr>
<td>Bard College 1</td>
</tr>
<tr>
<td>Barnard College 3</td>
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<tr>
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<td>Bridgewater State College 2</td>
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<td>Brigham Young University 1</td>
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<td>Bucknell University 2</td>
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<td>California, University of, Berkeley 26</td>
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<tr>
<td>California, University of, Davis 4</td>
</tr>
<tr>
<td>California, University of, Irvine 2</td>
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| Grand Total | 1,213 |

1Graduates of 231 Colleges and Universities in the United States and 172 Foreign Colleges and Universities entered the Institute.
Table VII Geographic Distribution of Students, 1977-1978

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| Alfred P. Sloan School of Management   |       |       |       |       |       |       |       |       |       |       |       |       |
| Management                             | 3     | 6     | 32    | 10    | 10    | 179   |       |       |       |       |       |       |
| School of Science                      |       |       |       |       |       |       |       |       |       |       |       |       |
| Biochemical Engineering                |       |       |       |       |       |       |       |       |       |       |       |       |
| Biology                                |       |       |       |       |       |       |       |       |       |       |       |       |
| Undesignated                          |       |       |       |       |       |       |       |       |       |       |       |       |
| Biophysics                             |       |       |       |       |       |       |       |       |       |       |       |       |
| Chemistry                              |       |       |       |       |       |       |       |       |       |       |       |       |
| Earth and Planetary Sciences           | 2     | 4     | 25    | 1     |       |       |       |       |       |       |       |       |
| Food Science and Technology            |       |       |       |       |       |       |       |       |       |       |       |       |
| Interdisciplinary Science              |       |       |       |       |       |       |       |       |       |       |       |       |
| Life Sciences                          | 1     | 3     | 91    |       |       |       |       |       |       |       |       |       |
| Mathematics                            | 1     | 12    | 59    | 2     |       |       |       |       |       |       |       |       |
| Meteorology                            |       |       |       |       |       |       |       |       |       |       |       |       |
| Neural and Endocrine Regulation        |       |       |       |       |       |       |       |       |       |       |       |       |
| Nutrition and Food Science             |       |       |       |       |       |       |       |       |       |       |       |       |
| Nutritional Biochemistry and Metabolism|       |       |       |       |       |       |       |       |       |       |       |       |
| Physics                                | 9     | 10    | 70    |       |       |       |       |       |       |       |       |       |
| Toxicology                             |       |       |       |       |       |       |       |       |       |       |       |       |
| Total                                  | 13    | 52    | 316   | 26    | 20    | 33    |       |       |       |       |       |       |

| Awarded jointly with Woods Hole        |       |       |       |       |       |       |       |       |       |       |       |       |
| Oceanographic Institution              |       |       |       |       |       |       |       |       |       |       |       |       |
| Biology                                |       |       |       |       |       |       |       |       |       |       |       |       |
| Earth and Planetary Sciences           |       |       |       |       |       |       |       |       |       |       |       |       |
| Electrical Engineering and Computer Science|       |       |       |       |       |       |       |       |       |       |       |       |
| Meteorology                            |       |       |       |       |       |       |       |       |       |       |       |       |
| Ocean Engineering                      |       |       |       |       |       |       |       |       |       |       |       |       |
| Grand Total                            | 85    | 158   | 840   | 175   | 207   | 476   | 10    | 9     | 36    | 2     | 2     | 17    | 24    | 33    | 51    | 121   | 102   | 156   | 10    | 20    | 16    | 427   | 531   | 1,592 |
Table IX  Number of Degrees of Bachelor of Science Awarded

All statistics are arranged by schools as of the current year. During the years 1868-1949 the general divisions were Architecture, Engineering, and Science. In 1950 the School of Humanities and Social Studies was established, and in 1951 the School of Industrial Management (after 1963 the Alfred P. Sloan School of Management) was added.

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**Total**

| - 61 | 201 | 755 | 634 | 1,651 | 81 | 58 | 55 | 66 | 49 |

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**Total**

| - 142 | 872 | 641 | 909 | 732 | - 3,296 | - - | - - |

### School of Science

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**Total**

| - 4 | 46 | 114 | 260 | 223 | 210 | 319 | 608 | 865 | 1,463 | 2,651 | 3,174 | 9,937 | 425 | 424 | 436 | 361 | 368 |

### Grand Total

| - 29 | 226 | 507 | 1,579 | 2,257 | 2,963 | 5,410 | 4,515 | 6,626 | 7,535 | 8,011 | 8,222 | 47,880 | 1,038 | 1,040 | 1,069 | 1,004 | 998 |

---

*Includes only February and June degrees

*2Received the degree in Naval Architecture, Course XIII-B, in 1916 and three in 1917

*3See also Table XI

*4Prior to 1923 degrees were awarded in Architecture

*5Prior to 1929 this course was designated as Option 3 (Electrochemistry) or Physics

*6Prior to 1938 these degrees were included in Mining Engineering and Metallurgy; changed from Metallurgy to Metallurgy and Materials Science, January 1968; changed to Materials Science and Engineering 1975

*7Prior to 1958 these degrees were included in General Engineering and General Science or General Course

*8Changed to Alfred P. Sloan School of Management 1963

*9Changed to Life Sciencces beginning January 1962

*10Changed from Geology and Geophysics to Earth Sciences in February 1961, changed from Earth Sciences to Earth and Planetary Sciences in February 1970

*11Prior to September 1965, these degrees were included in Economics, Politics and Engineering or Science

*12Prior to 1959, Business and Engineering Administration, changed from Industrial Management to Management in February 1967

*13Prior to 1960 Aeronautical Engineering
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¹ Includes degrees in the Schools of Architecture and Planning.
² Includes degrees in the School of Building, Engineering, and Housing.
³ Includes degrees in the Schools of Maritime Science and Nuclear Engineering.

**Table X** Number of Degrees of Master of Science Awarded
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### School of Science

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*Includes only February and June degrees

See Table XI

Prior to 1923 degrees were awarded in Architecture

Prior to 1959 included in Chemical Engineering

Prior to September 1964 included in Economics, Politics and Engineering or Science

Considered Engineering until 1950

Considered Engineering until 1956

Prior to September 1965 these degrees were included in Economics, Politics and Engineering or Science

Prior to February 1967 Industrial Management

 Changed to Earth and Planetary Sciences beginning February 1970

Includes six degrees in Political Science awarded 1965

Prior to 1960 Aeronautical Engineering

Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975
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<sup>1</sup> Includes only February and June degrees
<sup>2</sup> From 1935 to 1944, Bachelor of Architecture in City Planning
<sup>3</sup> Degree of Bachelor in Architecture changed to degree of Master of Architecture in 1972
<sup>4</sup> Degree of Master in Architecture changed to degree of Master of Architecture in Advanced Studies in June 1972
Table XII Number of Degrees of Engineer Awarded

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Awarded jointly with Woods Hole Oceanographic Institution

Ocean Engineer

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<th>Total by decade</th>
<th>Calendar year since 1974 (included in decade total)</th>
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*Includes only February and June degrees
¹Prior to 1960 Aeronautical Engineer
²Degree discontinued after 1955
³Degree discontinued after 1964
Table XIII  Number of Degrees of Doctor of Philosophy Awarded

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\(^{1}\)Economics
\(^{2}\)Group Psychology
\(^{3}\)Linguistics
\(^{4}\) Philosophy
\(^{5}\)Political Science
\(^{6}\)Sanitary Engineering
### Alfred P. Sloan School of Management

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### School of Science

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| Total                       | 8       | 29      | 91      | 258     | 419     | 846     | 1,339   | 1,167   | 4,157   | 143     | 120     | 161     | 141     | 102     |         |         |

### Awarded jointly with Woods Hole Oceanographic Institution

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| Total                       | -       | -       | -       | -       | -       | -       | -       | -       | 5       | 56      | 61      | 2       | 12      | 11      | 12      | 5       |

### Grand Total

|                      | 8       | 29      | 91      | 258     | 447     | 979     | 2,504   | 2,575   | 6,891   | 302     | 314     | 338     | 332     | 258     |         |         |

---
²Includes only February and June degrees
³Previously included in Industrial Economics
⁴Changed from Industrial Economics to Economics 1966
⁵Includes Industrial Management to Management 1967
⁶Includes Ceramic, Metallurgy and Materials Science changed to Materials Science and Engineering 1975
⁷Changed from Geology and Geophysics to Earth and Planetary Sciences 1970
⁸Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology
⁹Changed from City and Regional Planning to Urban Studies and Planning September 1969
¹₀Prior to 1960 Aeronautical Engineering
¹¹Changed from Naval Architecture and Marine Engineering to Ocean Engineering September 1971
¹²Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975
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*Includes only February and June degrees
1Prior to 1960 Aeronautical Engineering
2Changed from Geology and Geophysics to Earth and Planetary Sciences 1970
3Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology
4Changed from Naval Architecture and Marine Engineering to Ocean Engineering 1970
5Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975
6Changed from Metallurgy and Materials Science to Materials Science and Engineering 1975
# Table XV  Summary of Degrees Awarded

(1868-1978)

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</table>


WARREN D. WELLS
The annual reports that appear in this section are submitted by the heads of administrative departments and operations which report directly to the Office of the President and the Chancellor. The Council for the Arts reports to the President through Professor Roy Lamson, Special Assistant to the President for the Arts. The Director of Information Processing Services and the Director of the Undergraduate Research Opportunities Program report directly to the Chancellor. The Institute Information Services and the MIT Press report to Constantine B. Simonides, Vice President in the Office of the President and the Chancellor. The Director of the Plasma Fusion Center reports to the President.

Council for the Arts

The year 1977-78, the Council's fifth operating year, was one of continuing development for the arts at M.I.T. A staff of four -- Professor Roy Lamson, Special Assistant to the President for the Arts; Peter Spackman, Executive Director; Susan Knight, Associate Director; and Rebecca Burke, Secretary -- worked with Council members, faculty, and students to continue the development both of arts activities at M.I.T. and the particular arts-related goals established within the Institute's Leadership Campaign.

The Program Committee was chaired this year by Max Wasserman, following five years of leadership by Dr. Leo Beranek. Meeting three times during 1977-78, the Committee awarded $29,394 to 24 recipients representing a wide variety of programs in the arts. Grant recipients included the M.I.T. Dance Workshop, in support of their yearly activities; the Graduate Student Council to assist in funding a week-long residency of the Boston Repertory Ballet; and the M.I.T. Early Music Society to purchase two viols to expand the Society's instrument collection. Additional grants supported a year-long program of visiting poets and writers in the Department of Humanities; assisted the M.I.T. Logarithms with their 1978 spring tour; funded a student laboratory for the study and creation of holographic artworks at the Center for Advanced Visual Studies; and supplemented a National Endowment for the Arts grant to the Committee on the Visual Arts to publish a 96-page catalogue/walking tour of the M.I.T. Permanent Collection.

In the fall, the Program Committee instituted a small fund-raising program to supplement the budget allocation established each year for the grants program. The Committee experienced moderate success, raising funds for specific projects from sources previously untapped, most notably businesses in the Boston-Cambridge area. The Program Committee expects to continue this funding approach with the aim of developing further contacts and support in the business community, as well as among local and state funding agencies.

Five new members were nominated by the Membership Committee and were appointed to the Council for the Arts by President Jerome B. Wiesner for three-year terms. They are Olga Hirshhorn of Washington, DC; Bernard Palitz, Class of 1947, of New York City; Samuel Sachs of Minneapolis; Barbara Sedlin, M.C.P. 1960, of New York City; and
John Kunstadter, Class of 1949, of New York City. Total Council membership at the end of the year was 83.

The Council's major cultural event of the year was the debut performance of the M.I.T. Symphony Orchestra at Avery Fisher Hall, Lincoln Center, on April 12, 1978, cosponsored by the New York Alumni Center. Marcus Thompson, M.I.T.'s distinguished violist, was the featured soloist in a program chosen by conductor David Epstein. The program opened with Stravinsky's "Scherzo à la Russe," and included the New York premiere of Kurt Weill's Suite from the Opera "Silbersee," and "Harold in Italy" by Berlioz. Raymond Ericson, music critic for the New York Times wrote, "the orchestra, 95 players strong, showed how skillful its wind sections are by sparkling through the dry wit of Stravinsky's bit of native color. The strings added luster to the Weill suite.... Mr. Epstein did everything right in the Berlioz, as did Marcus Thompson, the Viola soloist.""

During the year the Council also sponsored a performance by the Merce Cunningham Dance Company during the Company's five-week residency in Boston. Organized by the Massachusetts Arts and Humanities Foundation, the Cunningham residency included repertory classes, workshops, and formal performances. The lecture/demonstration by 20 Cunningham dancers at Kresge Auditorium drew more than 300 people from Boston and Cambridge, and added an important element to the residency program.

The Council also sponsored a dinner for the Contributions Council of the Conference Board (New York City) during its fall meeting in Boston. Held at the St. Botolph Club, the dinner meeting included remarks by Dr. Jerome Wiesner and featured two films made by distinguished designers Charles and Ray Eames who were also present to meet with members of the Board.

A particular highlight of the Council's year was the Sixth Annual Meeting, held on November 2, 1977. The annual business meeting was opened by Chairman Luis A. Ferre who welcomed a record number of Council members and spouses to M.I.T. Brief reports followed concerning the Institute's recent major acquisitions by Tony Smith, Larry Bell, and Trova; the regional events held in connection with the Charles Eames Bicentennial exhibition, "The World of Franklin and Jefferson" at the Los Angeles County Museum of Art and the Art Institute of Chicago; plans for the M.I.T. Symphony Orchestra's spring tour to Lincoln Center; and the results of last year's grants program.

A major portion of the business meeting was devoted to a discussion of progress in the area of fund raising during 1976-77. Speaking on behalf of the Financial Development Committee, Chairman Gregory Smith reviewed the progress of the Leadership Campaign in general and the Council's own fund-raising efforts within the framework of the larger campaign, reporting that efforts during the past year had yielded the highest return in the Council's history. The successful year was enhanced by the Challenge '77 program (a dollar-for-dollar matching program administered through the Alumni Fund) which nearly doubled the number of donors contributing to the Council's programs. President Wiesner concluded the business meeting by announcing two major gifts to the Institute through the Council, one designated for a named professorship in the School of Humanities and the other toward a major new facility for the visual arts.

The second half of the morning session was "A Revue: The Arts at M.I.T.," a nine-part presentation by faculty and students working with different arts programs and activities at the Institute. Moderated by Professor Lamson, "A Revue" included a lively program of video works; early music performances; slides of recent acquisitions; film studies of the Center for Advanced Visual Studies project CENTERBEAM in Kassel, Germany; poetry readings; and dramatic performances. The fast-paced, multimedia presentation proved an ideal format for introducing to the assembled Council members the variety, richness, and excitement of the arts and humanities programs at the Institute.
At lunch in McCormick Dining Hall, the Council met with faculty and students in the arts, as well as with Leadership Campaign officers and directors. The luncheon was the occasion for announcing the fourth Eugene McDermott Award which carries a cash prize of $1,000 and is presented annually "for major contributions to the arts as a means of human fulfillment." On behalf of the McDermott Award Committee, Council Chairman Ferre announced that the committee had recommended unanimously and the Executive Committee had approved that the 1977 recipient be James R. Killian, Jr., Class of 1926, first Chairman of the Institute's Visiting Committee on the arts and life-long supporter of the development of arts and humanities programs at M.I.T.

A panel discussion entitled "Connections: Integrating the Arts and Sciences in Contemporary Education" was held in the afternoon. Panelists included Institute Professor Philip Morrison; Sarah Caldwell, Director of the Opera Company of Boston; John MacFadyen, an architect in New York City; Agnes Mongan, Kress Professor at the National Gallery of Art in Washington, DC; and David Rockefeller, Chairman of the Panel on The Arts, Education and Americans.

The Annual Meeting concluded with dinner at the President's House, followed by a showing of the recently released Roberto Rossellini film on Le Centre Georges Pompidou, the new museum of contemporary art at Beaubourg, Paris.

PETER SPACKMAN

Institute Information Services (I.I.S.)

During the past several years, the concept of the Institute Information Services has been useful in the improvement of the channels of communication among information-related offices. For the past five years, representatives of I.I.S. and other staff members across the Institute, whose responsibilities involve receiving and disseminating information, have met together in the Information Group to brief each other on current developments and to discuss common interests and tasks. This informal but continuous encouragement of more open and cooperative sharing of information across departmental lines will be especially helpful in this current period as the Institute continues to move toward making administrative services more economical and cost-effective.

The activities of the I.I.S. departments during the past year are reported below by Robert M. Byers, Director of the News Office, and Kathryn W. Lombardi, Manager of Campus Information Services.

CONSTANTINE B. SIMONIDES

NEWS OFFICE

M.I.T. was somewhat less in the news during 1977-78 than it was during the previous year, but, nevertheless, received considerable attention from national and regional news media. At year's end, the Alumni Association's honoring of a Pittsburgh steelworker and his wife who sent all four of their sons to M.I.T. received national television attention. Major attention in
the Washington, DC area was being focused on Centerbeam, the exhibit mounted on the Washington Mall by the M.I.T. Center for Advanced Visual Studies. Earlier in the year, stories that received wide attention included, but were not limited to, results obtained from the High Energy Astronomy Observatory satellite by Professors Walter Lewin and Hale Bradt, from the Small Astronomy Satellite by Professor George Clark and others, prospects for recycling of used concrete by Dr. Frondistou-Yannas in the Department of Civil Engineering, a Technology Review article on the neutron bomb by Harvard's Professor George Kistiakowsky, studies by Professor M. Nafi Toksoz on earth tide/earthquake relationships, the building and testing of a passive solar house on campus by Timothy Johnson and others in the Department of Architecture, development of a miniaturized electronic brain monitoring device for use with mice in the laboratory of Professor Stephan Chorover in the Department of Psychology, a tunable knee joint prosthesis by Professors Woodie Flowers and Derek Rowell in the Department of Mechanical Engineering, connections between zinc and esophageal cancer by Professor Paul Newberne and studies on nitrates by Professor Steven Tannenbaum in the Department of Nutrition and Food Science. The continuing story of ALCATOR C, including the story of movement of its new power generator from a Con Edison substation in New York City, also drew attention. President Jerome Wiesner's commencement address that dealt with caring was well reported. Numerous photographs made by staff photojournalist Calvin Campbell independent of specific stories continued to appear in newspapers throughout the US, in particular a picture he made of a woman graduate at commencement holding her infant child.

During the year, the News Office issued 234 news releases, down considerably from 336 of the previous year, a reflection of a desire, in the face of increasing costs, including postal costs, to be more selective and, in some cases, to explore using Reports on Research (since it holds a second class mailing permit) as a substitute for the press release. Over the past two years, the News Office has reduced the number of press releases it issues by nearly one half.

Tech Talk was published 39 times during the year for a total of 328 pages -- two issues less and four pages less than the previous year. The 1977-78 volume of 39 issues included 33 with eight pages, one with four pages and five with 12 pages. Tech Talk also carried five different supplements during the year, including the Report of the President and the Chancellor, the Report of the Ad Hoc Committee on Grading, the Institute Affirmative Action Plan, and the Open House Program.

M.I.T. Observer, which formerly appeared four or five times a year as a compendium of newspaper clippings about M.I.T., was suspended during 1977-78, and its primary audience, i.e., parents of undergraduate students, was sent, instead, eight issues of the Technology Review supplement, MIT78. That experiment in communications with parents appeared to be successful and will be repeated during the coming year.

Nine issues of Reports on Research were published as scheduled. Efforts were initiated during 1977-78 to reform the Reports on Research mailing list, requesting that individual offices, if possible, assume responsibility for maintaining on computer tapes their own individual constituency lists, thus relieving the News Office of that responsibility. The mailing list had grown over the years to embrace at least eight separate sublists and 4,000 names. The conversion effort is not yet complete and will be continued during 1978-79.

Only one staff change occurred during the year. Katharine C. Jones, formerly Assistant Director with special responsibilities for publicizing art, music, dance, and related activities at the Institute, accepted an appointment in the Office of Resource Development and Planning. Her successor is Paula Ruth Korn, formerly an on-camera television news reporter for WENH, Durham, New Hampshire, and before that a television and radio news reporter and producer in Maine and Rhode Island. Ms. Korn brings to the News Office a special expertise in electronic journalism that already has proven valuable to the Institute. William T. Struble, Assistant
Institute Information Services

Director, continued his effective service on behalf of the School of Science and its related centers and laboratories, as did Robert C. Di Iorio, Assistant Director, on behalf of the School of Engineering and its associated centers and laboratories, and Charles H. Ball, Assistant Director, on behalf of the School of Humanities and Social Science, the School of Architecture and Planning, and the Sloan School of Management and their associated centers and laboratories. Joanne Miller, Assistant Director in charge of Tech Talk, rendered especially effective service to many Institute offices, departments, centers, committees, and people in helping them communicate with the M. I. T. community, often on short notice, and, in face of continuing inflation, with somewhat reduced resources. Calvin Campbell, Assistant Director (Photojournalist), as noted above, continues to be much in demand and renders valuable service.

On the biweekly staff, Sheila A. Richards, Secretary, and Cathryn Chadwick, Editorial Assistant (Tech Talk) left the Institute, while Joan A. Kougasian, Editorial Secretary (Tech Talk) accepted an editorial appointment in the M. I. T. Department of Chemical Engineering. Helen L. Pollari joined the staff as Secretary. Elizabeth Van Horn, formerly Editorial Secretary (Press Releases), was made Editorial Assistant (Tech Talk) and Lisa C. Hirsh joined the staff as Editorial Secretary (Press Releases). Ms. Kougasian was succeeded as Editorial Secretary (Tech Talk) by Marsha G. McMahon. Paul M. Raeburn, Class of 1972, continued to serve the News Office as a temporary science writer, contributing importantly to Reports on Research.

ROBERT M. BYERS

CAMPUS INFORMATION SERVICES

During the past year, there was continued high demand for the services of all the offices within the Campus Information Services. Response to these pressures was facilitated by the major renovation of the Information Center and the News Office, which enables these offices to meet requests for information and service more efficiently and in more functional and aesthetic surroundings.

In the following pages are the reports of each of the organizations within the Campus Information Services: Design Services, the Information Center, and the M. I. T. Bulletin.

Design Services

In 1977-78 the Office of Design Services, under the direction of Jacqueline Casey, undertook 324 graphic design and publishing projects consisting of 481 parts. Of these publications 14 were in support of the M. I. T. Leadership Campaign, 75 were Alumni Association communications, and the rest were assignments from many individual offices and departments around the Institute.

The Office continues to provide design and production assistance to the growing number of conferences and special events on the campus. As a member of a working group on conferences, coordinated by the Director of the Information Center, Ms. Casey provides advice on publication requirements and coordinates the design and production of all publications needed by conference sponsors.

In December 1977, Joan Gale left the Institute and was replaced by Karin Baldwin who will serve as secretary and receptionist for the Office.
During the year, the work of Ms. Casey was shown in an international exhibition of graphic design at the Chelsea School of Art in London, England. The selection of publications represented many departments of the Institute. She was a juror for the UCDA (University and College Designers Association Competition). Ms. Casey and Ralph Coburn are included in the 1978 edition of Who's Who in American Art. She continues as a panelist reviewing government graphics for the National Endowment for the Arts in Washington, and is a member of the Board of Directors of the American Institute of Graphic Arts (AIGA) in New York. Mr. Coburn was a judge for the senior presentation graduation portfolio at the Art Institute of Boston. His work appeared in Graphis Posters 1978. The work of Ms. Casey, Mr. Coburn, and Betsy Hacker was exhibited by the Boston Art Director's Club. Mr. Coburn received a special Merit Award. Ms. Hacker's work was shown in the AIGA Cover Show and the New York Art Director's Club Annual Exhibition.

Nancy Pokross received five awards from CASE (Council for the Advancement and Support of Education). Four of these citations were for her work done for the Alumni Association and one was an Exceptional Achievement Award. Her design efforts were also recognized in the "Best Financial Support Program" for all M.I.T. Leadership Campaign publications, for which the Development Office was awarded a $500 prize.

**Information Center**

The past year was a banner year for the Information Center when a major task was undertaken for redesign, reorganization, and relocation. In March the Center officially opened in refurbished surroundings in the former Registry of Guests Office. Connecting this area to the redesigned News Office has established an extended operating facility for more efficient dissemination of information. By utilizing this space and consolidating services, the Information Center and News Office are able to maintain a central file room, combine distribution of material, and eliminate duplication of reference materials. The former location of the Information Center has been redesigned to serve as a lounge for visitors and handicapped students.

The Center's goals remain basically the same: service to the M.I.T. community and visitors as a source for reference and information on M.I.T. programs and activities, for coordinating special activities, and for supporting international faculty, staff, and visitors.

The distribution of reports, publications, and bulletins continues to meet demands. The following is a general list of distribution:

<table>
<thead>
<tr>
<th>Distribution Category</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulletin issues</td>
<td>15,844</td>
</tr>
<tr>
<td>Reports</td>
<td>12,707</td>
</tr>
<tr>
<td>Maps and Guides</td>
<td>35,139</td>
</tr>
<tr>
<td>Other Publications</td>
<td>22,325</td>
</tr>
</tbody>
</table>

The Center continues the practice of hiring students as guides and office assistants. During the past year 27 students worked in the Center, giving tours and providing general information to visitors as well as to members of the M.I.T. community. Almost 5,000 visitors took tours of the campus during the past year.
Every June the staff at the Information Center has mixed feelings as we say goodbye to our student staff members who have graduated. To these students we extend our warm good wishes for a happy future.

During the summer the Center's staff was augmented by M.I.T. students who helped give tours and answer the questions of the many summer visitors to the Institute. In June Susan Krolewski, a third-year student, worked full-time conducting tours and answering visitors' questions. She was joined during July and August by Mary Haselton, a fourth-year student.

In addition to overseeing the activities and projects in the Center, the Director helped to coordinate the planning and operation of eight major conferences and events at the Institute and continues to serve as Executive Secretary to the Committee on Commencement. This past June, a tradition was broken when the last class graduated from Rockwell Cage. It was a record-breaking Commencement both for students graduating (1,300) and attendees (over 3,200), and for the first time child-care was provided for 65 children ranging in age from three weeks to 12 years. The summer and fall of 1978 will be spent working on plans to hold Commencement 1979 in Killian Court.

Special assistance to international faculty and staff is provided by Virginia Lyons, who provides advice and guidance on issues relating to immigrant and non-immigrant visas. During the past year there were 696 foreign staff and faculty members from 62 countries holding appointments at the Institute. The largest numbers come from England, Japan, China, Germany, Canada, India, and Israel.

During the past year, considerable attention was focused on the subject of immigrant visa applications submitted by the Institute, particularly because of difficulties involving the labor certification aspect of these applications. Information regarding immigration procedures and documentation was prepared for, and discussed by, members of the Academic and Faculty councils and discussions will continue during the year as we seek to define institutional policy and desired Federal policy on these matters.

Regarding the immigrant visa applications, the following applications were submitted during 1977-78:

<table>
<thead>
<tr>
<th>Visitors During</th>
<th>July 1977 - June 1978</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Prospective Students</td>
<td>2,119</td>
</tr>
<tr>
<td>Number of International Students</td>
<td>441</td>
</tr>
<tr>
<td>Number of General Visitors</td>
<td>2,318</td>
</tr>
<tr>
<td>Total</td>
<td>4,878</td>
</tr>
<tr>
<td>Total Number of Visitors on General Tours</td>
<td>4,127</td>
</tr>
<tr>
<td>Total Number of Visitors on Special Tours</td>
<td>751</td>
</tr>
<tr>
<td>Total</td>
<td>4,878</td>
</tr>
</tbody>
</table>
16 Individual labor certifications
16 Third preference petitions
14 Adjustment of status or immigrant visa applications

The following were approved:

5 Individual labor certifications
13 Third preference petitions
11 Adjustment of status or immigrant visa applications

Of these, one individual labor certification and three third preference petitions were denied.

A total of 485 short-term foreign visitors were assisted by the Center during the 1977 calendar year; 474 appointments were scheduled for these visitors.

As the number of foreign staff and faculty mount and the Federal and state regulations regarding their employment change, more is expected of this office than in the past. We hope to continue to meet the demand and adapt to the changing times.

In addition to her work with the international community, Ms. Lyons arranges representation of M.I.T. at inaugural events of other universities. During the past year, 23 alumni and faculty members were chosen to represent M.I.T. at these functions.

The report would not be complete without mentioning the support staff working in the Center. Kathleen Barrett, Brenda Loew, Geraldine LoGalbo, and Terri Priest have all contributed to the work of the Center with a sense of duty and willingness.

M.I.T. Bulletin

In 1977-78, the M.I.T. Bulletin Office, under the direction of Janet Snover, produced the five annual Bulletin issues and several other Institute publications, including the expanded edition of the Report of the Treasurer, the small edition of the Report of the President and the Chancellor, and the Student Directory. In addition, a number of discussions were held with people involved in the formulation or implementation of policy regarding student recruitment to determine whether the present format and distribution of the two M.I.T. catalogues (Courses and Degree Programs and the General Catalogue) most effectively meet the needs of our current and prospective students. Postal issues were another concern to the Bulletin Office this year. Stricter enforcement of regulations for second-class mailing privileges necessitated a change in the contents of the Bulletin series which will be effective beginning in the next fiscal year.

In the past two years there has been increasing use of and requests for Courses and Degree Programs by people outside of M.I.T. This changing pattern of use coupled with concern about M.I.T.'s ability to reach and influence prospective students, increasing competition for the best candidates, and rising publications costs prompted the Bulletin Office to review the contents and distribution of our catalogues. Discussions were held with Peter H. Richardson, Director of Admissions; John B. Turner, Associate Dean of the Graduate School; Richard M. Douglas, Chairman of the Faculty Committee on Undergraduate Admissions and Financial Aid; Stewart C. Myers, member of the Committee on Educational Policy; Kathryn W. Lombardi, Manager of Campus Information Services; and Constantine B. Simonides, Vice President.
A number of possible alternatives to the current publications and distribution program were identified during these discussions, including a return to a single catalogue for both current and prospective students. Those involved in the discussions agreed, however, that a longer-term study of M.I.T.'s publications and recruiting program is necessary before any major changes in the content or format of the catalogues is made. A working group from the relevant committees and offices will be established to begin such a review during the coming year.

However, several experimental steps will be taken during 1978-79 which will provide us with more information for use in future planning. As a first step, the effectiveness of the General Catalogue and the Freshman Handbook as recruiting pieces will be tested. To do this, the Freshman Handbook will be sent to a random sample of 500 applicants and the General Catalogue to another group of 500 applicants. The books will be mailed early enough in the admissions process so that they are truly recruiting pieces. (In the past, the General Catalogue was sent only after a student had filed a final application; the Handbook was sent only to students who had been admitted.) This experiment should give us both a better idea of the effectiveness of each book and of the advisability of mailing them earlier in the process.

Another change for next year will be to place much greater emphasis on the General Catalogue as the primary document for use by people outside of M.I.T. Because we have not treated Courses and Degrees as the internal, registration and planning tool that it was intended to be, there has been a greater demand than we can meet for the book.

The working group will assess the impact of these changes in planning M.I.T.'s publications program for the future. The group may consider modifications in publications such as M.I.T. Today and the catalogues and may suggest completely new publications or the use of other media such as film or video to reach prospective students.

The contents of the Bulletin series of publications will be changed next year in order to retain the Institute's second-class mailing privileges. The Postal Service now requires that a college or university produce a minimum of four annual catalogues to qualify for reduced mailing rates. The Post Office ruled that M.I.T.'s Report of the President and the Chancellor and Report of the Treasurer had to be dropped from the Bulletin series because they are annual reports rather than catalogues. That meant that there were only three catalogue issues (Courses and Degrees, the General Catalogue, and the Summer Session Catalogue), so the Bulletin Office submitted several other Institute publications for consideration as possible fourth issues to the series. The Post Office approved the final I.A.P. Guide as meeting the qualifications of a catalogue. Though the I.A.P. Guide is not mailed extensively outside of the Institute, it was important to retain the second-class mailing permit so that the General Catalogue and Courses and Degree Programs could continue to be mailed at these greatly reduced rates. Production of the Report of the President and the Chancellor and the Report of the Treasurer will continue to be coordinated by the Bulletin Office.

The 1977-78 edition of Courses and Degrees received the "Best in Show" award from the National Composition Association, a section of Printing Industries of America. The book, chosen from among more than 650 entries to the national competition, was cited for its excellence in typographic design, layout, readability, and clarity.

In recognition of her increased responsibilities and professional commitment, Susan Shansky, the Bulletin's Editorial and Production Assistant, was promoted to the Institute's exempt payroll. In addition to providing outstanding service to the M.I.T. Bulletin Office, Ms. Shansky continued as editor of the Special Summer Session brochures. During the coming year, she will become involved with writing and editing publications for other special projects.
The Editor of the Bulletin, Janet L. Snover, has continued to provide exceptional production as well as editorial management of the publications. Ms. Snover has been elected president of the New England College Editors Association. In this capacity, she will plan and organize workshops on editing and production of college publications.

KATHRYN W. LOMBARDI

Information Processing Services (I.P.S.)

This past year has been a year of major changes for Information Processing Services in hardware, operating systems, software, and customer base, not only on the Academic and Research Services side of the activity but on the Administrative Services side as well. It was a year which included a major decision to pursue the Virtual Memory operating system (VM) rather than MVS on our IBM 370/168; the selection and acquisition of two data base management systems to enhance our business system development work; the upgrading and installation of an IBM 370/148 to replace the 145 in our Administrative Services facility; the establishment of a planning committee to study the long-range computational and data processing needs of M.I.T. for the next 10 years; notification by Harvard University that they plan to terminate our contractual computing arrangements June 30, 1979, ending an eight-year joint involvement; the establishment at M.I.T. of the Center for Computational Research in Economics and Management Science, bringing with it the TROLL subsystem and a nationwide collection of new users for our 370/168; and the hardware improvements necessary to support a VM/CMS environment including three million bytes of additional memory, a virtual memory assist feature for the 168 processor and a programmable communications controller increasing our remote user and networking capability.

Administrative Computing Services (A.C.S.)

During this past fiscal year more than 10,000 administrative production jobs were scheduled, and of those, some 9,500 jobs were delivered error-free and on time. This 95 percent ratio is two percent less than last year's; however, it is still above our targeted 90 percent.

As was anticipated, we have seen some reduction in the number of requests to modify existing systems, allowing us to redirect some of the programming resources normally utilized for this purpose to convert 1401 and DOS programs to COBOL under OS/VS1. In this regard, we began the year with 100 requests in the queue, opened 64 new tasks, completed 66, and closed with a balance of 98. In addition to the above, however, the Alumni Office's activities were transferred back into A.C.S. during the year. A large number of new change requests (26) were received on this system and of these, we were able to complete only 17. In the Business Systems Development section which follows in this report, a new information system for the Alumni Office is discussed. The improvements contained in it should alleviate many of the problems inherent in the current application.

New systems turned over to Operations during this past year included accounts receivable, requisition pricing on Lab Supplies, and the pension and exempt payrolls under the MSA package. In addition, we converted or rewrote systems for the Industrial Liaison Office, the Educational Council, the Sloan School of Management, the Summer Session Office; and we made a major revision to the Credit Union System.
Information Processing Services

Operations installed the 370/148 to replace the 145 in October. This allows us to run the VM (Virtual Machine) monitor system which, in turn, permits us to run two operating systems concurrently (DOS/VS and OS/VS1), substantially improving our ability to convert from a DOS to an OS environment. Hardware changes during the year also included new printers and the installation of a larger and more efficient disk storage subsystem.

Business Systems Development (B.S.D.)

In addition to installing the production systems mentioned above, the most significant events in systems analysis and design included the unexpected resignation of Paul Saia, Manager of Business Systems Development. In an attempt to turn this misfortune into an opportunity, we decided to combine the B.S.D. group with the functions previously managed by James Donohue, Manager of Systems Planning and Development (S.P.D.). Garret Sheldon of the S.P.D. group was chosen to replace Mr. Saia. This has significantly increased the OS technical leadership within the group and subsequently enabled us to install the two new payrolls and the accounts receivable system.

The acquisition of ADABAS and IDMS from software ag of North America, Inc. and the Cullinane Corporation, respectively, provides a totally different methodology for the design and installation of the new systems. Using ADABAS, we have already begun the design of a new system for the Alumni Office which we hope will provide a responsive and interactive version available for use by January 1979.

In the Financial Aid Office it was decided to combine their data with that of the Registrar's Office, and for the first time to integrate into one data management system the activities of two significantly different operations. Considerable interest has been expressed by other offices to access the student data which will be available in this combined data base. The ability to access the data directly via telecommunications services provided on the S/370/148 should greatly enhance the "usability" of this data.

In conjunction with the Center for Information Systems Research in the Sloan School of Management, a study was completed outlining the total personnel, financial, and operational impact which would be involved in converting all systems (mechanized and other) which are currently dependent upon the Social Security number as a personal identifier. This project was requested by Dr. Louis Menand and supported by Chancellor Paul Gray. Although no final decision as to what M.I.T. should or should not do in this regard has yet been made, it does put us in an excellent position to assess the impact of private sector privacy legislation on our operation.

Another activity involving C.I.S.R. is the Budget and Account Reporting System analysis and design currently under way.

Academic and Research Computing Services

Early in the year the I.P.S. was given the opportunity for a major change in direction for their IBM S/370 computing services. This opportunity arose when it was decided that the computer research group of the National Bureau of Economic Research, headed by Professor Edwin Kuh, was to be transferred to the M.I.T. Sloan School of Management. This group was to bring with it the expertise for the development and support of a large and well-known econometrics tool called the Time-shared Reactive On-Line Laboratory (TROLL) and they wished us to make that service available on our S/370. The TROLL System runs on a stand-alone or, more usually, a virtual machine as provided under the IBM VM monitor.
The I. P. S. had long considered running VM since, in our opinion, it provides a flexibility not otherwise available. For example, one can concurrently run several operating systems on the same physical system, allowing a much more orderly transition for our users from one system to another. (That is evidenced in our present transition from the MVT to the VS1 operating systems, both of which are currently being supported.) In addition, it provides a virtual memory environment, one in which the user is not bound to the physical memory limitations of the computer and which allows considerable simplifications in that each user can run on a "separate" machine with the consequent increase in reliability.

In addition to TROLL, the Energy Laboratory also expressed their need for a VM system so that they could transfer their work from an off-campus site to the central campus facility.

The decision was then made to set aside our current development plans for the new operating system (MVS) and to install VM on the S/370 as soon as possible, but by November 1, 1977 at the latest. (This November deadline was required by the Energy Laboratory's plans.) A considerable effort was required to bring up the system, to select and install the additional equipment, and to get the current operating systems to run under the VM Monitor with as little degradation as possible. Although there were problems, the system was in place by the November 1 deadline and the new services provided were being used by the Energy Laboratory.

It would be less than truthful to imply that this installation was accomplished without problems. Users of the older system found that the increased load and a yet-to-be-tuned system had serious detrimental effects on the response of the system. Eventually (and painfully) the various incompatibilities and inefficiencies in the systems were worked out, and in February, when the TROLL service started, the greatly increased workload was hardly felt, except perhaps in the availability of lines into the system.

By the close of the fiscal year it was apparent that the installation of VM had been successful and that the new usage that had been introduced would be sufficient to cover the additional cost. We now look forward to the non-trivial tasks of converting our users from the "batch oriented" method of operation and the old operating system to what we hope will be an on-line, interactive using community which uses the batch system only for the routine and repetitive type of processing for which it is best suited.

Meanwhile on the Multics side, an experiment in pricing was attempted and proved quite successful in attracting additional usage to that system. For at least the non-prime part of the day, the micro-charging scheme based on actual resources consumed was replaced with a single connect-time charge. Although in the aggregate the rates chosen for these off-shift connect charges were not intended to be price decreases, those users who would realize an advantage were free to move their usage to an off-shift and many did. Consequently, we realized some considerable decrease in total income at first while at the same time experiencing a large increase in resources consumed, especially CPU (central processing unit) time.

This new pricing proved so attractive to many people, however, that Multics users and usage increased considerably. For example, the number of active Multics projects in May 1977 was 178. By May 1978 that number was 334. Consequently, by the end of the spring term, Multics income was exceeding predictions by over 10 percent, and it appeared that total Multics revenue for the year would be close to that originally expected. In addition, the prime-shift users were enjoying improved service due to a general leveling of the load over the day. All in all this experiment has been rated a great success and we intend to continue the new pricing policy and perhaps to extend it to the S/370 at some future time.

Another major experiment started this year was the I. P. S. involvement in the facilities management and user support of the computer installation within the Sloan School of Management.
Information Processing Services

Here we are endeavoring to enhance computer access and data processing support to the East Campus community. If successful, such a program could act as a model for other decentralized facilities and form the foundation of a campus-wide network of localized computation and user services.

Systems Programming

Supporting both the administrative and the academic and research computer installations, the systems programming staff has had the primary responsibility of installing the new Virtual Machine Monitors now running on the S/370 148 and 168. Much of this work, on the Model 168, used by the academic and research community, has been in "tuning" the systems so that the additional workload does not unduly affect performance. During the last part of the year, development work on the replacement operating systems began and the next year should see a total switchover of the user community. The goal is to make this transition as smooth and as simple for the user as possible.

Committee on Future Computational Needs and Resources

In October 1977, Dr. Paul Gray and Professor Walter Rosenblith established a committee to determine the long-term (10-year) needs for computation and information processing services at M.I.T. Professor Michael Dertouzos was appointed chairman with the following committee: Weston J. Burner, Co-Chairman; Professors Fernando J. Corbato, Electrical Engineering and Computer Science; Edwin Kuh, Economics; Joel Moses, Electrical Engineering and Computer Science; Nicholas P. Negroponte, Architecture; Steven A. Orszag, Mathematics; Michael Scott Morton, Management; and Mr. Joseph R. Steinberg, I.P.S.

The Committee has met regularly since its appointment and is due to submit a report to the Provost and Chancellor in September of this year. In its deliberations, administrative, academic, and research computing issues are being addressed, with heavy emphasis placed on computer usage within the undergraduate community.

Needless to say, the future role of centralized computing services at M.I.T. will depend heavily upon the output of this Committee and its recommendations.

WESTON J. BURNER
JOSEPH R. STEINBERG

MIT Press

Fiscal 1978 was an active and exciting year at the MIT Press. The new list was the best ever in terms of sales and as a measure of the diversity of the Press's program. Sales were over $3.5 million, a 32 percent increase over the previous year. The extraordinarily successful Encyclopedic Dictionary of Mathematics was responsible for one-quarter of that increase by generating revenues of $230,000. That we published the same number of books as in the previous year points to success in increasing the quality and pertinence of our list and in improving marketing effectiveness.


In fiscal 1978 the Press published 50 new hardcover titles and 39 paperback titles and launched two new journals, *October* and *International Security*. Table A presents sales statistics for the past three years and Tables B and C the distribution of new titles by format and by discipline.

| Table A |
|---|---|---|---|---|---|
| **SALES** | **FY76** | **FY77** | **FY78** | **% Change 1977-78** |
| Net Sales, Domestic | 1,995,000 | 2,067,000 | 2,719,000 | 31.5 |
| Net Sales, Foreign | 600,000 | 638,000 | 867,000 | 35.9 |
| Total Sales | 2,595,000 | 2,705,000 | 3,586,000 | 32.7 |

| Table B |
|---|---|---|---|
| **Fiscal year** | **hard + paper** = **original** | **reprint** = **total** | **simultaneous hard & paper** | **import/distribution** |
| 1976 | 41 | 27 | 44 | 24 | 68 | 2 | 11 |
| 1977 | 58 | 36 | 74 | 20 | 94 | 7 | 25 |
| 1978 | 58 | 39 | 66 | 31 | 97 | 3 | 12 |
| 1979* | 70 | 25 | 75 | 20 | 95 | 2 | 10 |
| *estimated |
Table C

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In the more technical area, excellent reviews of *The Encyclopedic Dictionary of Mathematics* were published in *The New Scientist*, *The Times Literary Supplement*, and in the library media. Other books that received wide media coverage include *The Ungovernable City*, by Douglas Yates; *Ethics in Medicine*, by Stanley Reiser, Arthur Dyck, and William Curran; *The New International Economic Order*, by Jagdish Bhagwati; and *Science Textbook Controversies*, by Dorothy Nelkin.

MIT Press books received a number of important awards this year. *The Encyclopedic Dictionary of Mathematics* led off with prizes at the New England Book Show, the Association of American University Presses Annual Book Show, and the American Institute of Graphic Arts annual show. It also won the R. R. Hawkins Award for the best technical book of the year, presented by the Scientific, Technical, and Medical Division of the Association of American Publishers (AAP).

Twenty-seven contracts for translation of MIT Press books into foreign languages were completed this year compared to 19 contracts in fiscal 1977. The most notable book club activity of the year was the purchase by three clubs, including Book-of-the-Month Club, of Paolo Maffei's *Beyond the Moon*. Paperback rights to this title were sold to Avon for a record $20,000.

Our acquisition department was expanded during the year from four to six full-time editors, and staff in design, production, editorial, marketing, and fulfillment grew to accommodate program expansion. Fiscal 1978 was also a year in which the Press made major advances in the development of computer technology to support the management of our operations. A terminal to the M.I.T. time-sharing system was installed within the Press with programs to assist in projecting the financial performance of new books. In the summer, the Press signed a contract with STC Systems for the design and installation of an Ultimacc computer system to handle order entry, inventory control, billing, and royalty accounting. Ultimacc is expected to reduce annual data processing costs by one-third. Also during the year the Press made a commitment to install an in-house computer composition system, Computergraphics, which will supply all our book and journal typesetting needs.
On the financial side, net income improved substantially compared to 1977. Operating statements reported a savings of $107,000 on the planned bottom line for the year, producing the first net return on operations since fiscal 1970, and the largest in MIT Press history. The total debt to the Institute was reduced by $15,000 in absolute terms, while working capital debt as of July 1, 1978 was at the lowest in a decade.

The MIT Press Management Board, which serves as a board of directors for the Press within the Institute structure, met twice in 1977-78 in full session to review our operations. Serving on the Management Board in fiscal 1978 were: Richard B. Gladstone (Senior Vice-President, Houghton Mifflin Company), Arnoldo C. Hax (Sloan School of Management), Walter S. Owen (Department of Materials Science and Engineering), Hartley Rogers, Jr. (Associate Provost), Jack Schulman (retired Director, Cambridge University Press), Myron Weiner (Department of Political Science), W. Bradford Wiley (Chairman, John Wiley & Sons, Inc.), and Constantine B. Simonides (Vice President), Chairman of the Management Board.

ACQUISITIONS

The Acquisitions department expanded considerably in fiscal 1978. Rene Olivieri took on the responsibility of developing publishing programs in business and economics. Larry Cohen shifted from the Editorial to the Acquisitions department to acquire books in the physical sciences, mathematics, and the history of science and technology. Muriel Cooper divided her time between the School of Architecture, where she heads the Visible Language Workshop, and the Press, where she has begun to develop a program in visual communication. Two new editors joined the acquisitions department to replace departing staff: Roger Conover in architecture and urban studies and F. Treville Leger in life sciences, neuroscience, and health sciences. Barbara H. Ankeny continued to acquire in the social sciences, humanities, and linguistics, and Frank Satlow to develop lists in engineering systems, environmental studies, artificial intelligence/computer technology, and the quality of working life.

Developmental planning remains a fundamental part of the acquisition program. Emphasis was placed during the year on increasing the advanced text and reference components of our list, on exploring possibilities for revision of successful backlist titles, and on expanding series publications. The series launched in 1977-78 were Control and Signal Processing, Artificial Intelligence, Health and Public Policy, and Epidemiology. The Press entered into a co-publication agreement with the Architectural History Foundation for a series of books on architecture, art, and related fields; took over the backlist of the Wright-Allen Press; established the MIT Press/Wright Allen Series in System Dynamics; and agreed to distribute the Press Series on the Human Environment.

The acquisition editors presented 90 new book proposals to the Editorial Board at 13 meetings throughout the year. Eighty-five were accepted for publication. These figures compare with 76 proposals presented during the previous year and 72 accepted for publication. Approximately 600 unsolicited manuscripts and proposals were rejected by the editors. During the past year, approved proposals resulted in 81 contract signatures.

In 1977-78 the Editorial Board was led for the fourth year by Professor Hartley Rogers, Jr., Associate Provost of M.I.T. Professor Henry Millon (Architecture), Dean Harold J. Hanham (Humanities and Social Science), and Professor Joan Bresnan (Linguistics) served the second year of their three-year terms. Professors Robert M. Fano (Electrical Engineering and Computer Science), John G. King (Physics), Maurice S. Fox (Biology), and Charles Weiner (School of Humanities and Social Science) completed their terms; and Professors Jagdish Bhagwati (Economics) and Ascher Shapiro (Mechanical Engineering) served their first year.
Constantine B. Simonides, Vice President of the Institute, Frank Urbanowski, Director of the MIT Press, and Jay Lucker, Director of M.I.T. Libraries, served as nonvoting members.

PRODUCTION

In 1977-78 the Editorial department launched 55 original manuscripts (26,350 pages) into the publishing process. Under the management of Helen Osborne, the Press staff completed editorial work on 26 books and supervised the work of freelance copy editors for the balance of the list. There were a number of projects of major proportions -- the two-volume WAES (Workshop on Alternative Energy Strategies) Series on Energy Demand to the Year 2000 and Energy Supply Demand Integrations; Greep & Koblinksky, Frontiers in Reproduction and Fertility Control; Baan, Noordergraaf, and Raines, Cardiovascular System Dynamics; Pearce, Structure in Nature is a Strategy for Design; and Badawy, Coptic Art and Archaeology.

Books such as Pearce and Badawy demanded special attention to design and the production of dummy layouts and mechanicals. The Design department, under the direction of Sylvia Steiner, provided book and jacket designs for all MIT Press books as well as designs for book promotion and advertising. True to form, the Design department won a variety of awards during 1977-78, including an annual AAP award for Taylor, Human Reproduction and New England Book Show awards for Taylor's book, for Reiser, Ethics in Medicine, and for Walden, The Open Hand. The Encyclopedic Dictionary of Mathematics (EDM) won design awards from both organizations. In addition, MIT Press book jackets won awards from the AAP, the New England Book Show, and the Art Director's Club of Boston.

Under the direction of Richard Woelflein, our production department supervised the production of 97 titles, including 58 new hardcovers and 39 paperbacks, as well as the reprinting of 41 hardcover and 32 paperback titles. MIT Press spends almost $1 million each year on printing; about half is spent on reprints of books that are selling well. Of titles published during the past year, the following are already on their second or third printings: EDM; Albers, Despite Straight Lines; Portugal and Cohen, A Century of DNA; Yates, The Ungovernable City; Killian, Sputnik, Scientists, and Eisenhower; Bhagwati, The New International Economic Order; Schrank, Ten Thousand Working Days; Kaufman, A Fortran Coloring Book; and Bronowski, A Sense of the Future.

Beginning in fall 1976, MIT Press conducted a study using the facilities of a local composition firm to determine the feasibility of purchasing a large, multi-terminal computer editing system and on-line typesetter. This project, under the management of Mildene Bradley, typeset 13 MIT Press books at cost savings. Simultaneously, the Press undertook an in-depth study of available composition systems in order to determine which system would best suit our needs. As a result of these studies, the Atex 8000 system was selected and will be installed at the Press in the fall. On July 1, 1978 Andrew Koppel joined the Press to co-manage the in-house computer composition system, Computergraphics, with Ms. Bradley.

MARKETING, SALES

In the domestic market, where our books are sold primarily by three field representatives serving our major customer accounts in the East, Midwest, and the West, sales are summarized in the following table. Growth in almost every category reflects the overall improvement of the Press's list. Sales to wholesalers and jobbers (many of which are ultimately sales to libraries) increased about 30 percent without including the EDM.
International sales increased by 36 percent over fiscal 1977. Approximately 58 percent of this increase is accounted for by the excellent foreign sales of the EDM. International sales for the past three fiscal years are compared below.

Subsidiary rights income in fiscal 1978 was 27 percent higher than the previous year, due to greatly increased sales of translation rights. The three-year record is shown below.

During the fall, the Press mailed eight subject area catalogues to a total audience of 397,000 prospective customers. The catalogues were uniformly conceived and designed, and presented the Press's entire list of books in Architecture and Urban Studies; Linguistics, Language, and Reading; Humanities; and Economics and Management. Recent titles along with bestselling backlist titles appeared in catalogues in the Social and Political Sciences; Life Sciences; Physical Sciences; and Engineering, Systems, and Computer Sciences. New and recent books were promoted through the mail during the spring in 13 brochures written and designed in a style similar to that of the subject catalogues and mailed to a total of 110,468 prospective buyers.
Direct mail selling generated a net income of $390,000 in fiscal 1978 compared with $370,000 in 1977. More significant is that special discount sales contributed a total of 38 percent of direct mail sales this past year compared to 66 percent the previous year.

Also during the year the Press produced nine group text brochures, organized by course subject areas in: Cinema, Television, Photography, and Communications; Psychology, Education, and Language Study; Political Science and International Studies; Business and Economics; Urban Studies; Regional Planning; Medicine and Life Science; Earth and Space Sciences, and the Environment; and Computer Sciences, Information Theory, and Systems Analysis. Twelve additional brochures promoting individual books were also mailed. Brochures were sent to 138,000 prospective adopters; 8,500 books were sold and 7,600 sent out for examination. We sent 2,800 desk copies in response to firm adoptions, an increase of 21 percent over last year.

Increases in adoptions were noted in such standard books as Rasmussen, Experiencing Architecture; Dondis, A Primer of Visual Literacy; Lynch, Image of the City; Summerson, The Classical Language of Architecture. New titles, especially in psychology, language study, life science were widely adopted, and outstanding titles include Reiser, Ethics in Medicine, Fienberg, Analysis of Cross-classified Data, Harvey and Hallett, Environment and Society, and Bhagwati, The New International Economic Order.

Fifteen exhibits were set up and attended by Press personnel at professional and trade meetings. Books were also displayed at 61 combined exhibits throughout the year.


The Press also produced two general catalogues and seasonal announcements, which were mailed to 35,000 bookstores and library customers, as well as to selected reviewers and to the M.I.T. community.

JOURNALS

MIT Press currently publishes eight journals. Linguistic Inquiry, The Journal of Interdisciplinary History, and Cell have been with the Press for many years and continue to improve their subscription bases and increase revenues. Oppositions (the Association of American Publisher's best technical journal of the year), Neurosciences Research Program Bulletin, and The American Journal of Law and Medicine have completed their second year of publication. In addition, two new journals were launched. October is a journal of art theory, focusing on the visual arts: painting, sculpture, film, photography, dance, theatre. The journal examines
the arts from a wide range of contemporary perspectives and encourages new methods of critical analysis. *International Security* is a forum for thoughtful discussion of the pressing policy questions and research problems in international affairs today. The Press also has added a new Journals Department Manager, Ann Reinke, who will continue the fine work of Blair Bergstrom in expanding and consolidating the Press's journals operation.

FINANCIAL

The Financial department, under the direction of Controller Michael Leonard, continued to exercise close supervision over accounting and fulfillment operations and was instrumental in bringing the advantages of computer technology inside the Press. During the year the Press installed a printer-terminal tied into the Institute's time-sharing system. Members of the financial department then wrote and taught to Press acquisition staff a program for projecting net dollar gain or loss and cash flow of prospective titles. Using the computer program as a decision tool, acquisition editors are now able to try various approaches to pricing, setting print quantities, and estimating costs, and this can be done comparatively before, during, and after publication.

In December 1977, MIT Press signed a contract with STC Systems, Inc. for the design and installation of an Ultimacc turnkey business computer system to replace the outside data processing service currently used. The system takes advantage of the latest advances in computer technology, employing on-line video display terminals linked to a control minicomputer with auxiliary storage on disc drive units. When operational (October 1978), the system will permit sales orders to be entered by an operator working with the video display and keyboard. Inventory status is checked and quantities adjusted immediately upon acceptance of the order on the screen. In this integrated system various sales, royalty, accounts receivable, and promotion files are subsequently updated from the control console. While routine daily, weekly, and monthly management reports will be generated, the system will also allow on-line inquiry into files to obtain the latest data pertaining to a particular book or customer.

Annual savings under the new system are estimated at $35,000, based on current data processing charges by outside service centers. Another important benefit of the system is that it is flexible and sophisticated enough to allow for further applications to be developed and implemented in future years.

FISCAL 1979

Prospects are bright, and we anticipate a busier year ahead. Ultimacc is scheduled to go on-line in December and Computergraphics will be producing type in the spring of 1979. We expect to launch the development of several major reference works and a dozen new series, to accelerate programs of co-publication with foreign and domestic publishers, and to continue the expansion of our Journals department. Journals revenues in fiscal 1978 were $700,000, a 40 percent increase over fiscal 1977. We will in the coming year reorganize our market activities in Latin America to be represented by the university press consortium, Unilibros. The Press also will make a major change in our marketing network in East Asia.

The Press has during the past year developed publishing programs in conjunction with many programs and laboratories at M.I.T. including the Artificial Intelligence Laboratory, the
Center for International Studies, the Laboratory for Computer Science, the Division of Health Sciences and Technology, the Joint Center for Urban Studies, the Neurosciences Research Program, the Sea Grant Program, the Council for the Arts, and the Energy Laboratory. Our plans for the new year include continuing discussions and initiating cooperative publishing ventures with the Whitaker College of Health Sciences, Technology, and Management, the Program in Science, Technology and Society, and new series in Epidemiology, in Toxicology, and in Health and Public Policy.

FRANK URBANOWSKI

Plasma Fusion Center

This has been a very good year for the plasma fusion program. As reported a year ago, the Alcator C device is scheduled for operation in January 1979. We are still on schedule, thanks in good part to the appropriate and timely funding by the US Department of Energy.

The toroidal magnet and vacuum system produced an initial discharge in late March, and a lengthy and arduous program of cleaning the vacuum system by gradually increasing the plasma current and temperature has been proceeding throughout this period.

The 200 MW alternator donated by Consolidated Edison arrived in Cambridge in the middle of our worst winter but has been installed, and the reconstruction and operational testing is on schedule. We expect that barring mishap the alternator will be capable of full power operation by early fall.

While the new power supply is being made ready, the Alcator C is being operated using the 30 MW installation of the National Magnet Laboratory.

In addition to the main toroidal power supply, a great deal of auxiliary power equipment has been and is being procured. This auxiliary equipment includes the rectification and switching equipment for the 200 MW toroidal field supply, plus the poloidal and equilibrium magnetic field supplies.

In the meantime, the Alcator A device continues to operate most satisfactorily and has produced a great deal of good physics, in particular, has achieved a new world record of $3 \times 10^{13}$ ion-sec in the all-important time-density product. Without auxiliary heating the ion temperatures have remained at around 700 eV with electron temperatures somewhat higher.

During the year a great deal of effort on neutral beam heating has taken place at Princeton and more is planned at Livermore and at General Atomic. The initial results from the Princeton experiments have been encouraging to us all.

During the fall of 1977 we examined the problem of introducing neutral beam heating to Alcator C. Because of the high magnetic field and the limited space, this would be a difficult but not impractical task. However, with the great efforts taking place in other laboratories, it was agreed with the Department of Energy that we should attempt radio frequency heating on Alcator C, concentrating on the lower hybrid mode, and funding of $6$ million dollars for 18 months has been provided. Since work done on RF heating to date has been almost entirely of a theoretical nature, we shall introduce radio frequency heating not only in Alcator C but in Alcator A as well. A good deal of preliminary work will be done on the small experimental
Office of the President and the Chancellor

tokamak, Versator II. We are also giving some consideration to the radio-frequency, ion-cyclotron mode as a backup for the lower hybrid mode. This work is a collaboration of Professors George Bekefi, Ronald R. Parker and Miklos Porkolab, with Dr. James W. Meyer acting as Project Manager, and Professor Abraham Bers lending a theoretical hand.

During the past year Professor Lawrence Lidsky has taken a look at an alternate magnetic confinement scheme called torsatron, which is a lineal descendant of the old stellerator. Toroidal in shape generally, the torsatron has much greater working space and lower magnetic fields than Alcator, so it could be a viable alternate approach to practical fusion power. The Department of Energy is funding a study program with a very good chance that an experimental program will be initiated during the coming year.

Professor Louis D. Smullin and his group are making progress on the prevention of instabilities inherent to mirror devices, and are working closely with the large mirror program at the Lawrence Livermore facility. Dr. Daniel Cohn is directing very important design studies on ignition devices and on early energy-producing tokamaks.

On the theoretical side, Professor Bruno Coppi's group is becoming more closely coupled to the experimental work, and is attempting to set the theoretical limits for meeting the ignition conditions for tokamak fusion. Professor Thomas Dupree is continuing his general approach to plasma instabilities, Professor James E. McCune is directing his efforts more and more toward toroidal discharge studies, and Professor Bers' great interest in lower hybrid RF heating is of great importance to our experimental program.

In many respects the high point of the year was the formal dedication of the Alcator C on April 7, 1978. The dedication, which included talks by President Jerome Wiesner, Professors Coppi and Parker, and Dr. D. Bruce Montgomery, was highlighted by an introduction by Dr. John M. Deutch, Director of Research for the Department of Energy, stressing a need for new energy resources, and the conclusion by Edwin E. Kintner, Director of Fusion Programs for the Department of Energy, who stressed the importance of the Alcator approach to the US fusion effort.

At the end of May the undersigned resigned as Director of the Plasma Fusion Center and was succeeded by Professor Lawrence M. Lidsky of the Department of Nuclear Engineering as Acting Director. In August, Dr. Ronald Davidson will join us as Professor of Physics and as Director of the Center. Dr. Davidson, presently Professor of Physics at the University of Maryland, has served the past two years as Assistant Director for Applied Plasma Physics at the Department of Energy.

ALBERT G. HILL

Undergraduate Research Opportunities Program (UROP)

During the last nine years the Undergraduate Research Opportunities Program (UROP) has encouraged and fostered undergraduate participation in research with faculty across all of the M.I.T. academic departments. Well over half of the undergraduate student body participates in a wide variety of front line research efforts, including nearly 400 students involved with UROP projects situated off the M.I.T. campus. The national attention paid to UROP, the special regard with which admitted applicants to M.I.T. weigh UROP in their decisions, and the enthusiasm of graduates of recent classes attest to what one feels in the hallway -- i.e.,
that undergraduate research has indeed become a unique and valued part of the M.I.T.
educational experience. There is amongst professionals a growing recognition of the
creativity and contribution of M.I.T. undergraduates in demanding research situations.
This recognition parallels an increasing number of program inquiries by pre-first-year
students, non-M.I.T. students, and graduate students wishing to undertake research efforts.
These constituencies will mean new considerations and policy development for the Institute.

This past year UROP provided monetary assistance to 841 students. These funds were
awarded to students for project expenses or as modest wages. The majority of term-time
student work is done for credit; but in the summer, wages are needed. An advantageous
fund-matching policy ensures the effectiveness of program funds. The amount of wages
contributed to UROP students by the faculty has been rising steadily during the last five years
as a consequence of this policy. As tuition increases, we will see more pressure for term-
time wages.

Several awards administered by UROP offer special recognition as well as monetary support
to undergraduates involved in research. The Society of Sigma Xi for the first time awarded
two grants this fall to students doing original work; one award supported a student working in
the Department of Nutrition and Food Science, and the other, a student working in the
Department of Civil Engineering. These awards will be offered again next fall. Sigma Xi
supported a student to read an original research paper at an ophthalmology conference in
Florida, and made eight other awards for materials and services during the course of the
year. Nine students received Clapp and Pollak awards for excellence in engineering design
totaling over $15,000 in project support and scholarship aid. Eloranta Summer Fellowships
for outstanding research efforts during the summer months were given to five students whose
planned work ranged from one project undertaking anthropological research in the Soviet Union;
and another concerning corneal heating and astigmatism conducted at Boston's Beth Israel
Hospital; to a sophisticated laser frequency measurement to be undertaken on-site at M.I.T.

The Uniroyal Foundation granted wages and research expenses to six undergraduates
undertaking research work for the first time as an encouragement to beginners. The James
McCormack Fund supported students in several humanities projects, such as studying the
social impact of a nuclear generating plant in Plymouth, Massachusetts, documenting Mexican
Indian culture, and sculpting in ceramic and glass.

To foster intellectual exchange, to bring UROP before a wider audience, and, at the same
time, to enable students to gain experience communicating about their work, UROP sponsors
seminars, symposia, publications, and other professional outlets for student researchers.
For example, last year a UROP staff member led an Undergraduate Seminar course entitled
"Undergraduate Research in Energy." Eighteen invited student researchers gave presentations
and demonstrations to the class concerning aspects of energy supply and production. Early
in the fall term a UROP symposium gave five students with research topics in as many fields
an opportunity to describe their work to an audience of preponderantly incoming students and
others who had not yet undertaken research of any kind.

During January Independent Activities Period, an informal UROP Colloquium allowed present,
past, and future UROP students to compare notes and discuss their participation and research.
Also during I.A.P., a forum called "Have Your Cake and Eat It Too: Learning Outside the
M.I.T. Campus" was held jointly with the Public Policy Internship Program, the Career
Planning Office, the Preprofessional Advising Office, and the Electrical Engineering Co-op
Program (Course VI-A). Opportunities and experiences offered by all these off-campus
oriented resources and programs were discussed. Departmental UROP events with student
speakers were held by the Departments of Chemistry and Physics; in past years, Mechanical
Engineering and the Nutrition and Food Science departments blazed this trail.
Responding to interest in UROP at Wellesley College, UROP joined Wellesley in sponsoring their first UROP symposium, held at the Wellesley campus. Four Wellesley students presented the research they were doing with M.I.T. faculty. The interest generated by this symposium and the growing interest and participation of many Wellesley students may encourage Wellesley to play a more formal role in research arrangements for its undergraduates. The summer of 1977, for example, was the first time Wellesley offered partial financial support to Wellesley students working at M.I.T. during the summer; faculty grants made up the difference. This arrangement continues for summer 1978.

In May, four UROP students participated in the Cambridge Forum to talk about their research from the point of view of the Forum's spring series theme, "My Research and Its Social Consequences." The Forum was taped and will be aired on National Public Radio during the next year. WRBH will air the UROP tape locally on July 1, 1978.

UROP, the program and its staff, serve Institute interests on a considerably wider scale than its visible activities of support and encouragement of undergraduate research might suggest. As an office concerned with the role undergraduate research plays in general in the M.I.T. curriculum, UROP serves a necessary liaison function with a number of offices, committees, and nonacademic departments, and often catalyzes examination of, and changes in, policy. In order to assure that the interests of students and the Institute are sufficiently protected, UROP works in conjunction with the Committee on the Use of Humans as Experimental Subjects, M.I.T. 's Insurance and Legal Administration Officer, and legal representatives in the Office of Sponsored Programs. Project review has become particularly urgent as students (both foreign and American, and sometimes still minors) with their increasing sophistication become more deeply involved in medically related and other liability-vulnerable research areas. Issues are complex, as students work under the supervision of faculty and off-campus supervisors, either on or off the M.I.T. campus, for either credit or pay; these variables provide a multiplicity of liability exposures. Coordination of research activities is actively maintained with such other programs and offices as the new Engineering Internship Program, the Harvard-M.I.T. Division of Health Sciences and Technology, the Innovation Center, the Student Employment Office, and the Public Policy Program in the Departments of Urban Studies and Planning and Political Science.

Undergraduate research is carried on in virtually every department and center at the Institute with the central UROP Office functioning as the primary source of information, coordination, and academic agenda setting for student research efforts. This role is becoming steadily larger. Students, including graduate students, turn to UROP staff for guidance and referral to M.I.T. resources. Inquiries from industry, governmental agencies, research institutions, and inventors frequently route through UROP. UROP has become the Institute's student research broker; an important office function is that of Switchman/Ombudsman. To serve this larger role fully, UROP must evolve into an overall student research office with the concomittant responsibility of interpreting and occasionally establishing M.I.T. student research policies for the community as a whole. We are moving in this direction.

MARGARET L. A. MACVICAR
There is, in the reports of administrative departments which follow, a sense of momentum -- evidence of new initiatives, challenges accepted, problems attacked. These are not maintenance reports, confirming preservation of the past. Illustrations abound. We reached significant new levels in the admission of women and minority undergraduates. We were successful in gaining substantial increases in Federal student financial aid. Student placement activity reached new peaks. A new research staff appointment structure was created to meet new needs and solve old problems. The system for administering administrative staff salaries was changed to reduce the dissatisfying aspects without impairing its primary purpose. A new Supervisory Development Program began. Plans were refined for a better property management system. These and other initiatives during the year contribute to this sense of momentum.

The individual reports of the department heads will account in more detail for the more significant of their activities during the year. My comments will stress the highlights as I see them, influenced, doubtless, by the extent of my personal involvement.

The development of a new appointment structure for the professional research staff was a major initiative, stimulated by the Report of the Committee on M.I.T. Research Structure (the Press Committee). One of the major recommendations of that committee was the creation of a hierarchy of professional research staff positions to provide opportunities for full-time research careers at M.I.T. The structure, as it emerged from extensive discussion over the year, is intended to encourage scientists, engineers, and other research professionals to find opportunities for satisfying careers in research at M.I.T. It thus positions the Institute, at a time when growth in faculty is limited, especially at the junior ranks, to continue to grow in the direction and scope of its research. The structure provides the "individual professional contributor" the opportunity to advance from Research Scientist to Principal Research Scientist to Senior Research Scientist with increasing recognition and prerogatives. It affords that opportunity for recognition to those already at M.I.T. who merit it; it provides more attractive appointments for able scientists, engineers, and other research professionals whom the Institute may need to move into new fields or expand old ones. The new appointments also serve to unify the previously divided research structure by embracing the category of Research Associate, and creating the new title, Postdoctoral Associate, to describe those who are here for short terms, principally for further training.

The terms of the new structure were settled by the end of the academic year, and the new ranks became available for use as of July 1, 1978.

Revision of the Administrative Staff Salary Administrative Program was another significant action of the year. The evaluation which led to this revision was begun in spring 1977 by the subgroup of the Academic Council having cognizance over the Program. The primary conclusion of the subgroup was that the position classification system, a key feature of the Program, was serving its intended purpose of enhancing equity in salary administration, but that the classification levels (or grades) were becoming ends in themselves as measures of status. After extensive consultation with department heads and staff members affected by the system, a decision was made to retain all the basic features of the system except the
levels and broad position classifications. The effect was to increase our ability to recognize what individuals contribute to making a position what it is and to substitute individually determined salary ranges for the previous nine levels.

The change was put into effect in April. To date it appears to have been effective in achieving its purpose.

The reconsideration of M.I.T.'s retirement policy in response to the 1978 Amendments to the Age Discrimination Employment Act was a significant event of the year. The decision of Congress to raise to 70 the minimum age for mandatory retirement because of age shifted to the individual faculty, staff members, and employees the right to decide whether to retire at 65 or continue on to 70. Congress did delay application of the Act to tenured faculty until July 1, 1982. It did so in response to requests from a number of universities and university associations to exempt faculty from the Act altogether on the grounds that the intellectual vitality of a university depends on a continued infusion of junior faculty and that raising the retirement age would reduce the opportunities for such appointments.

The Institute is concerned with the consequences of the Act in limiting such opportunities, but will not take advantage of the Congressional option, being unwilling to deny the tenured faculty a right extended to every staff member and employee. The Institute will, however, continue under the law to treat age 65 as the "normal retirement date" and encourage retirement by that date. There are, of course, positive opportunities in the Act as well; for like most organizations, we have tended to be captives of our own policy, forcing everyone out at 65 and thus losing the full-time services of many vigorous, effective, and contributing men and women.

The Bakke decision was anxiously awaited. It was fully expected that during the spring the US Supreme Court would announce its decision in the appeal by the University of California from a decision of the Supreme Court of that state outlawing a racially based special admissions procedure in one of the University medical schools. The consequences of the decision, whatever its direction, were clearly far-reaching for minority aspirations for educational, and potentially employment, opportunity. Convinced of the importance of the Court's reaching a decision which would not deny considerations of race in admissions choices, the Institute had joined in an amici brief the previous spring urging the Court to support the University of California's position.

Hence, when the decision, which was announced just at the close of the year, sanctioned consideration of race in admissions under some circumstances, there was general relief that the efforts to increase educational opportunities for minorities at M.I.T. and other universities could continue without hindrance. The M.I.T. admissions procedures will be examined carefully in relation to the decision, but our present understanding of the decision persuades us that our procedures are not at variance with those sanctioned by the Court.

A new Student Loan Policy was developed and announced during the year. The impetus for review of our loan policy was the rapid rise in demand for loans, especially by graduate students, the need to borrow from commercial banks in increasing amount to provide the capital, and a concern over a potentially rising risk of delinquency and default. Our goal was to deal with these concerns effectively without impairing our ability to assist our students in meeting the cost of an M.I.T. education. The essence of our new policy is to make no new loans which are not either guaranteed or cosigned by a credit-worthy cosigner. Guarantees are provided, for the most part, by the Federal Insured Loan Program or the National Direct Student Loans. Cosigners are thus required principally from those whose borrowings exceed the Federal limits or foreign students who are not eligible for Federal guarantees. An International Student Loan Fund has been created to provide guarantees for foreign undergraduates; foreign graduate students are expected to support themselves without
recourse to M.I.T. loans unless a cosigner is available. Since the policy becomes effective in fall 1978, we will know better a year from now whether it is achieving its goals without undue hardship on the student body.

Extension of Federal College Work-Study Funds into the Graduate School also deserves brief mention in this report of successful initiatives. With the cooperation of the academic departments and extensive planning and communication by the Student Financial Aid Office and the Office of the Dean of the Graduate School, it has been possible to make extensive use of College Work-Study Funds in support of graduate teaching assistants, in many instances freeing funds for support of other students, graduate and undergraduate. This effort is noteworthy for its scale and creative initiative, especially in contrast to the practices of many sister institutions.

The initiatives described above are a consequence of the energy and ingenuity of many who serve with great effectiveness in support of the research and teaching processes at M.I.T. To all of them I take this opportunity to express appreciation on behalf of M.I.T. for work well and conscientiously done.

While the year had its moments of success and pride, there were times of sadness as well. Allan J. Urquhart, the Institute's Benefits Officer, died suddenly in July 1977, and M. Bryce Leggett, Associate Director of Admissions for many years, died the following month. They are greatly missed.

Two of our colleagues elected to retire at the end of the year. Robert J. Davis, Director of Personnel Relations, had served the Institute with great commitment and skill for 22 years. His knowledge is irreplaceable, and we shall feel his absence keenly. Priscilla E. Mead, who began her career at M.I.T. 36 years ago as secretary to Dr. Charles Stark Draper, retired as a valued and effective member of the Office of Personnel Development.

Patricia A. Garrison, Assistant Equal Employment Opportunity Officer, was selected as a Sloan Fellow to spend a year studying for her S.M. in Management in the Sloan School. We are proud of her, pleased at her opportunity, and look forward to her return.

JOHN M. WYNNE

Affirmative Action Program

Equal opportunity for handicapped persons was a matter of primary emphasis during the year. The Program for Employment of the Handicapped had been prepared and distributed at the end of the previous year. The transitional plan for removing architectural barriers was developed during this year, and the institutional self-evaluation was undertaken by an Institute-wide task force. These actions sought to be responsive to the needs of handicapped students and employees and to open M.I.T.'s doors wider to future applicants.

Our annual report on affirmative action progress was again presented in October to the Regional Director, Office for Civil Rights, US Department of Health, Education and Welfare (HEW). The report described changes in policy and procedure affecting affirmative action and outlined our successes and disappointments; the latter principally concerned our inability to effect any significant increase in black faculty and staff members at the Institute -- an effort to which we continue to give special attention.
Our Affirmative Action Plan was revised, updated, and republished in April and distributed
Institute-wide as a Tech Talk supplement.

In June, a Compliance Review Team from HEW spent four days on campus conducting a
"pre-award compliance review," a review to enable them to clear a contract in excess of
$1 million for award. While the team found some of what they described as "minor defi-
ciencies," they were, on the whole, quite complimentary as to the evidence of commitment
they saw, and the Regional Director has advised that we are "in compliance."

The Bakke case, by the very fact that the Supreme Court had it under review this past year,
dominated affirmative action thinking and planning. Fortunately, the Court's decision in
June, while still being studied, appears to permit a continuation of M.I.T.'s efforts to
increase minority enrollment at the Institute.

PATRICIA A. GARRISON

Office of Admissions

The increasing competition for top students and the increased interest in engineering on the
part of applicants are among the trends discussed in previous years. They continued in
1977-78. The breadth and flexibility of M.I.T.'s programs are not well known by many,
and we continue to be challenged by the task of presenting the reality of the opportunities
found here to prospective students, their parents, and their schools. This year we made
an extra effort with those offered admission through increased staff travel and involvement
of the Educational Council in get-togethers in many cities. While the yield increased, it
is not possible to be certain that the two events are causally related.

The questions of whom to seek out and to whom to offer admission become less clear as
the curriculum broadens, and this topic deserves additional faculty attention in the coming
year. The Committee on Undergraduate Admissions and Financial Aid (C.U.A.F.A.) did
change the requirement for the Science Achievement Test by adding Biology to Chemistry
and Physics, thus expanding the pool of potential applications. After many years of annual
decisions, the Academic Council established until further review a freshman class size of
1,050. These are not exactly major changes, but both are important ones for the day-to-
day work of the Admissions Office.

This was the year of the Bakke case, but the attention it received was only a very visible
part of the longer-term struggle to increase the number of minorities and women in the
professions and at M.I.T. With it came increased willingness on the part of applicants
and their parents to challenge an admissions decision. We will see more of these cases
in the years to come.

At the graduate level, some departments found a slackening of the demand for positions in
their classes. This is a development that could become more troublesome should the very
high quality of the applicants diminish. On the other hand, most departments found many
more attractive applicants than they could serve.
The unexpected death of M. Bryce Leggett in August 1977 left the Admissions Office without our wise and trusted counselor and colleague. He continues to be missed.

PETER H. RICHARDSON

OFFICE OF THE ADVISOR TO FOREIGN STUDENTS

M.I.T. is one of three educational institutions in this country continuing to report a foreign student enrollment in excess of 17 percent. The other two are Howard University and the University of San Francisco. On a national level the Institute ranks 15th in the total number of foreign students enrolled.

The Office of the Advisor to Foreign Students was first organized in 1944; thus this report marks the 34th annual review of its activities. Two significant ad hoc committees established new guidelines this year for matters of policy that impact on the foreign student community at the Institute. The first relates to a series of recommendations made by the Committee on Student Loan Policy chaired by Vice President John M. Wynne. Chief among them are the provisions that "virtually no loans will be made to undergraduate or graduate students which are not either guaranteed or cosigned by a credit-worthy cosigner." The task of identifying, as co-makers, US or Canadian citizens or resident aliens may for some foreign students prove to be very difficult, if not impossible. The effect on the present community of foreign students is yet to be measured, but the impact could be substantial, particularly at the graduate level. The Committee strongly recommended the establishment of an International Student Loan Fund. Contributions are to be sought to provide some loan capital from sources outside the M.I.T. community. The economic mix and geographic distribution of the foreign student community is apt to change substantially as this policy is put into practice over the next decade. A review of the new policy is to be undertaken from time to time to determine its long-range effects.

The second committee had to do with the organization of English language subjects offered for credit. Further, guidelines were provided to the several graduate departments about the standard test used to determine the effectiveness of an applicant's command of English. The established standards must be met for visa certification by the Foreign Student Advisor.

Maintaining services for foreign students in the face of these and other changes external to the Institute requires a staff trained and oriented to the complex cross-cultural differences that are present among the diverse foreign nationals on this campus. If one adds the number of foreign research and teaching faculty to the current foreign student population, we are hosting as many as 2,000 individuals here on temporary study and research assignments. In addition, we have a number of Americans (students and faculty) who study or work abroad. There is clearly seen, at least from the perspective of the Foreign Student Advisor, a growing need for a more precise and planned approach to international educational interchange on this campus.

EUGENE R. CHAMBERLAIN
OFFICE OF THE EDUCATIONAL COUNCIL

For 26 years the Educational Council has helped M.I.T. seek out the highest caliber young men and women as potential undergraduates. Though the Council has grown in size and activity, its basic mission remains unchanged -- maintaining the high standards of M.I.T.'s entering classes. In the face of more aggressive competition for the finest students in every part of the country, the Council's immediate objectives have been to inform students, parents, and guidance personnel about the opportunities available for undergraduates at M.I.T. The Council's mission is not to recruit or pressure but to inform; M.I.T. seems to sell itself to those who know it well.

In many cases the Educational Counselor is the only personal contact a student has with M.I.T., and the Cambridge office works to make that contact exciting, enlightening, and helpful. Office publications and communications with alumni by letter and phone are extensive; however, personal communication when EC's are on campus or when the staff is traveling is still the cornerstone of our efforts.

The actual backbone of the Council is the now more than 1,400 alumni volunteers without whom the Institute could not hope to compete effectively in the student marketplace. To increase our national effectiveness, the last year has seen the appointment of almost 300 new Counselors and the creation of 11 new Councils in the greater Boston area. To support these new members we have added new computer programs, word processing equipment, a new Council Handbook, and several new office publications.

JOSEPH A. EDWARDS

Office of Student Financial Aid

The Financial Aid Office experienced another year of program expansion -- the total awarded to undergraduates demonstrating need exceeded $10 million, and another $1.5 million was provided by outside agencies to students apart from need.

The Federal grant programs -- Supplemental Educational Opportunity Grant (SEOG) and Basic Educational Opportunity Grant (BEOG) -- provided a total of $1,120,000 in grant funds to needy students. The Basic Grants Program was a little below last year's level, but the SEOG Program provided $760,000. This increase, over 1977's level of $500,000, was attributable not only to a significant increase in the SEOG allocation to M.I.T. itself, but to the availability of 10 percent of the College Work-Study allocation, transferrable to the SEOG Program. Besides these two need-based grant programs, the R.O.T.C. program continued to provide about $400,000 to needy students.

Current gift funds for grants and scholarships exceeded $300,000, and included the largest accumulation of alumni gifts ever designated for this purpose.

Scholarships awarded directly to students from outside agencies also showed a significant increase, from $733,000 to $1,008,000.
The aid program enjoyed a modest increase in usable income from the scholarship endowment -- from $2,104,000 to $2,518,000. This increase was due in part to additional capital gifts added to the endowment in the amount of about $700,000 -- an increment smaller than last year's.

All of these designated grant funds, combined, again had to be augmented from the Institute's unrestricted funds, in the amount of $1,201,000. This is nearly $300,000 more than last year, and reflects the predicted escalation in the need for grant funds as M.I.T.'s costs continue to rise with inflation.

During the year, the Loan Task Force released an important study of the growth in demand for student loans at the Institute, and of the capital requirements necessary to support the program. The study recommends that no loans be made henceforth that are not guaranteed or cosigned. The recommendations will affect the Aid Office, in that loans to new foreign students will be curtailed in the coming year, especially in the Graduate School.

The contribution of the US Department of Health, Education and Welfare (HEW) to the National Direct Student Loan Program (NDSL) was comparable to last year's; in an effort to reduce a modest deficit in that account at the end of fiscal year 1976-77, the amount provided each eligible borrower was $100 less than last year. The number of borrowers increased, however, and the total loaned under the NDSL Program was nearly the same.

The NDSL Program now seems to be enjoying a temporary respite from the cycle of annual persecutions facing it over the last nine years. Administration proposals and budgets continue to ignore it -- Congress continues to fund it.

Expansion of the College Work-Study Program (CWSP), and widespread availability of guaranteed student loans from commercial sources combined to reduce the demand for loans from the Technology Loan Fund -- from $2,457,000 to $2,314,000 this past year. This reduction was distributed proportionately between the graduate and undergraduate schools. The level of guaranteed loans from outside M.I.T. rose from $1,250,000 to over $2 million, and reflects a welcome relief of the pressure on the Institute's own capital funds for loans.

With the largest allocation ever from HEW to the College Work-Study Program, the Office joined with the Graduate School to develop a broad program of funding Teaching Assistants who could demonstrate financial need. Apart from providing significant savings to many of the graduate departments (who needed to provide none of the TA's wage stipend), the program marked the advent into the Graduate School of Federally approved need analysis to a degree never before necessary.

Undergraduate wages were funded in part by the CWSP grant, as in the past several years. In all, about $1.5 million of student earnings were underwritten by this program.

The term-time employment payroll totaled $5,662,500 for 4,347 students, up from about $3.5 million last year -- the increase being almost completely accounted for by the addition of Teaching Assistants to this payroll.

Work on the revised financial aid data processing system proceeded in earnest throughout the year, and completion is scheduled for fall 1978. The new arrangement is expected to improve liaison among the Student Financial Aid, Student Accounts, Student Loans, and Registrar's offices.
After taking leave of absence to work in the Admissions Office for one year, Daniel T. Langdale resigned his position as Associate Director in June, to join the Admissions Office staff on a permanent basis.

JACK H. FRAILEY

Career Planning and Placement Office

This was the busiest year in the Career Planning and Placement Office in a decade. A strong demand in industry for engineers, combined with rising enrollments in engineering, brought recruiters and students to the Office in large numbers. Neither the great blizzard of February, which closed the Institute for a week at the beginning of the spring recruiting season, nor the moving of the Office from Building 10 to somewhat less visible (though handsome) quarters in Building 12, stemmed the flow. A total of 333 private firms and government agencies made recruiting visits, many of them coming several times. Students met with them in over 600 interviews. For the fourth year in a row the Office published a resume book containing the resumes of US students in engineering and science. This year 580 students submitted resumes, 80 more than the year before and twice as many as in 1974-75, the first year of publication. The resume book, which is made available to employers at cost, was requested this year by 130 employers.

A small but significant number of the recruiting companies were foreign. It is a development to be welcomed and encouraged, because the Institute's large contingent of foreign students generally has little opportunity to keep abreast of employment opportunities in their home countries. That they would like to stay in closer touch is clear. With the help of a grant from a Venezuelan national oil company, Lagoven S.A., the Office wrote in November to every foreign senior and every foreign graduate student informing them of the services of the Home Country Employment Registry in Washington, established by the National Association for Foreign Student Affairs. A reply card was enclosed permitting a student to enter his or her credentials in the Registry. By the end of the year 480 students had returned the biodata card. Their response is especially striking because a number of foreign students are wary of inclusion in any compilation that might get into the wrong hands.

Students continued to come to the Office to discuss their individual plans. They made over 650 appointments for this purpose, while a great many others came in unannounced. Students look to the Office for advice on every career field represented at the Institute, as well as careers with which the Institute has little connection. We try to be as responsive as possible, making of each conversation a joint investigation upon which we can draw the next time we get the same question. The students, sometimes boldly, sometimes shyly, present a wonderful range of interests, which they underwrite with knowledge, talent, and ambition. Advising them is both a challenge and a pleasure.

The strong demand in industry for the technically trained was reflected in the area of Alumni Career Services, which received 2,166 job listings for experienced personnel compared with 1,687 in 1976-77, an increase of 28 percent. Openings were particularly numerous in electrical and mechanical engineering, programming, technical writing, and certain fields of management (sales, marketing, finance, and business development). Many companies coming to recruit students took advantage of their presence on campus to list openings for alumni.
The number of alumni registering with the Office dropped to 370 from 450 in 1976-77. The number of alumni registrants has traditionally declined when jobs have been more numerous. This does not mean, however, that in good times all alumni making a move will find the process easy. During the past year the median search time among alumni using the Office was close to six months. Candidates for positions in senior management were typically in the market for several months. The age of registrants was older, with the percentage in their early 20s dropping to 25 from 37 percent the year before, and the percentage who were in their 30s rising from 30 to 45 percent. Thirty percent were over 40.

ROBERT K. WEATHERALL

OFFICE OF PERSONNEL DEVELOPMENT

The Office of Personnel Development (O.P.D.) had an active year, primarily in terms of continued activity in ongoing functions such as Tuition Assistance, the Administrative Development Program, orientation for new employees, the Administrative Procedures Program, coordination of the Working Group on office/clerical issues, technical typing classes, and the Lincoln Laboratory Management and Supervisory Development Program. In addition, a pilot Supervisory Development Program was completed on campus. The Office also responded to several requests involving departmental training needs for which special programs are being designed, as well as requests to participate in conflict resolution efforts for departments. One of the conflict resolution efforts involved extensive staff work, research, and a report, which hopefully served an educational purpose for the department as well as the Institute.

The Administrative Procedures Program, which has been taught by representatives of a number of administrative departments, continues to be well received by the biweekly and exempt employees who have participated. To date more than 350 employees have participated, and it is expected that the rate of participation will continue at about the level of the past two years. Participating instructors have worked diligently to fine tune their presentations and continue to report benefits in terms of more smoothly functioning operations within their departments.

The 17th Lincoln Laboratory Management and Supervisory Development Program was completed during the past fiscal year; 420 people have now completed the Program. The Program continues to be well received by the majority of participants, 85 percent of whom have rated the Program as good or excellent. Based on expectations stated by participants at the beginning of each program, there appears to be a trend toward participants' entering the Program with more positive expectations. A good deal of effort has gone into analysis of participant evaluation data during the past fiscal year, as well as into preliminary design of a suitable evaluation project that would go beyond the scope of self-report data from participants. We are hopeful that a more thorough evaluation effort will be initiated next year.

The pilot campus Supervisory Development Program, which was designed to tie specific M.I.T. policy with related human relations skills required for implementation, was presented in 10 three and one-half hour sessions to a heterogeneous group of M.I.T.
supervisors from 15 different areas of the Institute. All participants rated the Program as good or excellent, and all stated they would recommend the Program for other M.I.T. supervisors. Several specified that the Program would be especially important for new supervisors, for supervisors at upper levels, and for supervisors in the academic areas. Interestingly, several participants indicated that more class time was required for this Program. Instruction was provided by the O.P.D. staff as well as representatives from the Offices of Personnel Services and Personnel Relations, the Medical Department, the Special Assistant to the President and Chancellor for Minority Affairs, and the directors of the Libraries, Physical Plant, and Information Processing Services. The degree of interest in, and importance of, training for supervisors at M.I.T. was confirmed by the experience with the pilot program. With some revisions in format and participant identification processes it seems apparent that there will be continued need for an M.I.T.-specific program of this type.

The Communications Skills Workshop presented during the past fiscal year was over subscribed, as have been previous such workshops, and was well received by the diverse group of employees selected to participate. This workshop provides one of the few developmental opportunities available to biweekly employees at the Institute, and seems to be particularly appreciated by them. Participants in the workshop conducted this past year also included academic and administrative staff, sponsored research staff, and exempt and hourly employees.

The Administrative Development Program (A.D.P.), which has now been offered 11 times, continues to attract considerable interest. A total of 134 applications were received for the A.D.P. during the past fiscal year, with small but increasing numbers of applicants from the faculty, academic, and sponsored research staff members.

WORKING GROUP ON OFFICE/CLERICAL ISSUES

The Working Group on Office/Clerical Issues, in its fourth year of existence, continued to address concerns related to biweekly employees at M.I.T. For most of the year, the two predominant issues under study by the Working Group were the classification system and the general work environment for biweekly employees. A report has been published describing examples and characteristics of effective and ineffective work environments at the Institute. This report, which was made available to all employees, includes recommendations for improving the employee placement process, the communication and problem-solving processes within departments, as well as other aspects of the biweekly employee's work environment.

Near the end of the year, eight new members joined the Working Group and participated in a planning process that resulted in the development of three new task groups to study career development, flexible work hours, and ways to recognize long-service biweekly employees.

MAUREEN M. YAGODKA
F. ADAM YAGODKA
Benefits Administration

The Institute Community was saddened by the sudden death in July 1977 of Allan J. Urquhart, who had been the Institute's Benefits Officer for the previous eight years. Mr. Urquhart will long be remembered, both for his professional skills and for the personal warmth and compassion which characterized his service to the Institute and its employees. An intensive search for a replacement was concluded in November with the appointment of Richard P. Marvel as the new Benefits Officer.

An early retirement option, first made effective in 1977, was extended for a third year, becoming available to members of the Retirement Plan for Staff Members who meet the age, service, and plan membership requirements on July 1, 1979. The program provides for supplements to the annuities which the staff members have earned at the time of their early retirement, the amounts of which vary according to age, salary history, and period of plan membership. It was devised to create employment opportunities on the faculty and staff by making it possible for members who wish to retire early to do so on more favorable terms than would otherwise be possible.

The recent amendment to the Age Discrimination in Employment Act, raising from 65 to 70 the age at which retirement can be made mandatory, poses a number of significant policy questions and potential problems for the Institute, all of which are under study. Chief among these is the possibility that the number of openings for Assistant Professors, already in a declining trend because of budget cuts of recent years, will be further reduced if senior faculty members elect to remain in active status after the age of 65.

Collective Bargaining

Agreements with four unions representing some 1,700 employees in seven collective bargaining units expired on June 30, 1978. Employees represented by a fifth union are covered by a three-year Agreement which has another year to run. Negotiations were in progress as the fiscal year ended.

Wage and Salary Administration

A new appointment structure applying to members of the campus research staff was made effective on July 1, 1978. The new structure was developed in response to the recommendation of the Committee on M.I.T. Research Structure, chaired by Professor Frank Press, and is intended to provide a framework in which professional research personnel can find rewarding careers outside the faculty ranks. In place of a disconnected series of classifications and titles, it establishes an integrated hierarchy of research positions having responsibilities, benefits, and privileges commensurate with rank.

ROBERT J. DAVIS
Vice President, Administration and Personnel

OFFICE OF PERSONNEL SERVICES

The Office of Personnel Services has continued to focus on the development of ways to provide better information and counsel to members of the Institute community on a broad scope of personnel matters.

Staff Changes

Several changes occurred in staffing of the Office this year: Michael Parr left the assignment of Personnel Officer for the Vice President for Operations’ area to become Assistant Labor Relations Manager in the Office of Personnel Relations while Richard Cerrato accepted responsibility for advising these departments. Kathleen Rick joined the Office in January replacing Mr. Cerrato as Personnel Officer for the School of Engineering.

Employment Activity

The nonacademic employment population on campus as of May 31, 1978 was 4,145, showing an increase of approximately one percent over last year. Campus employment activity, including applicant, resume, and transfer activity, as monitored on the Applicant Flow Computer File, shows a record 4,004 applicants to the Personnel Office in the April 1, 1977 -- March 31, 1978 period, an increase of 398 persons over the same period a year ago. A corresponding increase in available positions to 1,377 from 1,185 (+16.2 percent) has combined with increased numbers of applicants to create a very busy year in the Office of Personnel Services.

Of the 4,004 persons who applied to our office, 3,140 were interviewed by Personnel Officers (an increase of 341 people receiving interviews); of these 2,797 were referred to supervisors having positions available. In addition, the Office processed 3,742 resumes of other applicants which were received, reviewed, and referred to supervisors for available positions in advance of personal interviews.

During the April 1, 1977 -- March 31, 1978 period, 838 Institute employees made contact with the Office of Personnel Services to apply for transfer. This activity represents a 46 percent increase in the number of persons seeking lateral or promotional transfers over the previous one-year period. Of these candidates for transfer, 319 were placed successfully in new positions. Also reflected here are organizational changes, resulting in work groups of employees transferring to other department structures.

The sources of referral of applicants for employment on campus continued to follow historic trends. Referrals from Tech Talk, M.I.T. relatives and friends, former employees, and student referrals accounted for more than half of those candidates applying this year. Response to increased advertising efforts produced 14.2 percent of all applicants, and agencies supplied another 5.2 percent. Interest in working in a university was responsible for another 13.9 percent of all applicants.
New Programs and Other Activities

While applicant and transfer interviewing and referral required the largest portion of staff effort, Personnel Officers continued to devote significant amounts of time to other functions, including career and personal counseling, labor relations, grievance mediation, and classification and salary reviews. In addition, members of the staff have been involved in special program assignments, Institute committee participation, and internal policy development.

An important activity this year has been the revision of written personnel policies by Susan Lester with assistance from an editorial group for inclusion in a new manual for use by supervisors and employees. The first section on paid leaves will be ready for distribution in the fall.

Office-clerical recruiting was a high priority for the office this year due to significant shortages in qualified and interested applicants. Peggy O'Brien was responsible for the development of new advertising and interviewing programs, including the expansion of a program successfully started last year, designed to familiarize secretarial school placement directors with the variety of employment opportunities at M.I.T. Discussions with departmental representatives were also initiated to share information on successful recruiting techniques.

A significant accomplishment by the Records and Data Processing group, led by Robert Nelson, was the data collection needed for the expansion of the Institute Staff Telephone Directory into a publication which includes all persons employed. This effort, in cooperation with the Telecommunications Office, was very well received by the community.

CLAUDIA B. LIEBESNY

Office of Child Care

The Office of Child Care continues its efforts to provide families in the M.I.T. community with assistance in locating suitable programs and services for their children. Although the emphasis is still on children from infancy to kindergarten, the number of inquiries concerning older children has increased.

As part of its responsibilities, the Office provides administrative and fiscal management services to Technology Children's Center, Inc. (T.C.C.). In an effort to reduce the amount of time spent in this area, a major revision of T.C.C.'s fiscal policies and procedures has been undertaken. As this effort nears its end, it is clear that the expectation that additional time will be available to provide service to other parts of the community will be met.
Vice President, Administration and Personnel

Technology Children's Center, Inc.

T.C.C. is a private, nonprofit organization which operates child care programs on the M.I.T. campus. Currently, there are two programs in operation: a cooperative nursery school which operates a half-day program during the academic year, plus a six-week summer program and a day care center which offer a full-day program on a year-round basis.

Plans for a new extended-day kindergarten program have received a great deal of attention this past year. The program will occupy one of the classrooms in Eastgate currently being used for the nursery and will accommodate 10 children during the first year. The program is scheduled to open this coming September and will operate on a full-day, year-round schedule. The program will be certified by the Cambridge School Department.

Family Day Care Program

Family Day Care (F.D.C.) has provided a great challenge, as usual. To gain some perspective on the scope of this program, one should understand that the M.I.T. Family Day Care Program is a network of independent homes. Each provider in the program operates as a self-employed, licensed (by the Commonwealth of Massachusetts) day care provider. The Child Care Office acts as a broker between those wishing to secure care for their children and those wishing to provide care. The goal is to encourage parents to make confident and knowledgeable decisions about what is best for them and their children.

This past year 74 children used the Family Day Care Program. An additional 11 children were placed in non-M.I.T. homes. The largest number of users of the program were student families, followed in descending order by faculty (including other academic appointments), staff, and biweekly.

MARGARET SAND

Office of Facilities Management Systems (O.F.M.S.)

The Office of Facilities Management Systems (O.F.M.S.) is responsible for the collection, storage, and retrieval of data for more than 20,000 individual spaces at M.I.T., comprising nearly 6.5 million net usable square feet of facilities. Using the M.I.T.-developed space accounting system, INSITE II, the data base manager produced three major updates to the space inventory, totaling over 20,000 changes to the data base. Each update was followed by the distribution of several standard reports to 129 academic and administrative offices, as well as numerous special reports produced throughout the year for the C.R.S.P. Committee (Committee for the Review of Space Planning), Comptroller, Director of Finance, Physical Plant Department, and the Planning Office.

The vast majority of the data base changes occurred through the activities of our facilities auditor. The primary purpose of the audit effort is to provide the required accurate, timely, and auditable space records for the Institute's reimbursement formulae to determine the portion of the annual $17 million plant cost pool that is associated with sponsored research. During the audit, other data was also gathered and reported to the Safety Office, Campus
Patrol, Telecommunications Office, Purchasing Office, and the Physical Plant Department, as well as special field surveys in support of the Comptroller's Office and C.R.S.P.

The other major responsibility of O.F.M.S. is to provide support to the existing consortium of external users of the INSITE II technology as well as to foster the continued growth of the consortium in both its membership and the quality of its facilities management. Fiscal year 1978 saw four new members of the consortium: Atlantic Operations, Inc., Jacksonville, Florida; Beth Israel Hospital, Boston; University of Massachusetts Medical Center, Worcester; and Continental Service Co., San Francisco. This brings to 24 the number of institutions which employ the INSITE II system and its associated methodology to manage their inventories of building space.

To assist each institution in reaping the fullest benefits of the INSITE II technology, O.F.M.S. offered four one-week courses in the INSITE II computer language and the associated methodology for maintaining a space inventory, and a two-day training course on the INSITE II-related Space Cost Analysis System (SCAN). In addition O.F.M.S. sponsored a one-day conference for all of the existing consortium members to exchange information on facilities management techniques, and a one-day workshop preceding the conference to continue the training of those already using the system. Approximately 50 people attended each of the latter two events.

Also, well under way is the design and development of the INSITE III system, the cost of which is being shared by both the consortium members and M.I.T. The system will provide a significantly enhanced capability as an aid to the process of allocating, operating, and planning for space. The design of the new system includes both an equipment inventory and a grant-tracking capability.

The Office also presented a one-week summer session course on Facilities Management Systems and Inventory Techniques, and produced two issues of INSIDE INSITE, a facilities management newsletter with a national circulation of over 400 organizations.

KREON L. CYROS
Vice President, Financial Operations

For the second year in a row the financial operating results show the Institute to be essentially back in balance between income and outgo on a current basis. Present estimates for 1979 indicate that this will continue for another year. Nevertheless, the year-to-year operating gap problem, particularly apparent in years of heavy inflation, continues to reappear and much work remains to be done to achieve balance in the immediate years ahead. Budget reductions get more and more difficult to achieve and the ultimate answer must come from the gift stream and the production of income.

In the area of student financial aid, a lack of scholarship and fellowship resources continues to put great pressure on M.I.T.'s unrestricted funds. A companion problem continues to grow in the student loan area where M.I.T. has had to turn to outside sources for loan capital and has had to devote more and more effort to retaining sound administration of student loan receivables; it is here that delinquency and some default experience, particularly in foreign student loans, have called for strong measures of resolution.

A proposed revision of the cost principles under which colleges and universities are reimbursed for their sponsored research costs has been published by the Federal Office of Management and Budget in the Federal Register. In addition to having a severe impact on M.I.T. and nearly all nonprofit educational institutions performing Federally sponsored research, the document fails to recognize the nature of the research effort in colleges and universities, their uniqueness and diversity in organization, and the role of students, particularly graduate students, in research. Needless to say, a great deal of effort by senior members of the M.I.T. administration has gone into preventing the issuance of the revisions in final form until they have been more carefully thought through by senior staff in both the Federal government and the academic community.

For a more fully detailed report on financial operations, please refer to a companion publication, Report of the Treasurer for the Year Ended June 30, 1978, which is included in this volume.

STUART H. COWEN

Audit Division

During the 1977-78 fiscal year, nearly half of the Audit Division's time was devoted to departmental reviews which ranged from encompassing evaluations to specific reviews of a phase of activity within the department such as cost transfer reviews. We observed that the effectiveness of the Institute procedures has improved; department personnel are aware of and actively pursuing techniques of budget and management controls which will enhance the continuing Institute effort to contain expenditures within defined budgetary limits.
The Audit Division participated in a joint audit with the Defense Contract Audit Agency in the review of M.I.T.'s Department of Aeronautics and Astronautics. The joint effort satisfied the needs of the two groups of auditors and also benefited the department under review.

The Audit Division is presently engaged in a review and compliance audit of Federally financed student loans mandated by the US Department of Health, Education and Welfare. The report on this audit will be rendered jointly to the management of M.I.T. and to the government officials, and represents a new and unique phase of cooperation between nonprofit organizations and governmental departments.

A further extension of Audit Division services was in the area of management services in the establishment and strengthening of systems and procedures. In one case, the administrative officers of a laboratory which is growing rapidly sought the participation of the Audit Division in a survey concerned with the processing of financial data. After many interviews with principal investigators, procedures for the processing of financial data were established and made operative. In a second case involving an administrative department, an auditor is working with the management of the department to develop a computerized system. The auditor will remain with this unit on a part-time basis until the system and the related manual controls are established.

In the control of assets, the Audit Division conducted its annual confirmations of receivables, verifications of inventories and travel advances together with periodic cash counts and bank reconciliation work.

In EDP (Electronic Data Processing) auditing, the group is concerned with three phases: system development in which participation in feasibility studies, quality assurance, and design is maintained by an EDP auditor acting as advisor and reviewer on the appropriate committees; current operating systems are reviewed to give assurance for validity and to determine weakness of control and the degree of risk to the Institute; recently installed systems are reviewed by way of a post-installation audit in which the Audit Division reviews the design and documentation of the system, and tests it by inputing data through the application programs, resulting in a review of the internal controls. This audit gives assurance that the objectives of the new system have been attained.

Special projects included: the annual report to the Internal Revenue Service concerning unrelated business income (from 990T), encompassing an extensive review of Institute accounts to determine the status of income sources; dissolution of the Northgate Community Corporation and the Turnkey Projects; a review of open Charles Stark Draper Laboratory divestment figures; and a pre-installation computer audit for the MIT Press.

As requested by the Treasurer's Office, estates and trusts are reviewed when accountings are submitted by the trustee banks and/or executors. These accountings are reviewed by the Audit Division which makes comments and recommendations concerning the Institute's signing of releases and waivers to the courts.

**Personnel**

Staff development within the Audit Division includes attending meetings of the Institute of Internal Auditors, EDP Auditors Association, and the Massachusetts Society of Certified Public Accountants. In the current year the presidency of the New England Chapter of EDP Auditors Association is held by the M.I.T. Manager of EDP Auditing (William J. Coady). Another EDP auditor (John M. Flynn) has made a presentation to a professional group on "How to Conduct an EDP Audit." One auditor has completed her qualification for a Master's degree and also has qualified as a CPA. Two auditors have completed the Institute
Comptroller's Office

Administrative Development Program, and another person is enrolled in this course. During 1977-78 an audit assistant who acted also as a receptionist of the group retired from the Division.

By the nature of the Institute, the internal audit effort is oriented strongly towards internal control and other types of compliance auditing both to accommodate the needs of management and the requirements of governmental contracts. The Audit Division in the coming year 1978-79 will continue to emphasize departmental reviews and operational evaluations.

EDWARD L. MCCORMACK

Comptroller’s Office

During fiscal year 1978, effort continued toward the eventual implementation of a new integrated payroll system. The software package has been installed and will be used to produce the Gross Pay to Net Pay portion of the payroll process. Programs for time input and salary distribution will be designed and written by Administrative Computing Services (A.C.S.). As of June 30, 1978, the Pension Payroll has been implemented and is operational. The Exempt Payroll is scheduled for implementation in July 1978, and it is anticipated that the Gross Pay to Net Pay portions of the other payrolls will be implemented during fiscal year 1979.

Student Loan notes receivable outstanding reached $27,100,000 as of the end of fiscal year 1978, an increase of nine percent over the prior year. These notes are funded by approximately $8,440,000 of M.I.T. loan funds established by friends and alumni of the Institute; $12,420,000 of Federal funds in support of the National Direct Student Loan Program (NDSL); $540,000 in funds borrowed from the Federal government to support our contribution to the NDSL Program; $5,250,000 borrowed from a local bank; and $450,000 advanced by the Institute.

During fiscal year 1978, the Accounts Receivable System for employees, Faculty Club, and general receivables was implemented in conjunction with A.C.S. The new system has been operational for several months.

Personnel Changes

There were several staff changes during the past year. Steven A. Lanney, who joined the Institute in April 1975, was promoted to Assistant Accounting Officer in the Payroll Office in August 1977. Maureen DeCourcey, with the Student Loan Office since 1960, was promoted to Manager in September 1977. Mary Ann Donofrio, with the Institute in various capacities since 1966, was promoted to Staff Accountant and Ann S. McCormick was named Loan Collection Officer, both in September 1977. Stephen J. Gorman was promoted to Assistant Accounting Officer and Dorothy R. Latsey to Accounting Officer in the Investment Office in October 1977. During the same month, David H. Henshaw was promoted to Assistant to the Comptroller for Special Studies and Paul J. Honiker was promoted to Assistant Accounting Officer. Messrs. Henshaw and Honiker both joined the Institute in 1964. Kenneth R. Phillips
was promoted to Staff Accountant in October 1977. Laurence J. Connelly, who has been with the Institute since 1966 in various capacities, was promoted to Accounting Officer in December 1977.

PHILIP J. KEOHAN

Lincoln Laboratory Fiscal Office

Funding

New funding provided to cover Lincoln Laboratory operations during 1977-78 totaled $106.5 million. The Department of Defense continues to afford the principal support for the Laboratory, furnishing 89.7 percent of the total. Other funds were provided by the Department of Transportation (5.0 percent) and the Department of Energy (4.5 percent). The balance of the support was received from the National Science Foundation, the Bureau of Mines, and the Nuclear Regulatory Commission.

Research Volume

The volume of sponsored research performed at Lincoln Laboratory during 1977-78 is expected to approximate $105.6 million, an increase of 19.8 percent over the total of $88.1 million last year. Approximately 13.5 percent of the increase may be attributed to real growth resulting from the net addition of 90 employees to the Laboratory head count, plus an expansion of subcontract and other outside procurement activities. The 1977-78 total volume includes $1.2 million representing the cost of research performed by on-campus laboratories for Lincoln Laboratory. In addition, 26 M.I.T. faculty members and 20 graduate students participated in research programs at the Laboratory during the year.

ROBERT V. DODD

Office of Sponsored Programs (O.S.P.)

For fiscal year 1978, the total volume of sponsored research performed on campus is expected to approximate $119,274,000, an increase of 14.6 percent over the fiscal 1977 volume of $104,078,000.

As shown in the tabulation below, the fiscal 1978 on-campus research supported by two Federal agencies is likely to exceed $20 million each after significant growth over the past 11 years.
## CAMPUS RESEARCH VOLUME BY SPONSOR

(In thousands of dollars)

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Department of Defense</td>
<td>17,477</td>
<td>14,731</td>
<td>13,220</td>
<td>11,678</td>
<td>13,694</td>
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<td>Department of Energy</td>
<td>8,089</td>
<td>7,607</td>
<td>13,923</td>
<td>20,943</td>
<td>32,338</td>
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<tr>
<td>Department of Health, Education and Welfare</td>
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<td>11,460</td>
<td>17,334</td>
<td>19,140</td>
<td>18,855</td>
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<td>National Aeronautics and Space Administration</td>
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<td>7,004</td>
<td>7,997</td>
<td>8,064</td>
</tr>
<tr>
<td>National Science Foundation</td>
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<td>11,274</td>
<td>20,845</td>
<td>21,469</td>
<td>21,832</td>
</tr>
<tr>
<td>Other Federal Sponsors</td>
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<td>3,329</td>
<td>5,007</td>
<td>6,313</td>
<td>7,363</td>
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<tr>
<td>Total Federal Sponsorship</td>
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<td>77,333</td>
<td>87,540</td>
<td>102,146</td>
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<td>Industry</td>
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<td>5,504</td>
<td>5,957</td>
<td>6,745</td>
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<tr>
<td>Foundations and Other Nonprofits</td>
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<td>8,832</td>
<td>7,674</td>
<td>7,917</td>
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<tr>
<td>Other</td>
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<td>1,505</td>
<td>2,674</td>
<td>2,907</td>
<td>2,466</td>
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<tr>
<td>Total Non-Federal</td>
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<td>10,835</td>
<td>17,010</td>
<td>16,538</td>
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<tr>
<td>Total Research Volume</td>
<td>50,597</td>
<td>70,658</td>
<td>94,343</td>
<td>104,078</td>
<td>119,274</td>
</tr>
</tbody>
</table>

(* Reclassified for purposes of comparison.

### Research Facilities

The M.I.T. Corporation at its annual meeting in October named M.I.T.’s newly created College of Health Sciences, Technology, and Management for Mrs. Helen F. Whitaker and her late husband, industrialist U. A. Whitaker, whose support over two decades has spurred unprecedented growth in health-related teaching and research at M.I.T. Whitaker College is being planned to provide a major intellectual, physical, and administrative focus for extensive health-related educational and research activities. In addition, the M.I.T. components of the Harvard-M.I.T. Division of Health Sciences and Technology will be an integral part of Whitaker College, with its new doctoral program in medical engineering and medical physics.

The new Center for Materials Research in Archaeology and Ethnology (CMRAE), established by eight educational, research, and cultural institutions in the Boston area including M.I.T., received core support with the award of two grants from the National Endowment for the Humanities. CMRAE is a major undertaking to encourage a new direction for research in anthropology, archaeology, art history, and related humanistic and social science disciplines by providing them with an expanded technical base in the sciences of organic and inorganic materials. M.I.T. will serve as the Center’s coordinating institution and handle its administration.
M.I.T.'s Electronic Systems Laboratory (E.S.L.), has been designated an interdepartmental laboratory, a move which reflects the increasingly interdisciplinary nature of the laboratory's research interests, including control theory, communication systems, algorithms, complex systems analysis, and selected applications areas. The laboratory, founded in 1939 as the Servomechanisms Laboratory, had been a departmental entity within the Department of Electrical Engineering (and Computer Science) throughout its history.

The ALCATOR C machine, one of the newest and most powerful experimental machines in the US program to harness fusion energy for generating electricity, was formally dedicated in a program held on April 7, 1978. The machine was constructed in M.I.T.'s Francis Bitter National Magnet Laboratory, with the support of the US Department of Energy, as a joint effort of the ALCATOR physics and engineering group and the M.I.T. Plasma Fusion Center. ALCATOR C is a follow-on machine from the highly successful ALCATOR A machine, in operation in the Magnet Laboratory since 1972.

**Personnel Changes**

During the year the following staff changes occurred in the Office of Sponsored Programs: Jonathan H. Bartels, formerly Grant and Contract Specialist in the Department of Elder Affairs, Commonwealth of Massachusetts, joined the O.S.P. staff as Assistant Director on July 18, 1977; Anthony R. Davis, formerly Regional Administrator for the Research Foundation of the State University of New York, joined O.S.P. as Assistant Director on November 1, 1977; John F. Doyle, formerly employed in legal research, joined O.S.P. as Assistant to the Director on October 1, 1977; David J. Harrigan was promoted to Research Coordinator on August 1, 1977; C. Frederick Bentley, Assistant Director, resigned on July 31, 1977, to become Associate Director in the Office of Academic Funding at Cornell University; John J. Hynes, Operations Coordinator, spent the year on assignment in the Student Financial Aid Office, as Special Assistant to the Director; and Francis H. McGrory, Associate Director, resigned to go into business.

GEORGE H. DUMMER

**Office of the Director of Finance**

The continued strong support of industry and friends through unrestricted giving, combined with constraint in expenditures, helped to make the year financially successful despite the pressure of inflation which increased by approximately seven percent for the year.

While the favorable financial trend since 1974 continued through fiscal 1978, the Institute is still faced with a budget that is dynamically out of balance as we look forward to the next few years. A decade ago this imbalance required us to raise new sources of unrestricted funds at the rate of $2,500,000 per year just to maintain current levels of operations and without additions to programs. Through the efforts of all departments, ways have been found to reduce expenses or to increase revenues. The result of this effort has brought the year-to-year change in the need for new unrestricted revenues to $500,000 per year.

The budget program for fiscal 1978 required the addition of approximately $600,000 in unrestricted funds to the academic departments to correct funding problems and to recognize the demands of shifting enrollment patterns. Gross budget reductions of $1,790,000 in support
services were more than offset by inflation and new programs, primarily expansion of the physical plant for research programs. The largest single budget reduction resulted from the completion of the Facilities Management System. This system provides continual monitoring and control of heating, air conditioning, and electrical systems in some 34 buildings, resulting in a savings in purchased energy of over $1 million per year.

The actual results for the year can be found on Schedule A of the Report of the Treasurer. While the Institute ended the year in a strong financial position, it cannot be sanguine about the future. General inflation plus mandated expense increases such as the new social security bill, and uncertainties with respect to government reimbursement of indirect expense, will require continual effort if the remarkable progress in bringing the budget closer to dynamic balance is to be sustained and improved upon.

During the year progress was made on the budget and management information system project. The Office of the Director of Finance together with the Office for Business Systems Development and the Center for Information Systems Research conducted extensive interviews with the Chancellor, Provost, Deans, Vice Presidents, Department Heads, Laboratory Directors, and Administrative Officers. The interviews provided information regarding management information requirements, departmental roles and procedures for planning, budgeting and accounts reporting, as well as suggestions for changes. The results of the surveys have been instrumental in providing information for the functional requirements of the budget system. It is anticipated that all phases of the project will be operational in fiscal year 1980.

Two applications for funds have been accepted by the Department of Housing and Urban Development under the College Housing Loan Program. Funds were requested for rehabilitation to reduce fuel consumption and operating costs at Random Hall and complete renovation of facilities for two independent residence groups. The use of these houses is helping to alleviate the current housing shortage.

Last year we described the development of the Parent Loan Plan (P.L.P.) as a significant step in helping middle-income families meet the rising costs of an M.I.T. education. P.L.P. provides loan opportunities at moderate interest rates to parents of our students -- to assist them in paying for costs at M.I.T. in monthly installments over an extended period of time. During this year, $323,000 in P.L.P. loans were made to the parents of 87 M.I.T. students (78 freshmen, seven sophomores, and two juniors), for an average loan of $3,710. Median gross annual family income was about $33,000.

Our first year's experience with the Plan has been quite satisfactory, and for the coming academic year the Plan is being extended to the eligible parents or guardians of any full-time M.I.T. student, graduate or undergraduate. The maximum annual loan amount is being increased to $7,000 to reflect rising M.I.T. costs. We expect the program to double in size this next year as the second full class of entering undergraduates is offered P.L.P.

JOHN A. CURRIE
Vice President, Operations

The unusually harsh winter of this past year, culminating in the February 1978 blizzard, tested the organization and stamina of our operating departments. They were not found wanting. The safety and well being of our residents and facilities were maintained in remarkable fashion and full operations were restored with skill and dispatch. This was the combined effort of many people who receive our profound thanks.

The operating staff was honored this year when Laurence W. Pickard, Manager of Grounds Services, was awarded one of two Gordon Y. Billard Awards at the Technology Day Luncheon "for exceptional service to the M.I.T. community, for sustained commitment of the highest quality." He was cited for his dedicated service, an example of which occurred during the February 1978 storm when "he performed near heroic work in minimizing the burden and damage of the storm." He was also cited for his daily efforts in maintaining the campus grounds, work which previously had received a Special Award of Merit from the Massachusetts Horticultural Society.

During the year, the General Purchasing Office and the Division of Laboratory Supplies were transferred to the area of responsibility of the Vice President, Operations. Barry M. Rowe, formerly of the Charles Stark Draper Laboratory, has been appointed Director of Purchasing and Stores to have direct responsibility for these activities.

In the following account covering the Physical Plant Department, emphasis is given to activities with respect to the management of utilities. This area constitutes a significant portion of M.I.T.'s operating expense, which, over the past few years, has seen both important cost increases and gratifying measures to offset them.

PHYSICAL PLANT

Utilities

The end of fiscal year 1978 marks the completion of the first full year of operation with the facilities management system (F.M.S.). We are pleased to report that F.M.S. is meeting the energy reduction targets which were forecasted in the original studies for real-time, interactive, central monitoring and control of individual building systems. These studies indicated, and experience has verified, a payoff period of less than two years for automatic control of building environmental systems. The end of this year also marks the final accounting for the construction cost of the F.M.S. installation. The system was installed and put into beneficial use within the $2 million budget figure established at the beginning of the program in 1976.

While the installation of the computer facilities and the main console for F.M.S. are physically located in the central utilities plant, one of the desirable aspects of central
monitoring and control which was perceived early on was the potential which it offered for consolidation and simplification of off-hours operation of the plant through monitoring of alarms and response to emergencies, an effort normally located at the Work Control Center in the Ford Building. The F.M.S. system now has full remote capabilities from the work control area and we are in the final stages of implementing a single location monitoring of alarms during unoccupied hours using personnel of our Telecommunications Office.

A remaining area for development of F.M.S. is future expansion of the central monitoring concept in new building programs. The design program for the Whitaker College of Health Sciences, Technology, and Management and the Health Sciences Building will fully exploit the capability of the central control concept.

F.M.S. is, of course, one element in the continuing quest for energy conservation on campus. The energy conservation program during the year was directed at the modification and conversion of existing building air handling, heating, and cooling systems for more efficient energy operation. The initial effort, which was so successful in the Hermann Building in 1977, is the pattern for equipment modification which is presently being planned and implemented in the Center for Space Research, the Dreyfus Building, the Ralph Landau Building, and the Fairchild Building, all of which are among our most energy intensive buildings.

The overall result of our energy conservation activity continues to be monitored. The level of effectiveness from all energy conservation measures in fiscal year 1978 is measured at a cost avoidance of over $3 million annually, based on pre-1974 operating parameters.

Early in calendar year 1978, the Commonwealth of Massachusetts adopted a comprehensive energy conservation code, a modification to the State Building Code. The new code impacts on both new building, space change, and renovation activity of the Institute. The Physical Plant Department is currently surveying the connected load and lighting levels in all spaces, campus-wide, to comply with the specific requirements of the new energy conservation code.

In other areas of utility services and systems, fiscal year 1978 saw the purchase of the East Campus Steam Line from the Cambridge Steam Corporation. Acquisition of this underground steam main, which interconnects between the campus system of M.I.T. and a commercial district steam service for the Kendall Square area, has made it possible for M.I.T. to extend its own steam service to our entire east campus area. The result of this acquisition is a greatly reduced cost for steam service for our existing campus buildings, and also provides improved reliability of service via a second source of supply, the Kendall steam station of the Cambridge Steam Corporation.

More than half of the Institute's energy cost is electricity, presently entirely purchased. Concern with the control of electric energy costs, today and in future years, has focused interest on the potential for total energy or on-site co-generation of electricity and steam at M.I.T. For the past year, M.I.T. has been making an internal investigation of the potential for co-generation, utilizing two academic teams to investigate and evaluate the feasibility of co-generation schemes. The final recommendations of these two groups have been presented to the Physical Plant Department, and a marginal feasibility for co-generation is indicated. The reports underscore the potential problems associated with on-site generation, particularly pollution compliance. These specific questions are under further study within the physical plant group, and it should be possible in the near future to make a definitive recommendation on co-generation.
Vice President, Operations

Architecture, Engineering and Construction

Construction of research facilities for the Energy Laboratory and the necessary upgrading of building services were substantially completed in the Sloan Automotive Building (Building 31) this year. This program included the installation of a three-megawatt combustion chamber imported from Holland, a fluidized bed facility and a major upgrading of an existing Magnetohydrodynamic (MHD) Simulation Facility. Also included in the installation is a data acquisition computer facility which will be shared by various research programs.

Other projects completed during the year included a 13,000 gross square foot Interim Animal Care Facility on Vassar Street between the Cyclotron and the Parsons Laboratory for Hydrodynamics; renovations to Huntington Hall (Room 10-250); and renovations to the first floor of Building 10 for the Alumni Center, Exhibition Hall, and the Electric Power Systems Engineering Laboratory (E. P. S. E. L.). Also completed was an additional 4,000 gross square feet for cancer research space in the Seeley G. Mudd Building. Finally, the construction of a new outdoor track, field, and game facility comprising the Henry G. Steinbrenner (Class of 1927) Stadium was completed and dedicated in April 1978.

The following major projects are in design: a 113,000 gross square foot building for the Whitaker College of Health Sciences, Technology, and Management; a 95,000 gross square foot health services facility; an athletic facility (100,000 gross square feet) which will include a special events center, ice rink, and field house; and a complete renovation of the Webster Building.

Building Operations

The Physical Plant mechanical maintenance shops were reorganized to meet changing conditions resulting from energy conservation measures and implementation of the Facilities Management System as well as changes in our preventive maintenance program. Preventive maintenance work is now being performed on new evening and night shifts because of the greater availability of equipment for shut-down during off-hours. The Preventive Maintenance Survey of all Institute mechanical equipment, initiated three years ago, is now complete, and a total of 7,500 items in the computer program inventory are being serviced periodically on a preset schedule.

Administrative Services

The administrative section of Physical Plant and the Telecommunications Office were merged into an Administrative Services Group. Telephone personnel who previously were isolated in both a physical and operating sense were absorbed into the mainstream of departmental operations. A 24-hour communications control office was established which now provides telephone operator service seven days a week from 7:15 a.m. to midnight. In addition, service is provided for all off-hour and holiday operator coverage for the department's Work Control Center and the Facilities Management System.

Planning Office

During the course of the year, the Planning Office prepared the design guidelines for the East Campus Plan, a preliminary program for the development of activities that are to be housed in this expanding part of the campus. The Office coordinated the work of the planning and
design consultants, Gruzen and Partners-Mitchell/Giurgola, who were retained to prepare
a design plan for the East Campus area. This work has now been completed and a site has
been cleared for the first two new buildings, the Whitaker College of Health Sciences,
Technology, and Management, and a new health services building for the M.I.T. Medical
Department.

Transportation needs for the Institute community were dramatically emphasized by the
blizzard of 1978. The provision of emergency bus service for M.I.T. commuters during the
snow emergency provided an excellent test of the utility for M.I.T. of communal transportation.
As a result, a van pool system is being designed and will be operational in the next academic
year.

The access needs of the handicapped and the requirements of new national legislation led to
the completion of the Institute's Transition Plan for improving access and eliminating campus
barriers for the handicapped.

The Office provided planning support during the year to the Schools of Architecture and
Planning and Management, the Division of Laboratory Animal Medicine, and the Dean of the
Graduate School.

At long last, after 12 years, the neighboring Kendall Square Urban Renewal Project has moved
into the development stage. Developers have been selected and they are actively planning
their projects. The Planning Office has worked closely with the Cambridge Redevelopment
Authority to assure that the Institute's needs are well represented and that our respective
developments are sympathetic.

All around the campus, change is in the wind and the quality of life at M.I.T. will be the
better for it. Still, the Institute is short of housing, first-class lecture halls and classrooms,
and the resources to continue our landscape development program. Hopefully, we will make
progress on these matters in the near future.

For a number of years the Planning Office was privileged to work closely with Eliot Noyes,
the Architectural Advisor to the President and Corporation. Mr. Noyes died suddenly this
past year and will be greatly missed. A distinguished designer in his own right, he made
important contributions to the quality of planning and design on this campus.

HOUSING AND FOOD SERVICES

This past year saw a number of personnel changes. Six people retired including James E.
Gross, who had overall responsibility for the various maintenance functions of the Department.
Robert Thompson assumed these duties as Manager of Campus Housing Maintenance Services.

To accommodate the larger entering class, Random Hall was reopened as a dormitory for the
1977-78 academic year. Although some maintenance was accomplished before occupancy,
basic renovation work will be performed during the summer of 1978. A major part of this
work involves energy-saving improvements, and this will be funded through a low interest
loan from the US Department of Housing and Urban Development. Through the efforts of both
residents and staff members, Random Hall is functioning as a full-fledged part of the housing
system.

We continue to have a varied and extensive program of maintenance and renovation, and
projects were completed in each of our units. Major projects this year included replacement
Vice President, Operations

of all operable windows at Eastgate, replacement of doors and locks at East Campus, and a comprehensive freshening up of Tang Residence Hall. We made continued progress toward a system with 100 percent sprinkler protection.

Several new food service contract plans were introduced this year, and a major effort was undertaken with the residents of Baker House to increase participation in their food service program. We continue to seek ways to improve the system and to maintain its long-term viability.

A successful effort was undertaken this year to effect increased communication with students and faculty residents. We initiated periodic meetings with house officers and staff members of other offices as appropriate to discuss general housing and food service issues. One of these meetings dealt with room and board rates for the next year, and another focused on the roles of the Safety Office, Physical Plant, and the Campus Patrol.

Members of the department continue to be actively involved in training and career development programs including M.I.T.'s Administrative Development Program and the Supervisory Development Program introduced this year.

CAMPUS PATROL

It is encouraging to report a reduction in the number of complaints filed with the Campus Patrol in the year just ended when compared with the previous year. This is the second consecutive year in which the number of complaints has declined. At the same time, the number of service-related requests made to the Department continued to increase sharply.

There were 1,868 complaints, 38 fewer than last year. The category we consider to be most important, that of crimes against persons, has held relatively constant during the past several years, this year's total being 36 reported incidents. The service calls handled by the Department reached a record high, 8,421, compared to last year's total of 8,068, itself a record number. This total includes some 3,500 calls for personal escorts, most during the hours of darkness.

Dormitory larceny totals crept upward to a final loss figure of $11,734, whereas Institute property losses, on the other hand, dropped 8.5 percent, to total $62,549.

A vigorous "Crime Prevention Program," under way for some time, continued unabated. It is believed that this program accounts for at least a portion of the drop in this year's loss statistics. The program involves a door-to-door canvass of all Institute academic and administrative areas by teams of Patrol officers who advise the community of recent trends in reported criminal activity and solicit community cooperation through education and awareness. While on routine patrol assignments, officers issued more than 800 "Crime Prevention Notices," calling attention to lax conditions and to unsecured and unattended areas, which are major sources of losses in all categories.

A continuing drop was recorded in the number of motor vehicles stolen from the campus and surrounding city roadways. The number of bicycles reported stolen, 114, is a small increase over the previous year's reported total.

The emergency ambulance service handled 1,466 calls. The Emergency Medical Technician certification program continued this year. At present, the Department's ranks include 16 Registered Emergency Medical Technicians.
Vice President, Operations

As an integral part of its operation, the Campus Patrol continues to support on an everyday basis other Institute groups such as the Office of the Dean for Student Affairs; the Medical Department, including the Social Service and the Psychiatric Service; the Safety Office; the Housing Office; and the Physical Plant Department, as well as carrying out necessary liaison with outside agencies. Because of the Department's unique position, it has been able to render many kinds of assistance, often on an informal, "behind the scenes" basis to Institute agencies and community members.

SAFETY OFFICE

This past year was highlighted by a strengthening of the Institute's activities regarding safety. A Council on Environmental Health and Safety was created and began to function during the year. It is composed of the chairpersons of the various safety committees as well as representatives of the professional safety offices. It serves in a coordinating role and is responsible for broad environmental health and safety policy.

Laboratory Safety

Implementation of a "chemical spill response" effort is under way. It is hoped from this that proper equipment can be made conveniently available in areas where spills are likely to occur. A spill cart has been designed, stocked, and will be put into service this coming year.

Cardiopulmonary resuscitation instruction has become popular during this past year due to local media publicity. The Safety Office gave 42 courses of instruction which involved 482 students and employees in 22 departments.

Fire Protection

Automatic sprinkler protection continues to be expanded, and sprinkler systems were installed in several additional building areas this past year.

Much active work is going on in evaluation and upgrading of M.I.T.'s overall fire protection program. Efforts such as the following have been completed or are in progress: upgrading of the Autocall fire alarm system and computerization of fire alarms; the creation of an Institute Fire Response manual; upgrading of non-dormitory fire alarm systems, resulting from actual alarm testing.

Industrial and Public Safety

In the Physical Plant Department a training coordinator for the mechanical trades has been appointed. The Safety Office has worked with the training officer to put on a series of safety training sessions. A Union-Management Safety Committee has been formed and a number of issues have been raised and discussed.

General Safety

The Safety Office continues to furnish safety services to remote site areas, particularly the LINAC in Middleton, and Haystack in Westford. Similar visits to Lincoln Laboratory will begin this coming year.
Increased involvement also has occurred with programs for the handicapped, such as the Intercampus Committee for Handicapped Students, National Rehabilitation Association.

The City of Cambridge Building Department has initiated an inspection program of all M.I.T. buildings. The Physical Plant Department and Safety Office are cooperating in this effort. The Cambridge Fire Department is inspecting all dormitories as a result of increased sensitivity to recent dormitory fires around the nation.

**Industrial Accidents**

Industrial accident experience appears to be holding constant with a slight decrease in frequency from last year. Increased medical costs and weekly benefits have continued to raise premiums. We are showing, however, significantly better experience than the average. Currently our losses are running at a rate 47.7 percent less than the industry average.

**Graphic Arts**

Among the more visible developments during the year were the renovations made in the Graphic Arts Building. The customer area was enlarged, and improved office space was provided for Graphic Arts personnel. The benefits resulting from these changes included not only more aesthetically pleasing surroundings and increased customer space, but also improved employee efficiency and better communications between supervisors. A new telephone system also was installed. Recommended by the M.I.T. Office of Telecommunications, it provides greatly improved internal communications, more circuits, and faster response to incoming calls. In addition, a reduction in annual costs of maintaining and operating a telephone system was realized.

Operationally, total revenue was up approximately 15 percent to $2,500,000 for the year. The newest activity, supervising and administering the M.I.T. owned high-speed Xerox copy machines on campus, accounted for a third of the increase and results from the fact that fiscal year 1978 was the first full year of operating the units. This has proved to be a successful concept, producing favorable comments from users and appreciable savings to M.I.T.

By any yardstick, from customers served, to units produced, to orders processed, activity at Graphic Arts Service during the past year was on the rise. Demands on the Copy Centers continued to be especially heavy, to the point where expansion will be necessary in the near future if Graphic Arts is to adequately service the needs of the M.I.T. community.

**Endicott House**

Endicott House was open 12 months of the year, with mid-winter and mid-summer being the lightest periods. Heavy use during the other months, however, compensated for this. It is gratifying to note that resident use of the house, and especially M.I.T. resident use, increased considerably this past year. Thirty-two resident conferences were held during the year. Overnight accommodations totaled 4,997, giving an average of 26.7 guests per night. Although the number of non-resident groups decreased, the total number of guests involved increased considerably. Eighty-six non-resident groups, with a total of 6,617 guests, used the house.
Vice President, Operations

Major expense projects completed during the year included the purchase of new china and bath linens; redecorating in the bedrooms and upstairs hallways; replacement of the kitchen range; rebuilding and resurfacing the tennis court; chemical treatment of the pipes which supply water for the grounds; and extensive repairs to the Cottage, including a new roof, and installation of storm windows and storm doors.

A "first" for Endicott House took place this year. This was the Head of State visit in June, when Endicott House hosted President and Lady Khama of Botswana and their entourage of 14 persons for two nights. It was a demanding and exhilarating experience that no one at Endicott House shall soon forget.

PHILIP A. STODDARD
Vice President, Research

The 1977-78 year has, on the whole, been a good and exciting one.

The Research Laboratory of Electronics has continued its vitality. One of the most exciting events has been the addition of research in submicron electronics, a joint effort with the Center for Materials Science and Engineering. Dr. Henry Smith of Lincoln Laboratory, who has been appointed to the faculty of Electrical Engineering and Computer Science and who has inventions outstanding in X-ray lithography, is leading the effort.

The Center for Materials Science and Engineering has responded positively under the leadership of Professor Mildred Dresselhaus. Research funding has increased by several percentage points more than inflation. The thrust areas have been redefined, and increased funds are being committed to new research starts by young faculty.

The Energy Laboratory has made considerable progress in adding high-level and permanent staff while expanding research activity by almost a third (constant dollars).

The Nuclear Reactor Laboratory, which left Department of Nuclear Engineering status three years ago to become an interdepartmental laboratory, now involves six departments and three other interdepartmental laboratories in its research program. Director Otto Harling is due much credit for reducing the operating deficit by 50 percent over the past two years.

The Laboratory for Nuclear Science continues to be the locus of some of the world's most exciting nuclear physics and funding is growing more rapidly than inflation. The Bates Linear Accelerator facility in Middleton is in the process of building new facilities costing over $5 million.

The Francis Bitter National Magnet Laboratory expanded its combined research programs by a whopping 40 percent. Much of the growth is attributable to one of M.I.T.'s newest entities, the Plasma Fusion Center, which is obliged, at this time, to depend heavily on the National Magnet Laboratory's giant electric machines and space, and therefore shares many other common services. In the long run this interdependency will be reduced by bringing an additional 225 megawatt generator, located in the parking lot, into service predominantly for fusion research (Alcator C); older fusion experiments will be phased out and 71,000 square feet of space will become available (about January 1980) as a result of the gift pledge of their adjacent building by the National Biscuit Company.

The Center for Space Research continues a decline in engineering research and activity because of NASA programming of funds into the development of the Space Shuttle. On the other hand, the astronomy satellite researches are growing somewhat in funding and are providing mind-boggling new information on the universe.

The reports that follow detail the activities, findings, and directions of what has proven to be a very good year.

THOMAS F. JONES
Francis Bitter National Magnet Laboratory

This past year was a period of continued growth and change in the Laboratory's activities. Expenditures under all contracts for the year (excluding large subcontracts) were about $13 million compared with $8,596,000 for the previous year. The staff increased from 74 to 100 and total employees increased from 140 to 180. The high field facility was in operation for a greater number of hours than in any previous year, and the demand for magnet time by both visitors and laboratory staff is expected to remain at record levels for the coming year. The Alcator C thermonuclear plasma fusion machine has been assembled and initial testing is under way. The 225 MVA alternator power supply for Alcator C, donated to the Institute by Consolidated Edison of New York, was delivered and installed in a new building adjacent to the existing generator room. The programs for research and development on large superconducting magnets for magnetohydrodynamic and fusion generators have expanded.

In the fall, the Laboratory was reorganized. Four technical divisions were created. The Research Division, headed by Dr. Simon Foner, comprises most of the research activity supported by the National Science Foundation (NSF). The Technology Division, headed by Dr. D. Bruce Montgomery, is responsible for magnet research and development for all programs. The Fusion Division, headed by Professor Ronald R. Parker, is comprised of the Alcator A and Alcator C experiments, as well as other plasma-related work. The Instrumentation and Operations Division, headed by Lawrence Rubin, is responsible for magnet plant operation and for the accommodation of visiting scientists. At the same time, the management structure of the Laboratory was strengthened by the appointment of three Associate Directors. Dr. Roshan Aggarwal is responsible for the overall administration of the programs of the NSF. Dr. Montgomery and Dr. Parker were also named Associate Directors. Dr. Foner was appointed Chief Scientist.

Important results of the NSF-sponsored research program include: the experimental demonstration of the validity of the Fisher group renormalization theory as applied to critical phenomena in the very nearly isotropic 3-dimensional antiferromagnetics RbMnF$_3$ and KNiF$_3$; the measurement of the anisotropy of the upper critical fields of single crystal superconducting Nb$_3$Sn using the 300 kilogauss hybrid magnet; new results from spin polarized tunneling in heavy rare-earth metals; the discovery of motional Stark narrowing as well as broadening of atomic spectra in high magnetic fields and their application to high resolution and astrophysical spectroscopy; determination of the shape of electron-hole drops in germanium in high magnetic fields; and the development of the magic angle technique in high magnetic fields for high resolution nuclear magnetic resonance spectroscopy for solid-state, chemical, and biological studies. Mössbauer spectroscopy in external magnetic fields has been used to elucidate the electronic structure of the active sites of reduced bacterial ferredoxin proteins and points to significant effects of the local environment in determining the properties of a unique complex of the form $\{Fe_3MoS_4(SR)_4\}$ which may be related to the as yet unknown active site of the iron-molybdenum protein in nitrogenase, the enzyme responsible for nitrogen fixation. A dramatic effect of external magnetic fields on the toxic effects of certain sulfhydrol oxidizing agents in the ciliate protozoan Spirostomum has been observed. Cell mortality in the presence of the drug is significantly increased by magnetic fields and indicates an interaction between the external field and intracellular membrane vesicles which bind Ca$^{2+}$ ions. An active research and development program on optically pumped lasers has led to the achievement of a system providing 800 kW of 385 $\mu$m radiation having a high spectral purity. This radiation source, together with an improved far infrared detector developed jointly with Lincoln Laboratory, constitutes an important milestone in the effort to develop a
more effective technique for ion temperature measurements in tokamak plasmas using Thomson scattering. In the area of laser-plasma interactions, new results have been obtained on stimulated Brillouin scattering in a magnetic field, electron cyclotron heating and improved X-ray diagnostics for laser-produced plasmas.

A new record density-confinement time product of $3 \times 10^{13} \text{ cm}^{-3}\text{s}$ was reached in the Alcator A experiment. Important new information on basic plasma processes in high field tokamaks was obtained. A number of large superconducting magnets for the nation's magnetohydrodynamic power generation development effort were designed and are in process of procurement through industry. A new large-scale testing facility for superconducting magnets and components has been set up here and theoretical studies of the stability of composite superconductors have been confirmed by experiments. The Alcator thermonuclear programs and the superconducting magnet development efforts are supported primarily by the new US Department of Energy.

The Low Field Group has developed a scanning system for detecting magnetic impurities in the lung and utilized it for a comparative study of particle clearance rates in the lungs of smokers and non-smokers. Early results indicate significant differences between the lungs of the two groups. Components of a second model of an electromagnetic mass driver for space applications with a target acceleration of $5000 \text{ m/sec}^2$ have been designed in collaboration with a group at Princeton University.

BENJAMIN LAX

Center for Materials Science and Engineering (C.M.S.E.)

The Center for Materials Science and Engineering is housed in Building 13, the Vannevar Bush Building, and provides the focus for materials research at M.I.T.

The aims of C.M.S.E. are to initiate, encourage, fund, and coordinate interdisciplinary research in materials. The focus of the research program is provided through core funding by the National Science Foundation (NSF) Materials Research Laboratories (MRL) Program. The research program is further supported by small block funding and individual grants to faculty members through other government agencies, industry, fellowships, and M.I.T. itself.

In 1977-78 a total of about 35 faculty received project support under the NSF-MRL program, involving about 100 graduate and postdoctoral students, as well as visiting professors and scientists and other staff. C.M.S.E. makes it a practice to provide research funding for high-risk seed projects as well as for newly arrived faculty members. During 1977-78, eight junior faculty received seed funding. Faculty, staff, and students of the Departments of Chemistry, Chemical Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Physics participate in the NSF-MRL program.

In addition to support of research, C.M.S.E. initiates and maintains an impressive group of Central (Service) Facilities in support of materials research throughout the Institute. Supervised by faculty members and operated by laboratory supervisors on a day-to-day basis, the facilities provide state-of-the-art laboratories for materials preparation, structural and compositional characterization, various testing laboratories, and a machine shop. Major improvements in our central facility capabilities were made during the past year. In the
summer of 1977, C.M.S.E. acquired a dedicated scanning transmission electron microscope (STEM) facility, thereby providing M.I.T. with forefront capabilities in high resolution electron microscopy. Also at that time, the microelectronic laboratory was established as a central facility and was very significantly expanded in both space and capabilities. During the year, the laboratory for submicrometer structures fabrication was initiated in Building 13, and plans were laid for the establishment of a new central surface analytical facility based on the acquisition of a scanning Auger microprobe.

The NSF-MRL core-funded program supports research in five major areas, each area staffed by faculty from several departments with common interests in that particular area of thrust. These areas are: IA) Predicting Flow and Fracture in High Temperature Alloys; IB) Deformation and Fracture in Polymer Composites; II) Structure and Properties of Microcrystalline and Glassy Metals; III) Platinum Surfaces and Platinum Based Catalysts; IVA) Optical Materials and Devices; IVB) Amorphous Semiconductors; and V) Phase Transitions.

Some highlights of research, abbreviated, are given below as examples of the types of studies which are supported under each area of thrust. Many programs are the result of close collaboration among several faculty from several departments. For a more complete view of research in materials, the reader is referred to the Annual Report on Research in Materials at M.I.T., a publication which is compiled and issued by C.M.S.E. for an international audience.

Highlights for Area of Thrust IA

Fine-structured Carbide-hardened Superalloys (Professor Nicholas J. Grant). Professor Grant's group has succeeded in producing roller quenched superalloys, poured at temperatures up to 1650°C by developing molybdenum-clad copper or stainless steel rolls. Two-kilogram quantities of fine foils of alloy Mar-M-508, quenched at $10^8$ to $10^{10}$°C per sec., have been produced and hot extruded at a reduction ratio of 30:1. The resultant extruded 13 mm D bar was completely sound, and all test results have shown excellent properties. As far as is known, these are the first superalloys roll-quenched at these high rates.

High Temperature Fatigue of a Solid Solution Superalloy (Professor Regis M. N. Pelloux). The fatigue crack growth of Hastelloy-X, a solid solution strengthened superalloy, was measured as a function of $\Delta K$, the range of the stress intensity factor, at 23, 538 and 760°C, at frequencies of 10, 1.0, and 0.10 Hz in air (10$^3$N/m$^2$), vacuum (10$^{-5}$N/m$^2$), and in pure oxygen with very low pressures of 10$^{-3}$ and 10$^{-1}$N/m$^2$.

The principal dependence of growth on frequency was found in the mid-$\Delta K$ regime. The effect was greater in atmospheric air than in vacuum, presumably due to oxidation effects. The threshold $\Delta K$ was less in air (7MN/m$^{3/2}$) than in vacuum (16MN/m$^{3/2}$). Oxygen at 10$^{-1}$N/m$^2$ gave results similar to those for a vacuum. The frequency dependence was predicted better by a damage accumulation model than by a crack opening displacement model, but observed crack growth rates were still less than the theoretical ones by a factor of over three.

Fatigue Crack Propagation in Material with Creep Damage (Professor Ali S. Argon). In work being completed, large bars of 304 stainless steel were deformed at 760°C in bending into the power law creep range to develop gradients of creep damage ranging up to 25 percent intergranular creep cracking. At 760°C and with an intermediate stress intensity range, fatigue crack growth rates in the most severely damaged material were decreased to half of those in an undamaged reference material. Since the roughness of the fractured surface was increased by a factor of four, the retardation effect of crack meandering appeared to overcome the effects of prior creep damage. At low temperatures, the inverse was true. Transverse intergranular creep cracks retarded fatigue crack propagation by a further factor or two. In
all cases, however, fatigue crack growth rates in air were about an order of magnitude above those in a vacuum of $10^{-4}$ N/m$^2$. Thus environment is a more important factor than prior creep damage in determining fatigue crack growth.

**Highlights of Area of Thrust IB**

Mechanisms of Viscoelastic Deformation in Carbon-Black Filled Elastomers (Professor Robert E. Cohen). One of the experimental techniques employed in the investigation of viscoelastic deformation mechanisms of carbon-black filled elastomers has been the non-isothermal creep T-jump experiment. In order to interpret data from such experiments correctly, it was found necessary to quantify the transient changes in length which follow abrupt temperature changes imposed on elastomers stretched to various equilibrium elongations. Thus, a comprehensive study was completed of thermal expansion transients in these materials, with carbon black loading and structure as the material variable and the level of equilibrium strain as the major experimental variable.

Results of this study may be summarized as follows: The time dependence of the thermal expansion transient was relatively insensitive to the level of strain and to the structure and loading of the filler. The magnitudes of the linear expansion coefficients and even the sign (positive or negative coefficient) were very sensitive to changes in the three variables mentioned. By considering the point of thermoelastic inversion (strain at which zero linear expansion coefficient is observed) the influence of filler structure and loading could be explained. The model used in this regard included considerations of an "effectively occluded" rubber phase, a concept which has been previously proposed in the literature on carbon-black filled systems. The excellent agreement of the model with the thermoelastic data represents the first experimental verification of the occluded rubber concept using a method other than conventional stress-strain testing.

Mechanisms of Plastic Flow and Crazing in Block Copolymers (Professors Argon, Cohen, and John Vander Sande). Samples of a semi-commercial new High Impact Polystyrene (HIPS) containing a multiplicity of phase form, obtained from Monsanto Company by private arrangement, and two K-Resins (KRO-1 and KRO-3), obtained from Phillips Petroleum, have been crazed, fixed with osmium tetroxide, microtomed, and examined both with TEM and with the STEM. Most of the exciting and definitive results have come as a result of the availability of the STEM central facility. The experiments have already confirmed that the craze initiating effectiveness in HIPS of a particle depends strongly on the morphology of its interface. Such studies in the K-Resins have revealed hitherto unknown forms of cavitation localization with the KRO-3 Resin having a remarkable capacity for accumulating homogeneous cavitation damage without craze-like localization. Such observations have posed many new questions on the crazing process and mechanisms of cavitation localization that will be explored in the future.

**Highlights of Area of Thrust II**

Al-Li Alloys: Wrought Alloys from Particulates Produced by Rapid Quenching from the Melt (Professor Grant). While there is today one US aluminum-lithium alloy (2020: 4.5% Cu-2% Li alloy), it rarely has been used commercially. As an ingot product, the alloy is strong, enjoys high ratios of strength-to-density and stiffness-to-density, but lacks toughness and has poor crack growth rates in fatigue tests. Large (30 to 50 microns) intermetallic inclusions lead to early crack initiation and rapid crack growth rates in fatigue.

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* An abrupt temperature change superimposed on steady creep deformation; particularly useful for materials in which the internal structure changes during deformation.
Using a base 2024 composition (4.5% Cu, 1.6% Mg), alloys containing 1 and 3% Li (by weight) were prepared, roller quenched from the melt into thin foils and heated to the extrusion temperature, and extruded at 400°C for a reduction ratio (area) of 30 to 1. Test results for ingot product 2024 and roller quenched and extruded 2024 with 1 and 3% lithium show that: 1) the yield strength almost doubles for the 3 percent lithium alloy, with excellent improvements also at the 1 percent level; 2) ductility decreases with increasing strength but remains at satisfactory levels, especially for the one percent lithium alloy in the T4 condition; 3) elastic modulus increases almost 20 percent for a 3 percent lithium addition while density decreases about 10 percent for an exciting 30 percent increase in the stiffness-to-density ratio; 4) the yield strength-to-density ratio increases over 100 percent for the 3 percent lithium alloy; 5) at 150°C the stress for 1000 hours rupture life for the 1 percent lithium alloys increases by almost 50 percent -- the results for the 3 percent Li alloy are poorer; 6) the stress for a fatigue life of $10^7$ cycles, in reversed bonding, increases from 25,000 psi for the ingot product 2024 alloy to 32,000 and 42,000 psi for the particulate based 1 percent Li and 3 percent Li alloys, respectively. For a stress of 42,000 psi for $10^7$ cycles, this represents a ratio of fatigue stress-to-ultimate tensile strength of 0.5, the first time such a high ratio has been reported for a ductile aluminum alloy -- the ratio for commercial aluminum alloys is normally only 0.3 to 0.35; 7) crack growth rates for precracked specimens of the 1 percent Li alloy are lower than for the conventional 2924 alloy, but are higher for the 3 percent Li alloy. These results are of great interest to aircraft builders because of the extremely large improvements in strength-to-density and stiffness-to-density ratios compared to usual ingot alloys. The large increases in fatigue resistance, when coupled with slow crack rates in precracked specimens, are also important property characteristics. The studies which led to these results made extensive use of central facilities at the Center for Materials Science and Engineering. Professor Pelloux collaborated in the fatigue and crack propagation studies.

Localized Electronic Structure and Chemical Bonding in Amorphous Alloys, Produced by Rapid Quenching from the Melt (Professor Keith H. Johnson). A novel theoretical model for the local electronic structures of amorphous metallic alloys has been developed on the basis of first principles SCF-Xα molecular-orbital calculations for clusters representing local configurations of atoms in these alloys. Results obtained for CuZr alloys, for example, suggest that bonding-antibonding interaction between the Zr d orbitals and d orbitals on neighboring Cu atoms (viewed as "ligands" of a coordination complex), in conjunction with a small effective transfer of electronic charge from Zr to Cu, leads to the rehybridization and spatial delocalization of Zr d orbitals, thereby promoting the formation of directed Zr-Zr bonds in which the Cu atoms can be viewed simplistically as "interstitials." Similar theoretical studies are in progress for amorphous NiTi alloys and preliminary results indicate similar bonding-antibonding interactions between Ti and Ni, some effective electron transfer from Ti to Ni, and the promotion of Ti-Ti directed bonds. These results are in good agreement with available photo-emission spectra (which show a diminished density of states around the Fermi energy), with specific heat data, with the formal differences in orbital electronegativities between the alloy components, and further suggest a rather general concept of "real-space" chemical bonding effects in glassy alloys based on transition metals near the "left" of the periodic table.

The Mechanical Stability of Metallic Glasses Near Tg (Professor Argon). A close collaboration with Professor Grant and Dr. Janez Megusar in the study of the plastic deformation of Pd$_{80}$Si$_{20}$ has established that the mechanical stability of metallic glasses above about 0.6 T$_g$ is a direct result of the increasingly high strain rate sensitivity of their flow stress. This collaborative research together with the fundamental observations on sheared soap bubble rafts has resulted in a new theory of plastic deformation including flow dilatation, and flow localization. This in turn has served to suggest additional fundamental experiments.
Corrosion Resistance of Microcrystalline 316 Stainless Steel, Produced from Rapidly Quenched Particulates (Professor Ronald M. Latanision). We have developed a model through which one may explore the question of whether structure or chemical composition plays the more important role in determining the corrosion resistance of a material by examination of shifts in open-circuit electrode potentials. On this basis, it seems clear that the inertness of microcrystalline 316 stainless steel is due in fact to its structure. Polarization measurements show as well that the microcrystalline alloy is more easily passivated than its conventional commercial counterpart. Studies of localized corrosion characteristics are in progress.

Highlights of Area of Thrust III

Analogies Among Active Sites of Coordinatively-Unsaturated Platinum Complexes, Surfaces and Supported Catalysts (Professor Johnson). SCF-Xα molecular-orbital studies of a) coordinatively-ununsaturated platinum complexes of the type that bind alkyls, b) platinum atoms supported on silica (SiO₂), and c) low-coordination sites on the periphery of "surface" of a platinum cluster indicate that there are important analogies among the local electronic structures of these metal sites. In common is the splitting off in energy of a strongly antibonding metal d-orbital (d_{yz} for the chosen coordinate system) from the nonbonding part of the d-orbital manifold, as a result of the interaction of this orbital with a) the 2p-like lone-pair orbitals of the ligands, b) the oxygen 2p-like lone-pair orbitals that constitute the top of the valence band of crystalline silica, and c) the d-orbitals on the neighboring atoms (viewed as "ligands") of the metal cluster. In the last example, the d_{yz} orbital has the significance of a "surface state" that is split off in energy from the main d-orbital manifold (the "d band") of the metal cluster. Because the d_{yz} orbital is symmetry-conserving with respect to electron-accepting orbitals of reactant molecules, its shift in energy relative to the free-atom d-orbitals has implications about the reactivity and catalytic activity of the metal site. These theoretical studies suggest a common basis for understanding the catalytic activities of isolated platinum coordination complexes, supported platinum catalysts, and elemental platinum clusters or particles of the types under experimental and theoretical investigation in Area of Thrust III.

Highlights of Area of Thrust IVA

Semiconductor Lasers (Professor Clifton G. Fonstad). Variable duration, pulsed current excitation has been used to make the first measurements of the effective minority-carrier lifetime in the active regions of lead-tin telluride diode lasers. The internal efficiency and threshold of any semiconductor laser are directly related to the minority-carrier lifetime in the active region and knowledge of this parameter is central to characterizing, modeling, and improving laser performance. Lifetime measurements have been completed as a function of temperature on low threshold diffused lead telluride lasers. These measurements, the first of this type ever done on Pb-salt lasers, show an unexpected peaking in the minority-carrier lifetime at 20 K. This behavior is not yet understood and further measurements and analyses are planned before this program ends. The explanation of this effect may very well lead the way to improved device performance by helping to identify loss mechanisms in the active region that can be eliminated once they are understood.

Highlights of Area of Thrust IVB

Luminescence in Chalcogenide Glasses (Professor Marc Kastner). The valence-alternation model of Kastner, Adler, and Fritzsch (KAF) has provided an explanation of the structure and properties of defects in chalcogenide glasses. Among the predictions of KAF was the
suggestion that the charged valence-alternation pairs (three-fold coordinated, positively charged chalcogen and one-fold, negatively charged chalcogen, for example) might form neutral centers (i.e., IVAPs). However, until recently, it had been believed that the observed luminescence was due to charged centers. This year Hudgens and Kastner have found evidence that the luminescence in As$_2$Se$_3$ may in fact be due to IVAPs. First, they found that excitation of photoluminescence with the lowest energy photons absorbed by As$_2$Se$_3$ leads to non-radiative recombination. If the luminescence centers were isolated charged centers, as generally believed, one would expect photoluminescence to be most efficient at the lowest excitation energy. Second, they found no effect on the luminescence intensity of polarization of intense electric or magnetic fields. This indicates that electrons and holes are indeed tightly bound. These results together with their earlier diffusion experiments led Hudgens and Kastner to propose that the luminescence centers are neutral.

**Highlights of Area of Thrust V**

**Critical Behavior in Smectic Liquid Crystals (Professors Robert J. Birgeneau and James D. Litster).** The liquid crystal $SS5$ exhibits successive isotropic-nematic ($80^\circ$C), nematic-smectic A ($63^\circ$C) and smectic A-C ($55^\circ$C) transitions. Specific heat measurements indicate that the latter two transitions are second order, but little is known about the critical behavior at the A-C transition. At this transition the molecules, which are normal to the layers in the A phase, tilt continuously away from the normal as the system enters the C phase. This suggests a two-component order parameter $\psi_C$ characterized by a magnitude (size of the tilt) and phase (angle with respect to some fixed axis on the smectic planes). On universality grounds de Gennes has argued that the A-C critical behavior should be identical to that of superfluid helium.

Using high resolution X-ray techniques Professors Birgeneau and Litster have monitored the variation in the smectic layer spacing of $SS5$ throughout the C phase. Changes as small as 0.0005 deg in a scattering angle of $\sim 3$ deg can be measured reproducibly. This angular precision together with millidegree temperature control has allowed a determination of the critical behavior of $\psi_C$ with unprecedented accuracy. For $T_C - T < 0.7K$, $|\psi_C|^2$ is described by the mean field exponent $2\beta = 1.00 \pm 0.05$, which is much larger than the value 0.66 expected on the basis of the helium analogy. One possible explanation of this unexpected result may be that there is a large intrinsic coherence length in this system due to the fact that it represents a transition from one long-range ordered state to another. If this is the case then arguments based on the Ginzburg criterion would lead one to conclude that the true critical region (with $2\beta = 0.66$) is unobservably small. Work on the $SS5(1-x)7S5_x$ mixtures should help elucidate this conjecture.

**Critical Behavior of Gels (Professor Toyoichi Tanaka).** The collapse of the polymer network in acrylamide gels has been observed by Professor Tanaka upon lowering the temperature and upon increasing the acetone concentration of an acetone-water gel fluid mixture. This behavior has been explained in terms of a mean-field theory based on an extension of Flory’s formula for the free energy of gels. There are essential differences between phase separation in gels and that in binary fluid mixtures due to the covalent crosslinks in the gel polymer network. Theory predicts, and Professor Tanaka has observed in polyacrylamide gels, the existence of a critical end point.

The critical behavior of polymer network density fluctuations in acrylamide gels has also been studied by following the temperature dependence of the intensity and the correlation time of scattered light. Both the intensity and the correlation time increase by a factor of more than 200 as the temperature decreases, and these quantities appear to diverge at the same temperature. This behavior has not previously been theoretically predicted or experimentally
observed in gels. The static behavior can be explained in terms of mean-field theory, and Professor Tanaka has recently developed a mode-coupling theory for the dynamical behavior.

MILDRED S. DRESSELHAUS

Center for Space Research

The transition in the national space program, referred to in last year's report of the Center, to a relatively smaller number of science-oriented programs, has continued the downturn in the number of opportunities for new space experiment development projects in the Center for Space Research (C.S.R.). During the past year, the potential impact of these trends gained the attention of senior NASA (National Aeronautics and Space Administration) personnel in respect to prospective near future university involvement in the space program. Alternative plans have been formulated and discussed for bridging the gap to the period in the early 1980s when the operating Space Shuttle is expected to provide both the means for implementing new space experiments of particular interest to the university community and for releasing the needed funding resources. Approximately one-half of the total NASA budget for 1978–79 will be used to implement the Space Shuttle transportation system.

Among other alternatives being considered, the Center has been requested to submit a proposal to NASA for establishing a regional center at M.I.T. for space experiment developmental efforts in support of both M.I.T. principal investigators and other university and institutional investigators from the New England area. Under this plan, the Laboratory for Space Experiments of the Center would assist in the preparation of new proposals, help negotiate operating plans and budgets, provide the management and engineering support for development and delivery of the experiment hardware, and provide the necessary experiment launch support.

Continuation proposals have been submitted for ongoing research programs in X-ray astronomy, plasma physics, infrared astronomy, vestibular experiments on manned space flight, and studies in astrophysics. New proposals also were submitted for research on the foregoing topics as well as on gamma-ray astronomy, very long baseline interferometry, solar physics, optical astronomy, ultraviolet astronomy, physics of the upper atmosphere, and studies on the use of the Center for Space Research as a regional space research center.

The Small Astronomy Satellite program, under the direction of Professor George W. Clark, Department of Physics, completed its third year of successful operation in May 1978, and appears capable of at least another year of productive X-ray observations. Professor Clark is assisted in this research by Professors Hale V. Bradt, Walter H. G. Lewin, and Saul A. Rappaport, all of the Department of Physics. The satellite is under constant direction from a control center at C.S.R. Among the most interesting results during the year have been the discovery and precise location of two faint extragalactic X-ray sources which were subsequently identified as quasars through observations with optical telescopes. This suggests that future X-ray observations with more sensitive detectors will prove to be the most effective means for the discovery of these most luminous and distant of all celestial objects. SAS-3 also detected two new highly luminous and variable X-ray stars in the Small Cloud of Magellan. A study of the properties of these and the other Magellanic X-ray sources has led to the conclusion that they are much more luminous than similar X-ray stars in our galaxy and that the reason for the difference is probably the much lower abundance of heavy elements in the Magellanic Clouds.
On a subject much closer to Earth new light was thrown on the nature of the transient X-ray sources in our own galaxy with the discovery by SAS-3 of a 3.6-second pulsation in one such transient called 3U0115+63. Doppler analysis of the variations in pulse period demonstrated that this object is a neutron star in the widest and most eccentric binary system so far measured among X-ray sources. Systematic studies of the X-ray burst sources with SAS-3 has shown that their properties agree in several important respects with the calculated properties of a nuclear flash-burning model in which helium in a layer on the surface of an accreting neutron star undergoes a sudden explosive episode of nuclear fusion into carbon and heavier elements. These episodes recur at intervals of several hours, and after each episode the fusion energy, equivalent to the energy radiated by the sun in one week, is emitted as blackbody radiation in the X-ray region of the spectrum.

A notable addition to the field of X-ray astronomy observations occurred with the launch of the High Energy Astronomical Observatory on August 12, 1977. The A-3 experiment on HEAO-1 is a joint M.I.T. and Smithsonian Astrophysical Observatory effort. Professor Bradt is the principal investigator. He is assisted by Rodger Dosey, Richard Dower, Mark Johnston, and Alan Ramsey at M.I.T., and Herbert Gursky, Daniel A. Schwartz, Joseph Schwarz, Richard Griffiths, and Giuseppina Fabbiano at SAO. The A-3 experiment was activated two days after launch and has performed to expectations. One of eight X-ray counters failed shortly after launch, but this reduces the experiment sensitivity only slightly. A slow degradation of the thermal shield resulted in lower than expected operating temperatures, but has not, and will not, compromise the data in any way.

The production data processing system was put together as a joint M.I.T.-SAO effort. The bulk of the processing is accomplished at a dedicated mini-computer facility located at SAO. The production processing began shortly after the arrival of the first production data and has continued on a timely basis. At this time, the data from the first five months of orbital operations have been completely processed.

Scientific analyses of the processed data are carried out at both M.I.T. and SAO. The primary goals of these analyses are: 1) to locate accurately the positions of unidentified X-ray sources and make optical or radio identifications of the sources, 2) to verify or refute suggested source identifications which have been proposed, 3) to study the spatial structure of extended X-ray sources. To date, seven papers regarding these results have been accepted or published, and four more are in draft form. In addition, numerous invited and contributed papers have been given at scientific meetings (American Astronomical Society, American Physical Society, and the Committee on Space Research).

Precise HEAO A-3 positions have directly led to the optical identification of seven galactic X-ray sources. These sources include Nova Oph 1977, a bright X-ray transient; 4U0115+63, a recurrent transient and X-ray pulsar; GX339-4, a rapidly variable source, similar in some respects to the black hole candidates Cyg X-1 and Cir X-1; MXB1659-29, an X-ray burst source H0449-55, a high latitude fast (~1 hr) transient; 2A1052-606, a high latitude faint galactic source; and 2A1822-371, a faint galactic plane source. Precise HEAO A-3 positions have assisted in the identification of 2S1254-690 and 2S1538-522, two galactic plane sources having precise SAS-3 positions. A number of extragalactic identifications, based on large X-ray error boxes, have been confirmed with precise HEAO A-3 positions. These include the Seyfert Galaxies, MCG8-11-11, NGC 4151, Mkn 279, and ESO 141-G55, the emission line galaxy NGC 2992, and the BL Lac object Mkn 501. Precise positions for two sources in the Large Magellanic Cloud, LMC X-1 and LMC X-3, have revived interest in proposed optical counterparts, but further optical work is required for identification. Precise positions have been obtained for another ~25 sources which have no optical counterparts as yet.

HEAO A-3 has obtained important data on source structure for a number of sources. LMC X-1 and Cen A have been shown to be consistent with point sources, contradicting previous published reports. Data on structure of three supernova remnants (Crab, Cas A, Tycho) have been
obtained and are being analyzed. Data for the Perseus cluster of galaxies clearly show
structure and model fitting are being attempted. Measurements or lower limits on size
will be obtained for a number of faint clusters of galaxies.

The A-4 experiment, also on the HEAO-1 observatory, was activated soon after launch and
has performed up to expectations. Professor Lewin is the principal investigator, assisted
by Drs. Jeffrey Hoffman, William A. Wheaton, Eugene Tsiang, and Francis Primini.
Expansion of the A-4 data reduction computer program with the addition of a Data General
Eclipse system has been proposed as a means to speed up production of the A-4 high-energy
X-ray source catalogue for use on the HEAO-B mission.

The construction of the focal-plane Bragg crystal spectrometer payload for the HEAO-B
mission has been completed and delivered to NASA with the expectation that launch will take
place in November 1978. The HEAO-B project is under the direction of Professor Clark,
assisted by Professor Claude Canizares, Department of Physics.

The program of optical studies of X-ray sources has been carried out actively by Professor
Canizares and Dr. Jeffrey McClintock using M. I. T.'s McGraw Hill Observatory in Arizona
and the Cerro Tololo Interamerican Observatory in Chile. Highlights of the year's activities
include: 1) the first detection of optical bursts from an X-ray burst source (done in
collaboration with J. Grindlay of Harvard); 2) the discovery of optical counterparts for four
galactic X-ray sources (two bursters, a pulsar and a transient) and of strong candidates for
two others (the transient was discovered in collaboration with other McGraw Hill Consortium
members); 3) the study of the optical properties of a number of X-ray stars and of an X-ray
globular cluster with the aim of defining and characterizing new classes of X-ray emitting
objects; detailed optical observations of an unusual seven-second X-ray pulsar were recently
carried out with simultaneous X-ray coverage by SAS-3; 4) detailed spectrophotometric and
photometric observations of the second X-ray QSO (discovered by SAS-3) which gave strong
support to the hypothesis that all QSOs are powerful X-ray emitters; and 5) the identification
and study (in collaboration with McGraw Hill Consortium members at the University of
Michigan and with M. I. T. visitor, Dr. Jan van Paradijs) of an unusual X-ray emitting
galaxy, which belongs to a class of active galaxies only recently detected as X-ray emitters
but possibly responsible for much of the diffuse X-ray background.

The long duration X-ray balloon observations scheduled for launch in Palestine, Texas in
April 1978 had to be postponed as a result of a balloon launching failure. Discussions of
plans to reschedule these flights are in process. This research is under the direction of
Professor Lewin assisted by Dr. George Ricker. It includes a significant collaborative
effort by the Cosmic Ray Working Group in Leiden, The Netherlands.

Over the past several years, the M. I. T. X-ray astronomy sounding rocket group under the
direction of Professor Rappaport has designed, constructed, and flown an imaging X-ray
experiment. The system utilizes a low-cost X-ray telescope of the Wolter I type, with
moderate angular resolution (3'), and a position sensitive proportional counter to record the
X-ray image. The detector was built in collaboration with the X-ray group at the University
of Leicester. The imaging payload was flown successfully on two Astrobee-F sounding
rockets in July 1977 and in March 1978. During these two experiments, three old supernova
remnants were imaged in soft X rays (E \textless 1 keV): Cygnus Loop, Puppis A, and IC443.
These represent the first true X-ray images of supernova remnants (i.e., recorded with
imaging X-ray optics). These experiments also marked the first use of the Wolter I type
telescope for imaging extra-solar system objects.

The sounding rocket group is presently designing a wide-field (8°) soft X-ray (50-250 \textmu A)
camera for use on rocket-borne experiments and on the Space Shuttle. The telescope objective
will comprise three nested mirrors that are basically of the Wolter I type, but with surfaces
slightly modified to minimize off-axis aberrations. The imaging detector will be a micro-
channel plate (~50 mm diameter) to be provided by our collaborators at the University of
Leicester. It is estimated that the first flight with the new wide-field camera could take
place as early as fall 1979. This type of instrument would yield important astrophysical
results in five areas: 1) a study of stellar sources with characteristic temperatures in the
range $10^5$-$10^6$ K; 2) a map of the ultrasoft diffuse X-ray background; 3) images of extended
extragalactic sources; 4) images of near-by supernova remnants; and 5) discovery of new
astrophysical classes of soft X-ray emitters.

The Voyager 1 and Voyager 2 spacecraft (formerly referred to as the Mariner Jupiter/Saturn
1977 Mission) were successfully launched in late August and early September 1977. These
spacecraft will fly past Jupiter in early 1979 and Saturn in 1981. If the spacecraft continue
to operate well, the orbit of Voyager 2 will be corrected so that it will encounter Uranus in
1986. Each spacecraft carries 11 separate science investigations including a plasma exper-
iment which is under the direction of Professor Herbert S. Bridge, Department of Physics.
The Voyager plasma experiments are designed to investigate the properties of the solar
wind and to study the magnetospheres of Jupiter and Saturn. Some problems have been
experienced with the plasma experiment on Voyager 1 but at present both experiments are
operating well and are providing a wealth of new and exciting information about the properties
of the solar plasma.

Professor Susan G. Kleinmann, Department of Physics, with Dr. C. Telesco and student
assistants, have continued their infrared celestial observations using the Kuiper Airborne
Observatory, the Kitt Peak, Mauna Kea, and Haystack observatories. Observations of the
stars associated with double-lobed reflection nebulae reveal that their far-infrared spectra
resemble those of planetary nebulae, to which they are generically related. Other groups of
objects include carbon and M-stars and HII regions or pre-main-sequence objects. At least
seven percent are emission-line stars that are not associated with regions of active star
formation. Young objects have been observed surrounded by extremely cool dust that is
apparently associated with molecular clouds in which the stars are imbedded.

Continuation of the observations is being planned under a program of narrow-band and broad-
band photometry near 20 $\mu$m of sources detected in the Air Force Geophysics Laboratory
(AFGL) Sky Survey. Goals are to improve the accuracy of the AFGL Catalogue, search for
dust resonance features, provide data in support of far-infrared studies of new AFGL sources,
and search for variability in the brightest sources.

Institute Professor Philip Morrison and Professor Kenneth Brecher, both of the Department
of Physics, have continued their research on a number of topics in theoretical astrophysics
and cosmology under NSF sponsorship. The principal areas of study are: neutron star
properties including equations of state, possible quark-nucleon phase transitions and neutrino
cooling; thermal and non-thermal radiation from white dwarfs; models of slow and fast
variable galactic X-ray sources; the physics of supernova explosions; double radio source
ejection from active galaxy nuclei; physical cosmology, including physical models of a
"Cosmological constant" and constraints on variation in microscopic fundamental "constants"
set by observations of distant objects; and astrophysical process, particularly magnetic field
generation and annihilation in stars and in the less dense plasmas found in supernova remnants
and double radio sources.

Research on the use of composite materials for the structure of a communications satellite
has been continued by the Director of the Center assisted by Dr. Oscar Orringer of the
Department of Aeronautics and Astronautics. The studies were sponsored by the US Air
Force. Two candidate designs for a graphite/epoxy antenna-feed truss were comparatively
evaluated by dynamic analyses, fatigue stress analyses, and preliminary experiments.
Studies included: using an angle-ply delamination coupon as an interlaminar strength test;
determination of interlaminar shear strength as a function of cyclic thermal fatigue; thermal fatigue tests of steel-graphite/epoxy joints under simulated earth-shadow conditions; shear-lag analysis of bonded joints with tapered adherend; analysis of antenna deployment transient dynamics; and, reliability-based design/test criteria for tubular graphite/epoxy components.

Research by the staff of the Man-Vehicle Laboratory under the direction of Professor Laurence R. Young, Department of Aeronautics and Astronautics, continued in the areas of: habituation to novel visual vestibular environments with particular reference to space flight; compensatory visual neural changes with eye movements; visual vestibular interaction and its application to flight simulation; special pedagogic strategies in arithmetic; and ski accident research. Professor Young is assisted in this research by Professor Charles Oman and Drs. Howard Hermann, Alfred Weiss, and Alan Natapoff, all of the Department of Aeronautics and Astronautics. A recent important addition to this research has been the program of laboratory and flight tests in Spacelab 1 to investigate space motion sickness, and any associated changes in otolith-mediated responses occurring during weightlessness, and the carryover of any such changes to post-flight conditions. The experiments are being prepared in conjunction with other investigators of the Defense and Civil Institute of Environmental Medicine in Canada. Launch of Spacelab 1 is currently scheduled for December 1980.

JOHN F. MCCARTHY, JR.

Detroit Institute of Technology-M.I.T. Association

M.I.T. continued to serve as the cooperating institution to the Detroit Institute of Technology which is the recipient of a major development (Title III) grant from the US Department of Education. During the year Dr. Hugh Thompson, the new President of D.I.T., concluded that the institution was not viable in trying to be all things to all people; that it was, in many ways, duplicating the programs of a number of other nearby institutions, both public and private. After a preliminary survey of the Detroit area he asked M.I.T. to put together a consulting team to assist him in charting the institution's future. A team consisting of Professor Walter Thomas of Western Carolina State College, Professor Carl Houston of the University of Houston, and Professor Kenneth Woolf of Delaware County (Pennsylvania) Community College surveyed the Detroit area and rendered a report before Christmas, as requested. The Board of Trustees of D.I.T. accepted the report and processes were put in motion for the institution to develop a strong focus on engineering technology by providing special bachelor's degree opportunities to Associate in Technology graduates of the area's two-year community colleges. During the spring the consulting committee developed cost studies and implementation plans.

Dr. Thompson announced in June the appointment of Dean of Technology Robert Ellis of Florida International University as Executive Vice President. Dr. Ellis, we are told, will spearhead the development of the institution toward the academic goals of a specialized institution serving needs of Greater Detroit that are not presently being met.

At Dr. Thompson's request, Howard Markowitz, who was the M.I.T. liaison officer during the year, made an intensive study of the status of competency testing in the eastern United States and a report has been submitted.
Vice President, Research

At our suggestion, the University of Houston has been named as an additional helping institution for 1978-79. M.I.T.'s role has, consequently, been reduced to less than half that of 1977-78 and the liaison position, which was part time in 1977-78, has been eliminated.

THOMAS F. JONES

Energy Laboratory

During the past year Energy Laboratory research has continued to center on three major areas of concern: the processing, combustion, and utilization of fossil fuels (both natural and synthetic) and resulting health and environmental effects; the design of facilities for central power generation (both fossil fuel and nuclear) and associated safety and environmental issues; and the effects on energy supply and demand of policy, economic, and management influences resulting from the behavior of governments, firms, and other groups. Some projects fall outside of these general categories, since a concerted effort is being made to broaden both the Laboratory's scope of research and its involvement with other groups at M.I.T. Because the transportation sector accounts for more than half of United States petroleum demand, increasing attention has been given recently to expanding Laboratory activities in the transportation area. One result of this effort has been establishment of the Laboratory's first joint program with the M.I.T. Center for Transportation Studies. Other efforts in the transportation area are being pursued, and expanded programs are beginning in other new areas of interest, including development of new concepts and processes for utilizing solar energy in its various forms.

Energy Laboratory research activities now involve about 60 Energy Laboratory staff, 70 faculty members, and 150 students from various departments in all five M.I.T. Schools. The annual sponsored research budget of $8.5 million is supplemented by grants and gifts from industry and foundations.

A major change in the Laboratory's administration came with the appointment of Dr. Malcolm A. Weiss as its first deputy director. Dr. Weiss joined M.I.T. in September 1977, coming from a career in research and development and technology management at Exxon Corporation.

Two important administrative appointments in the Center for Energy Policy Research (C.E.P.R.) were announced. Professor Henry D. Jacoby, a member of the faculty of the Sloan School of Management since 1973, became the C.E.P.R.'s first director. As director, Professor Jacoby has been providing leadership for the C.E.P.R.'s research programs. On July 1, 1978, Loren C. Cox will become the first executive director, assuming responsibility for management and operation of the C.E.P.R. in its daily activities. Mr. Cox comes to M.I.T. from his position as coordinator and member of the professional staff (Energy) of the Ways and Means Committee of the US House of Representatives. C.E.P.R. Associates (organizations that participate in the research work of the C.E.P.R. at a professional level) now include the following: Aluminum Company of America, Atlantic Richfield Company, B. P. North America Inc., Cabot Corporation, Chem Systems Inc., E. I. Du Pont de Nemours and Company, EG&G, Inc., Environmental Defense Fund, Exxon Corporation, Gulf Oil Corporation, Hughes Tool Company, League of Women Voters of the United States, Massachusetts Audubon Society, New England Electric System, Olin Corporation, Panhandle Eastern Pipe Line Company, The Public Agenda Foundation, Sun Company, and Wheelabrator-Frye Inc.
Research activities supported by the C. E. P. R. are included in the brief descriptions of Energy Laboratory projects that are listed following this overview.

The Electric Utility Research Seminar and Workshop Program held workshops in three areas: nuclear reactor and plant engineering; environmental management; and coal utilization. These workshops resulted in nine research projects, eight of which are still under way. In addition, negotiations are in progress regarding three additional projects that would begin in September. In 1978 workshops will consider the three areas mentioned above as well as new topics to be defined by the utility participants. The nine utilities currently participating in the program are: Boston Edison, Consolidated Edison of New York, Eastern Utilities Associates, Fitchburg Gas and Electric, General Public Utilities Service Corporation, New England Electric System, Northeast Utilities, Public Service of New Hampshire, and Public Service of New Jersey.

Substantial progress was made in the program to upgrade and extend experimental facilities to support work in fossil fuel utilization technology and health effects. Both the combustion research facility and the pilot-plant sized fluidized bed combustor have recently been completed, and experimental work is beginning. A new blowdown turbine test facility with a linear cascade and a turbine water cooling research facility have been completed. They are being used in research on gas turbine performance in combined cycle electric power generation processes. The small-scale magnetohydrodynamic (MHD) simulation facility has recently been upgraded and now provides a realistic simulation of the conditions inside a full-scale MHD generator. In order to obtain the maximum information from these facilities, advanced instrumentation has been used and a powerful modular central data acquisition system has been installed. Close to $3 million has been invested by M.I.T. to provide these improved facilities.

Much progress has been made toward solving the Laboratory's growing space problems. In the fall of 1977 Laboratory researchers in the economics and policy areas moved to renovated offices on the fourth floor of the Suffolk Building (E38) in Kendall Square. After additional renovation, members of the C. E. P. R. will become consolidated on the fifth floor of that building in fall of 1978. Architectural designs are nearly complete for the overall renovation of the Webster Building (E40). The schedule for this work provides for consolidation of all headquarters and nonexperimental Laboratory people in this building by early 1980.

Recognition of the need for better communication of Laboratory activities and research findings has resulted in several new periodical publications. Project Summaries, dated last July and planned as an annual document, contains a description of each Laboratory project and lists the people involved and publications released. A quarterly newsletter, e-lab, intended for external distribution, describes selected research programs in the Laboratory and lists highlights of other Laboratory activities and new publications. Over 2,000 copies of the first issue were mailed in April and comments from recipients have been most favorable. The second issue will be sent out in early July. Finally, a monthly internal newsletter was begun to inform M.I.T. faculty and Laboratory staff about research and other activities in the Laboratory.

The following summaries describe some of the Energy Laboratory projects that were active during the past year. Although most projects involve research teams consisting of faculty, staff, and students, only principal investigators are mentioned by name because of space limitations.
ENERGY MANAGEMENT AND ECONOMICS

The photovoltaic project focuses on providing policy support to the US Department of Energy (DOE) on commercialization and market acceptance of photovoltaic technology. The following nine paragraphs describe the individual subtasks of this major effort.

Professor Thomas Nutt-Powell is continuing research on concepts and methods of institutional analysis relating to the introduction of new technologies. During the past year these concepts have been applied in developing survey data and information for the Mead, Nebraska solar photovoltaics field test experiment.

Dr. Richard Tabors and associates have continued research on the potential demand for photovoltaics in the residential sector. During the past year a method for evaluating the economic worth to a homeowner of a photovoltaic installation, given insolation conditions and utility pricing schedules, was developed and applied for selected regions of the country.

Professor Gary Lilien has continued his research on new technology diffusion. During the past year a preliminary model of the solar photovoltaic technology diffusion process was developed and calibrated for two sectors: agricultural-irrigation (in conjunction with the Mead, Nebraska photovoltaic field test experiment) and residential (in conjunction with a demonstration unit at the Nebraska State Fair).

Professor Martin Weitzman has completed a theoretical study to develop simple decision rules for technology research and development decisions when each choice has differing probabilities of success and expected benefit.

Dr. Raymond Hartman has continued research on developing and applying econometric methods for the analysis of potential demand for photovoltaic-based technologies.

Dr. Thomas Neff is completing a social cost/benefit analysis of alternative photovoltaic technologies, as they compare with conventional sources of electricity. The purpose of this work is to provide part of the basis for establishing national research, development, and demonstration priorities for photovoltaics and to anticipate potential regulatory, health, and environmental constraints that might otherwise inhibit development.

Drew Bottaro, Esq., continues work on the effect of public utility commission practices on the competitiveness of photovoltaics and has initiated a study of the economic and legal implications of DOE participation in standard setting for photovoltaics.

Dr. Lawrence Linden and Mr. Bottaro have completed a study of the effects of market imperfections on the development of new technologies including, as a case study, the photovoltaics industry.

Dr. Neil Goldman developed a decision-analysis framework of the technology development process for flat-plate and concentrator photovoltaic systems.

In a separate project, an Energy Laboratory venture analysis led by Dr. Tabors supplied information to a larger study carried out by the Solar Energy Research Institute (SERI) evaluating the potential impact of a large-scale photovoltaic procurement program proposed by DOE. The Energy Laboratory team assisted in estimating long-term markets for photovoltaics and provided a panel of reviewers for initial methodological reports prepared by SERI.
Dr. Tabors has recently begun a review and analysis of currently available information on experiments and simulations conducted to date on the impact of dispersed residential solar hot water and heating systems on the New England Electric System.

Professors Jacoby, Morris A. Adelman, and Robert Pindyck are developing improved methods and data for analysis of the world oil market. The project includes studies of worldwide oil demand, analysis of supply from key producer areas, and the integration of supply and demand functions into a market simulation. Supply-demand analyses are combined with behavioral studies of the OPEC nations to produce forecasts of likely future developments in the oil market.

Research continues on the demand for energy services. Professor Jerry Hausman has completed an analysis of the demand for room air-conditioners using the technique of conditional probit. This technique, developed by Professor Hausman for modeling the demand for new technologies, is based on the apparent consumer demand for the attributes of known competing technologies. John Boshier, visiting Harkness Fellow from New Zealand, completed a study of United States energy conservation policy. David Wood, Associate Director of the Laboratory, and Professor Ernst Berndt, visiting scholar from the University of British Columbia, continued their research on energy demand and capital formation in United States manufacturing. Professor Berndt also completed a study of energy efficiency and productivity that includes an exposition of the analytical relationship between engineering and economic efficiency.

Professor Pindyck is examining a number of issues in the economics of natural resource exploitation, including the study of the impact of price controls on patterns of resource exploration and production, the behavior of renewable and nonrenewable resource cartels, and the role of uncertainty in resource use. He would like to find ways of linking the detailed statistical models that describe individual resource producers with models of aggregate resource industry behavior.

Professor Pindyck is also developing models of optimal exploration and production of nonrenewable resources, applying these models to the behavior of some actual resource markets, and combining these models with models of conflict resolution and bargaining as a means of analyzing the potentials for exploitation of "supranational" resources (i.e. resources that have no national boundaries).

Dr. Esteban Hayilicza and Professor Gordon Kaufman are developing improved estimates of energy supplies from natural resources utilizing optimal stochastic control methods. They are also considering links with macroeconomic variables and price formation mechanisms under alternative market structures. This research builds on the prototype models developed during the initial phase of the project by incorporating statistical descriptions of the discovery process for petroleum within a framework of intertemporal optimization.

Professors Adelman, Kaufman, and Martin Zimmerman, and Dr. John Houghton continue to perform an analysis of methods used in estimating the availability of primary energy resources and reserves, as well as a comparative analysis of historical estimates.

Professor Zimmerman has completed an analysis of the economic and environmental conditions influencing the development and production of western coal reserves.

Independent assessment of energy policy models is an important element in establishing model credibility and in increasing model utility in policy analysis and debate. Under the leadership of Professor Edwin Kuh and Mr. Wood, the Model Assessment Group is providing independent assessments of important energy policy models and developing guidelines and procedures for alternative approaches to assessment.
In January 1978 Professor John Donovan and his colleagues officially completed the NEEMIS (New England Energy Management Information System) project, a cooperative research effort by the M.I.T. Energy Laboratory, Sloan School of Management, and a variety of other corporate and public sponsors. The primary objective of the NEEMIS project was to design, develop, and utilize advanced computer software techniques for use in modeling, forecasting, and technical analyses in the field of energy. With particular emphasis on the needs of the New England Region, these tools and capabilities were made available on a continuing basis to the New England states and various other regional organizations for their use in energy policy planning, energy management, and related applications.

POLICY STUDIES AND TECHNOLOGY EVALUATION

Professor Jacoby and Dr. Thomas Neff are conducting research focusing on the security, or assurance, of nuclear fuel supplies internationally as it depends on economic, political, and technical factors, and on measures that might be taken by consumer or supplier countries to improve fuel assurance.

Professor Donovan has recently completed an analysis of proposed US House of Representatives legislation that would have required a substantial increase in the use of United States vessels in transporting foreign oil. He considered the cost impact of this legislation on various sectors of the market and on the New England region in particular. The study also posed possible long-range ramifications of such legislation for the related industries and markets associated with oil transport in the US.

Dr. Tabors and Professor Donovan studied the potential of electric vehicles to compete with internal combustion vehicles as second cars in the US. They identified potential market areas in which electric vehicles would be competitive by statistical analysis of ownership data from the Federal Highway Administration and surveys carried out by the University of Michigan.

Professor Daniel Roos and Dr. Weiss are developing plans for the restraint of motor fuel demand in the event of a national emergency such as another oil embargo. The plans to be considered will focus on, but are not necessarily confined to, private passenger transportation on highways. Rationing plans are excluded (other Department of Energy programs cover them), as are plans relying on price disincentives (prohibited by law).

Dr. Knut Mork and Professor Robert Hall are considering the short-run aspects of the relationship between energy prices and the economy. They are studying the effect of energy price changes on the rate of inflation, using a model that describes technology, productivity, pricing behavior, and energy demand in the aggregate. The ultimate object is to build a complete model describing the relationship between energy prices on the one hand, and inflation and short-run fluctuations in employment and economic activity on the other.

Professor Glen Urban is leading a study to identify topics of marketing research interest in the energy field. Two topics have been identified. The first -- development of strategies to promote conservation -- can be approached by setting up outreach programs. This approach combines monetary incentives, research of local circumstances, and promotion of results by local people. The research focuses on quantitative determination of an appropriate communications mix for a given campaign. The second topic is modeling of the process of adoption of an industrial product. Understanding this process provides a basis for decisions on the marketability of a product.
Using a structured, uniform analytical approach, Professors Benjamin Ball, Jr., and Peter Lorange are investigating the decision-making systems of 13 firms to determine their strategic capability for handling energy issues in their particular situation. The project will result in an improved understanding of how the private sector does in fact make its energy-related decisions.

Under the direction of Professor David White, a project to assess the potential for coal utilization in the industrial sector is being started by developing a data base on the economics of coal substitution. Consideration will be given to the constraints imposed by environmental regulations and tax legislation, and to opportunities offered by new technologies. A model will be developed to do comparative economics for test cases as a guide for developing a full-scale study of the industrial sector.

Professor David Rose, Mr. Wood, and their colleagues continued research to identify and evaluate both technical and nontechnical initiatives and strategies to improve construction and operating efficiencies of light water reactors (LWRs). The analysis considers direct effects upon LWRs as well as the broader economic effects upon the electric power sector.

In the residential and commercial sector, about half of the energy consumed is used for space heating. Dr. Leon Glicksman is investigating future options for space heating, including heat pumps with thermal storage, solar energy, and district heating. His goal is to determine the economic and energy savings potential of each option as well as institutional factors that may hold back its development. Advanced technological systems utilizing heat pumps are being identified.

Professor Julian Szekely has prepared a critical review of the current status of stack gas scrubbing technology as applied to SO$_2$ emissions from coal-fired power stations. The principal conclusions are that stack gas scrubbing equipment may be operated reliably and at a predictable cost. New developments are also discussed, including novel scrubber arrangements and alternatives to the direct combustion of pulverized coal. While some of these new processes are promising, they have not yet been demonstrated on a production scale.

A comparative study of the Federal government's efforts to regulate the automobile industry's products in the area of emissions, safety, and fuel was completed by Professors Jacoby and John Heywood and Dr. Lawrence Linden. This interdisciplinary effort involved a comparative study of methods of regulation and the nature of the problem in each of the areas mentioned above. Other topics considered include: the impacts of uncertainty in measuring emissions and air quality on urban air pollution; market strategy implications of fuel-economy standards; the political implications of the standards versus taxes choice; and an analysis of the political implications of efforts by the US Congress to regulate auto emissions.

The Energy Laboratory was retained by the Central Maine Power Company to evaluate several technologies as possible alternatives to the construction of Sears Island #1, a 600-MWe coal-fired generating plant scheduled for startup in 1986. Led by Michael Ruane and William Jones, the study concluded that, because of technical, regulatory, and institutional limitations and the lack of commercial experience, these technologies could not reliably be expected to supply the power and energy of the proposed plant.

**ENERGY CONVERSION**

A comprehensive interdepartmental research and development effort led by Professor Jean Louis is focusing on key aspects of MHD. Work to date has emphasized testing and evaluation.
of electrode materials and electrode modules; coal combustion studies; theoretical analysis and modeling of critical phenomena in MHD generators and of MHD plant components; experimental studies in a disk generator; and participation in the US/USSR Cooperative Program in MHD Power Generation.

In order to better understand fluidized bed combustion, Professor Louis, Dr. Shao Tung, and their colleagues have developed an initial (first order) system model that can approximately compute: carbon loading, combustion efficiency, carbon particle size distribution, SO$_2$ emission, stone utilization, heat transfer coefficient for immersed tubes, bed temperature, and NO$_x$ emission. The model will be further upgraded. A model 204 data base management system has been selected for full implementation.

Professor James Melcher is investigating the application of the electrofluidized bed (EFB) to the collection of particulate products of coal combustion, especially as required for utilization of atmospheric pressure fluidized bed combustors. The EFB has been shown by previous studies to be suited to the high performance collection of submicron particles. A facility has been constructed and tested that allows for atmospheric pressure tests at about 100 cfm over the temperature range of 400°F to 1500°F. Theoretical and experimental studies have been made of bed conduction phenomena and high-temperature particle charging techniques.

A team led by Professor Louis has undertaken work that supplements the Energy Conversion Alternatives Study (ECAS) by investigating in greater depth the potential environmental effects of the various advanced cycles that are being developed or considered for development for future central generation stations. The Energy Laboratory has a subcontract from Exxon Research and Engineering, the prime contractor for the Environmental Protection Agency; cooperation between government, industry, and academia has been very successful.

Professor Louis is also conducting an analytical and experimental research project to support the future development of combined gas turbine/steam turbine cycle power plants with overall efficiency and operation cost advantages over contemporary power plants. Three critical and highly coupled problems affecting the allowable inlet gas temperature to the turbine stages of the gas turbine engine are addressed: turbine cooling, materials corrosion, and fuel gas desulfurization.

Extensive programs for the rapid improvement of mining methods and machinery are not often followed by commercial utilization of the new technology thus developed. The mining industry has been resistant to new technology, often for nontechnical (but legitimate) reasons. Professor Carl Peterson is organizing a workshop that will explore and define the role of industry in overcoming obstacles to commercial utilization of new technology.

**STATIONARY COMBUSTION**

Under the leadership of Professor Janos Beér, a 3MW thermal Combustion Research Facility (C.R.F.) has been designed and constructed for the application of results of fundamental studies to industrial type turbulent flames. The main research objective is to develop combustion strategies for the clean combustion of coal and coal-derived gaseous and liquid fuels. The construction of the C.R.F. for burning gaseous fuels has been completed, including full instrumentation. It is expected that by September 1978 equipment for preparing heavy fuel oils and oil-water emulsions will be commissioned. Design of coal and coal-oil mixture handling and storage systems is in progress; installation is planned in 1979.
Professor Beér is also studying processes of NO formation and destruction in fluidized combustion. Kinetic parameters of the reactions between NO and coal char, and NO and NH$_3$ respectively are determined from laboratory-scale fixed and fluidized bed reactor experiments. Results of these studies are used in mathematical modeling of NO emission from fluidized combustion, and serve also for devising combustion modifications that will reduce NO emission. Effects of these modifications upon performance and pollutant emission are studied in the two-foot by two-foot experimental fluidized combustor.

Professor Louis is leading an effort to design and experimentally develop an ultra-high swirl, second stage magnetohydrodynamic combustor in the form of a multi-annular swirl burner that will be placed at the exit of a "conventional" MHD coal slagging gasifier first stage combustor. The first step in the development includes water model studies of the test combustor for the effects of combustor geometry and operating variables upon mixing and flow aerodynamics. The water model facility will be designed and is expected to be available for research in September 1978.

Through parallel gaseous and liquid fuel combustion experiments, Professor Adel Sarofim has determined the dependence of bound-nitrogen emissions from the combustion of nitrogen-doped fuels upon temperature and fuel equivalence ratio. The results support the hypothesis that in certain fuel-rich regimes increased flame temperature results in decreased emissions.

Professor Sarofim also has provided input into the formulation of the Environmental Protection Agency's Fundamental Combustion Research (FCR) program in the area of NO$_x$ emission control from fossil fuel combustion. He has critically reviewed the current level of understanding of NO$_x$ formation and destruction mechanism, both homogeneous and heterogeneous, and is developing a predictive gas-phase chemical kinetic mechanism of fuel-nitrogen conversion.

**TRANSPORTATION**

Dr. Joe M. Rife is formulating a comprehensive program for research in automotive vehicles with major emphasis on the trade-off between fuel economy and unregulated emissions.

A major activity in the transportation area involves the development and application of advanced modeling techniques to internal combustion engines. In many cases these models are limited by gaps in the fundamental understanding of engine processes. For example, current thermodynamic models of engine cycles do not include knock. Since knock is an important limitation on the operating parameters of internal combustion engines, the utility of these models for parametric analysis is substantially reduced. Dr. Rife is planning single cylinder engine experiments and analyses in order to develop a method for including knock in the cycle calculations.

Performance and emission models for internal combustion engines also require specification of the flame speed. The most important controlling parameter in the flame speed is the turbulent fluid motion in the vicinity of the flame front. Dr. Rife is combining flow visualization experiments, combustion bomb experiments, and theoretical analyses in order to relate the turbulent fluid mechanics in the combustion chamber to engine geometry and operating conditions.

Lean or diluted operation of internal combustion engines is a proposed control strategy now under consideration. The ability to run lean is presently limited by the ability to ignite the mixture consistently. Understanding of spark ignition processes could help extend this limit.
and lead to improved fuel economy and emission characteristics. Professor William Unkel is investigating spark ignition processes in order to a) provide a data base of ignition-related characteristics for conditions typical of engine operation, and b) develop and confirm an analytical model of the spark ignition process.

Flame speed directly influences the important engine operating parameters such as efficiency. Professor Heywood and Dr. Manoochehr Rashidi have developed a method for obtaining direct measurements of flame speed in an operating spark ignition engine. They take high-speed movies through a quartz piston in a specially instrumented engine and use thermodynamic analysis to determine gas conditions in the cylinder. The equipment and analysis procedures have been developed to the point where self-data can be obtained. This approach shows great promise for quantifying the effects of combustion chamber design and fuel characteristics on spark ignition engine combustion.

Professor Heywood also is continuing a fundamental study of the mechanisms by which hydrocarbons form in spark ignition engines. Hydrocarbon emissions standards impose important design constraints that significantly reduce fuel economy. A scaling law for the flame quenching process, which leaves a hydrocarbon layer at the wall, has been developed. A technique for measuring the properties of this quench layer in an operating engine using a rapid-acting sampling valve has been developed. A square cross-section engine for flow visualization studies has been constructed and is now operating. Exhaust system models to describe the oxidation of hydrocarbons are under development. Steady progress is being made toward developing models for the important individual processes in the overall hydrocarbon formation mechanism.

FUEL CONVERSION AND HEALTH EFFECTS

Having hypothesized that forward mutation in S. typhimurium might provide a system of mutation assays superior to the widely used reversion assays, and having already developed what seemed to be a reliable new forward assay, Professor William Thilly and his colleagues performed quantitative comparison of sensitivities of this forward assay to all of the available S. typhimurium reversion assays. They also studied 16 mutagens representing disparate chemical classes and found that a single forward assay could replace the set of reversion assays in terms of sensitivity to individual compounds and to a spectrum of different chemical classes.

Using bacterial forward assays, Professor Thilly and his team have been able to account for the mutagenic activity of a polycyclic aromatic hydrocarbon fraction in terms of the activity of its individual chemical components. These researchers are the first to show mutagenic activity of certain polycyclic aromatic hydrocarbons [benzo (a) pyrene and acepyrylene] and a methylene chloride soot extract using a human cell assay.

Professor Lawrence Evans is leading a project to develop a system of computer programs for process design and economic analysis of fossil fuel conversion plants. The process simulator, called ASPEN (Advanced System for Process Engineering), will provide new capabilities and data banks for processes involving vapors and liquids as well as for solids including coal and oil shale.

Professor Jack Howard is determining the effects of such commercially important reaction conditions as temperature, total pressure, hydrogen partial pressure, heating rate, and particle size on the thermal decomposition behavior of US coals. Measurements are performed using small-scale batch and entrained flow reactors; data on yields, compositions, and rates...
of formation are obtained for hydrocarbon gases, liquids, tar, and char. Correlations and predictive models of rapid pyrolysis and hydropyrolysis are developed using the experimental results. Program results will be beneficial in identifying methods for improving the efficiency, performance, and economics of existing and future coal conversion processes.

Professors Howard and Sarofim are obtaining fundamental kinetic data on the rates of gasification in $H_2O$, $O_2$, and $CO_2$ atmospheres of chars obtained from an operating coal gasification pilot plant. Specially developed laboratory research furnaces allowing close control of temperature, pressure, residence time, and char particle size are employed in this work. Practical benefits will include vastly improved design information for effecting complete char utilization in coal gasification processes.

Professor John Elliott is developing from data from all sources in the literature means for predicting the thermodynamic properties of components that may be present in coal slags. Of particular interest are the vapor pressures of highly volatile species such as compounds of potassium.

Professor John Longwell is studying the effects of hot solids such as dolomite on the pyrolysis of coal. The gas formed by this process is of higher heating value and contains less sulfur than that formed by pyrolysis without the hot solids. In addition, tar yields are modified.

Professor Longwell and Dr. William Peters have been coordinating the development of new research programs aimed at obtaining clean fuels and/or chemicals from biomass and solid wastes. Research capabilities in thermal and biological direction of biomass conversion pathways have been identified in several M.I.T. departments. In addition, a current exploratory laboratory project, jointly directed by Professors Longwell and Howard and Dr. Peters, focuses on determining the storage characteristics of liquids produced by biomass pyrolysis.

In another exploratory project, Professor Preetinder Virk has been studying the mechanism whereby hydrogen reacts with coal during certain liquefaction processes based on so-called donor solvents. Preliminary experimental results are consistent with a novel hypothesis that the detailed molecular structure of the solvent exerts an important influence on the liquefaction process. A larger research effort is planned to allow detailed systematic studies of this mechanism.

Dr. Tung and Professor Longwell are beginning a study of massive iron catalysts used in the Fisher-Tropsch synthesis of liquid fuels. The study will include: a) effects of alloy composition on catalytic reactivity; b) procedures for making a low-density, large-sized massive iron catalyst; and c) effects of particle size on slurry reactor performance. Apparatus is being constructed and experiments are expected to be initiated soon.

Professor Sallie Chisholm is studying methods of growing lipid-rich microalgae. These lipids, which are highly reduced compounds and somewhat similar to petroleum, could be refined by existing technology to produce high quality liquid fuels. Her objective is to define the operating conditions that will maximize lipid production and liquid yields on a mass culture scale.

Professor Frederick Putnam has built and tested a high precision volumetric absorption apparatus. This apparatus is now being used to determine the surface structures of model catalysts such as platinum black, supported platinum, molybdenum disulfide, and molybdenum trioxide. The surface structure information will in turn be used in conjunction with reaction rate studies to compare catalytic reaction rates on various types of surface sites.
Dr. Haggerty and Roger Cannon are investigating laser methods as means to produce small, uniform diameter particles of ceramic powders of the types used in ceramic turbine components. Two processes are being studied. In the first, particles are formed directly from laser-heated gaseous reactants; precise control of the nucleation and growth processes yield powders with the desired characteristics. Professor C. Forbes Dewey, Jr., has assumed responsibility for studying some aspects of the laser-driven chemical reactions.

In the second, the laser is used to cause selected oversized particles and particles of agglomerates to decompose until they reach the desired size. Silicon nitride has been selected as the primary study material because of its technological importance.

Dr. Haggerty studied the feasibility of using dielectric optical wave guides to collect and transmit solar energy for remote lighting. He found that the maximum flux density and numerical apertures were only matched to the low irradiance solar source for wave guides with substantially larger diameters than are used in optical communication systems. Technically feasible designs and component materials were identified that have a reasonable probability of becoming cost effective. Present value analyses of light collection and transmission systems reveal that they have approximately 15 times higher value per unit area of aperture than solar systems used to generate heat.

Dr. Haggerty and Professor David Adler are investigating deposition and doping techniques to demonstrate that long mean free paths and carrier lifetimes can be achieved in chalcogenide glass semiconductors. This work is based on recent theoretical advances in amorphous semiconductors and experimental evidence with amorphous silicon. If anticipated results are achieved, high efficiency, low cost photovoltaics will be possible for the first time.

Professor Jeffrey Steinfeld has evaluated a number of systems for their potential in storing solar energy and converting it to a form useful for lighting purposes. The most promising possibilities appear to be direct excitation of long-lived phosphors and conversion to stored electricity by means of photoelectrochemical cells.

Professor Rowland Cannon has studied the effects of starting powder characteristics, additives, and fabrication techniques on the sintering and grain growth in SiC. Further understanding of these processes provides greater flexibility in fabricating SiC with microstructures tailored to give improved properties such as strength and toughness.

Douglas Mahone is leading a broad-ranging effort with the general goal of increasing research activity in the Department of Architecture and the Energy Laboratory in the field of energy and buildings. Specific projects are being explored, including work on passive solar architecture, radiant thermal comfort, solar computer simulation, energy recovery in buildings, and urban design for energy efficiency. Interdisciplinary research teams will be assembled to pursue the most promising projects.

Professor Richard Schrock studied the reaction of new early transition metal organometallic complexes with small molecules in order to discover homogeneous catalysts for unique reactions (the ultimate goal of the work). Such energy-efficient, selective reactions will always be of utmost importance in the chemical industry since, whatever our source of carbon and hydrogen in the future, we must build larger molecules (fuels, fibers, and drugs) from small ones (like ethylene, carbon monoxide, and hydrogen).

Professor Dietmar Seyferth is performing a study of RCCO$_3$(CO)$_9$ complexes, especially those in which R is a functional group that allows CCO$_3$(CO)$_9$ into the side chains or backbone of a polymer. His work also involves a study of coal solubilization via silylation of reactive OH functions.
Professor Rene Miller is investigating the development of wind turbine design technology with specific reference to aerodynamics, dynamic stability, and the prediction of fatigue loads.

Dr. Haggerty is coordinating a lecture series with the objective of bringing to the M.I.T. campus lecturers who will address important energy-related issues and technologies. This forum will help to put the various options for satisfying future energy needs into a correct perspective. The lecturers in this series will address broad issues primarily from a technical perspective.

NUCLEAR TECHNOLOGY

Professor Norman Rasmussen has initiated a project to develop a simple method of predicting the effect of various changes in plant design on light water reactor (LWR) accident risks. The project is using information and data from the Reactor Safety Study (WASH 1400) and is based on an average US reactor site. The capability that will be provided by the results of this work could be used to judge the importance of proposed backfits or changes in design of new plants. Also, such information might provide the logic needed to support various positions in the licensing process.

Dr. William Hinkle and Professors Peter Griffith and Mujid Kazimi have continued to study sodium boiling behavior under liquid metal fast breeder reactor (LMFBR) accident conditions. This has included a) preparation of a state-of-the-art report based on contributions from several Department of Energy (DOE) contractors and laboratories, and b) initiation of experimental and analytical work aimed at developing improved analysis models and computer codes.

Professors Rasmussen and Lothar Wolf have initiated a project in the area of nuclear plant reliability analysis. The objective of this project is to examine the technical specifications of a specific nuclear power station and to develop the procedures and data needed to calculate the optimum test interval on a number of the plant's safety systems. The result of the project will be a developed and practically demonstrated approach to setting up and carrying out such calculations.

Professor Wolf is also continuing his work in the area of LWR core thermal hydraulic analysis. The objectives of this work are: a) collection and assessment of M.I.T.'s experience with the computer code COBRA IIIC/MIT; b) comparisons of reactor transient calculations with COBRA IIIC/MIT and COBRA IV-I; and c) assessment of results to establish upper limits of applicability of COBRA IIIC/MIT.

Professor Michael Driscoll is evaluating changes in core and fuel cycle design for pressurized water reactors (PWRs) to assess means for reducing uranium ore utilization. Two main subtasks are involved: once-through fuel cycles using current lattice designs on the uranium fuel cycle, and tight-pitch high-conversion ratio cores operating on the thorium fuel cycle. Extensive analyses of thermal/hydraulic performance are involved in the latter option.

Professor Driscoll is also investigating the potential for economic recovery of uranium from seawater using inorganic absorbers. Conceptual system design analyses and economic modeling are being carried out to determine a best estimate for the cost of U₃O₈ from this process, and to see whether it is sufficiently inexpensive to permit current converter reactors to compete with breeder reactors. Required absorber bed capabilities are being defined, and laboratory work of limited scope is being carried out to evaluate key properties.
Professor Griffith has been examining the unique heat transfer modeling problems associated with an LWR emergency core cooling system that conveys water from outside the vessel directly to the top of the reactor core. This work has included consideration of: injection, condensation, runback, down flow heat transfer, flooding, and spreading.

Professor John Meyer has continued to investigate some of the basic analytical models needed to calculate the performance of nuclear fuel rods. New methods for calculating forces and stresses during reactor up-power ramps have been developed. Computer code results also have been compared to a range of available fuel rod experimental data.

Professor Meyer also has studied analyses to quantify the effects of LWR fuel pellet cracking and subsequent movement (relocation). The pellets tend to operate cooler because the broken pieces are closer to the surrounding metallic clad. The pellets also tend to operate hotter because of internal cracks. The analyses have been used to find the net result for cases of interest to utility sponsors.

Dr. Marvin Miller and Professor Rasmussen are investigating methods of assessing the proliferation risk of various possible nuclear fuel cycles. Once developed, these methods can be used by DOE to help formulate US policy with regard to nuclear proliferation.

ENVIRONMENTAL MANAGEMENT

Professor Donald Harleman is studying cost, conversion efficiency, and environmental impacts associated with cooling systems of steam-electric power plants. Five areas are addressed: engineering optimization of dry and wet/dry towers; engineering optimization of artificial cooling ponds; operation of evaporative cooling towers to supplement once-through cooling; comparison of cooling systems at a single site; and national implications associated with cooling system selection.

Dry cooling towers permit power plant waste heat to be rejected directly to the air, avoiding water consumption and thermal pollution of waterways. The periodic cooling tower, a unique design by Dr. Glicksman, has been invented and successfully tested in the Energy Laboratory as a means of reducing the capital costs of a dry tower. Dr. Glicksman is now undertaking a full-scale design of the periodic cooling tower in conjunction with a large manufacturer and an architect/engineer to assess the environmental and economic impact of the concept.

Dr. Glicksman also is developing a new design for a cooling tower that approaches the cost and hot day performance of an evaporative cooling tower while consuming far less water. Heat transfer tests indicate that with the new design, evaporation can be reduced to less than one-half that of an evaporative tower. Design optimization studies are now under way.

Professor Michael Golay is developing a direct simulation model for prediction of atmospheric plume behavior. The model is based on numerical solution of the conservation equations for mass, momentum, energy, and turbulence parameters.

Dr. Eric Adams is analyzing the induced temperature and velocity fields resulting from the submerged discharge of power plant condenser cooling water for a range of diffuser types. He is paying particular attention to the details of discharge port orientation and spacing for a staged diffuser design. Performance is evaluated in terms of the time-temperature relationships of entrained organisms as well as Eulerian descriptions of the induced temperature rise.
Ocean Thermal Energy Conversion (OTEC) plants derive energy from the variation in temperature over depth in a tropical ocean. Dr. Adams is drawing on experimental and mathematical models to document the flow and temperature fields surrounding generic OTEC plant designs for the purposes of evaluating potential recirculation (degradation of thermal resource) and providing input for environmental impact assessment.

Professor David Marks is considering the water yields and transfer possibilities of water rights in the semiarid western states with large coal reserves. He has developed a model that deals with both institutional and hydrological aspects in considering alternative water rights for energy conversion facilities.

Professor John Wilson used simple analytical and numerical models to analyze the effects of mine site geometry, mining and spoil placement methods, and spoil properties on groundwater flow fields and piezometric heads during and after mining. A regional cross-sectional view was used to investigate the relative impacts of mines placed in regional recharge areas and mines placed in regional discharge areas. Other characteristics were examined.

**ELECTRIC POWER SYSTEMS**

Dr. James Gruhl is developing a site- and technology-specific simulator of large-scale electric power generators. The products of the resulting computerized tool are predictions of air emissions, air ambient levels, and health effects levels, as well as some economics and resource use, considering the chosen fuel types, pretreatment, generators, abatement, site types, and health models.

A project under the direction of Professor White has resulted in a model that estimates the impact of industrial cogeneration from a national benefit-cost viewpoint. Directions for further research on the interaction between cogeneration and industrial fuel replacement policy were also examined. Preliminary estimates show the least cost share for generation in total electricity supply in 1985 to be nine percent. Too much cogeneration can hurt as much as too little: more than a 20 percent share or less than a 4.5 percent share for cogeneration would cost the nation at least $10 billion extra in discounted capital and fuel expenses.

**DAVID C. WHITE**

**Laboratory for Nuclear Science (L.N.S.)**

The L. N. S. 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. It also supports some projects involving application to other fields of experimental techniques developed in its primary activities. It provides a computing facility for its program. This facility is shared by some activities of the Center for Space Research, the Energy Laboratory, and some others.
The primary experimental programs are in three areas. The largest effort is in intermediate energy nuclear physics centered at the Bates Linear Accelerator operated by L. N. S. in Middleton, Massachusetts. The second area is elementary particle physics, with major projects at the Fermi National Accelerator Laboratory (FNAL) in Batavia, Illinois; at the European Center for Nuclear Research (CERN) in Geneva, Switzerland; 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 Lawrence Berkeley Laboratory.

EXPERIMENTAL HIGH ENERGY PHYSICS

The L. N. S. program in this field is organized in three groups of roughly equal size. During fiscal year 1978, the Electromagnetic Interaction Group, headed by Professors Samuel C. C. Ting and Ulrich J. Becker, obtained initial results from their experiment on muon pair production with the Interacting Storage Ring Facility at CERN. This experiment is designed to investigate new particles, similar to but heavier than the J particle discovered by them at BNL. At the same time, this group is preparing an experiment to use the positron-electron colliding beam facility (PETRA) at DESY, scheduled to start operation in January 1979. This is designed to throw light on the interrelation between electromagnetic and "weak" forces, a problem of great current interest. The construction of the apparatus is a collaborative effort with German and Dutch groups. L. N. S. has undertaken the logistic support for most of the construction and procurement of the large magnet and the particle detectors. This has been a great challenge to our administrative and other supporting facilities, especially because the PETRA installation is being completed ahead of schedule.

The Accelerator Physics Collaboration group under the leadership of Professors Irwin A. Pless, Robert I. Hulsizer, Jr., Richard K. Yamamoto, and Vera Kistiakowsky, continues its program at FNAL to study mechanisms of high energy reactions by means of a bubble chamber and other detectors. They play the leading role in a consortium of United States and European teams to exploit a "hybrid" detector system designed by them and scheduled for a major experiment to start in mid-1979. During fiscal 1978, they were engaged in the development of this system and in the evaluation of earlier experiments.

The Counter-Spark Chamber group, under the leadership of Professors Henry W. Kendall, Jerome Friedman, Lawrence Rosenson, Louis S. Osborne, and Wit Busza, has completed a series of experiments at FNAL utilizing the particle spectrometer developed by them in collaboration with other institutions. Their results promise to provide the definitive data on a wide range of reactions involving protons, pions, and kaons as projectiles and products. In addition, they have extended their studies of the interaction of high energy particles with complex nuclei, a subject pioneered by Professor Busza some years ago.

INTERMEDIATE ENERGY NUCLEAR PHYSICS

The principal activity in this field is centered at the Bates Linear Accelerator, under the leadership of Professor Peter T. Demos. This has become the national facility for high energy electron physics in the US. During fiscal 1978, the accelerator was scheduled for 5,000 hours of operation of which 3,000 hours were available for experiments. Beam currents up to 100 micro amperes and a duty cycle up to 1.8 percent were achieved. Ten institutions in the United States, three in Canada, and three in Europe participated in the experiments.
Approximately half of all running experiments were led by outside users and such users participated in an additional 25 percent of the experiments. Among research programs making progress during fiscal 1978, the Electron Scattering Program continues to be the largest effort. Other interesting results were obtained concerning photo production of protons from calcium.

Construction on a second experimental area has progressed to the point where occupation is scheduled for the spring of 1979. The increased experimental activity has required expansion of the computing capability at the accelerator site. A Digital Equipment VAX 11/780 is scheduled for delivery in August 1978. L.N.S. has proposed to double the energy of the accelerator by construction of an electron recirculator. This proposal gathered important support from the scientific community during fiscal 1978.

Members of the Laboratory also participated in experiments at Indiana University and BNL.

HEAVY ION PHYSICS

The research programs at BNL and Berkeley continued to be active in fiscal 1978. Important additions were made to the recoil spectrometer at BNL developed under the leadership of Professor Harald A. Enge, and to the fission detector at Berkeley developed under the leadership of Professor Lee Grodzins.

APPLICATIONS OF NUCLEAR TECHNIQUES

A small group under the leadership of Professor Martin Deutsch, in collaboration with Professor Alexander Rich, is developing an X-ray diffraction facility for protein crystallography based on a wire drift chamber detector originally developed at CERN.

Professor Osborne has undertaken the development of a positron detector, also based on wire drift chambers, which is designed to be substantially superior to the currently used scintillation detectors in medical applications. Substantial funding for this project has been obtained for fiscal 1979. L.N.S. is collaborating with Professor Michael S. Feld of the Spectroscopy Laboratory in an experimental study of laser induced nuclear orientation.

Several members of L.N.S. have been engaged in other applied projects, primarily in the biomedical area.

SUMMARY OF SUPPORT

Participants in the various research programs during the past year amounted to approximately 415 people. This includes 51 academic staff members, 66 graduate students, and at least 70 undergraduates from M.I.T. and other institutions. The latter were involved in senior theses, Undergraduate Research Opportunities Programs, work-study, and similar programs. There were 38 research staff members with Ph.D.s, including visitors and guests, and 170 employees in supporting categories such as engineers, technicians, machinists, computing and administrative personnel, etc. Over 50 active user physicists from some 22 institutions.
participated in the program of the Bates Linear Accelerator. L. N. S. provided on-the-job training for five participants in the Cambridge-Arlington Comprehensive Employment Training Program. Ten Ph. D.s, three S. M.s, and six S. B.s were awarded based on thesis research within L. N. S.

Support during fiscal year 1978 from the contract with the US Department of Energy (DOE) is expected to total $10,141,000. This represents an increase of about 14 percent over the preceding year. This sum breaks down as follows: operations costs (salaries, wages, materials, services, travel, and overhead) were $8,085,000; of this, $3,060,000 was for experimental and theoretical high energy physics, $3,952,000 was for intermediate nuclear energy physics for the support of the Bates Linac facility, and $1,073,000 was for nuclear structure theory and heavy ion experiments. Equipment costs totaled $1,826,000; of this $706,000 was for high energy physics and $1,120,000 was for medium energy and heavy ion physics. A total of $230,000 will be expended for general plant projects associated with the Bates Linear Accelerator. Support for relatively new Laboratory programs relating to the application of high energy techniques to medical and biological problems totaled some $320,000. (Support came from the National Institutes of Health, National Science Foundation, and IBM.) Support for other programs within L. N. S. (nuclear orientation studies, special travel, etc.) including support from other institutions and laboratories for collaborative work undertaken directly by L. N. S. totaled about $550,000.

MARTIN DEUTSCH

Nuclear Reactor Laboratory (N.R.L.)

The past year was the second year for the newly constituted N.R.L. The rebuilt M.I.T. Research Reactor (MITR-II) operated reliably at its maximum licensed power of 5 Mw. Several new projects were initiated in the N.R.L., and increases in reactor utilization and resulting income kept the net cost within the estimate for the fiscal year. Further improvements in the financial position of the N.R.L. are deemed probable for next year.

The neutron scattering research in Professor Clifford G. Shull's group was at a high level of activity. Several visiting scientists added to the level of activity in this group. The other major neutron scattering group, that of Professors Sow-Hsin Chen and Sidney Yip, with the support of N.R.L. staff, continued to progress in the completion of their new high resolution inelastic scattering spectrometer. It is expected that this instrument will begin taking useful data within the next few months. Research on the therapeutic uses of nuclear radiation continued in Professor Gordon Brownell's group. Several irradiations of neonate dogs were completed for the boron capture therapy research in brain cancer. Brain tumor remissions appear to have been induced by the fission of boron within the cancerous tissues. Further tests on dogs to develop this technique are planned by Professor Brownell and Dr. Brian W. Murray during the coming year. The blanket neutronic measurements program for liquid metal breeder reactors was continued by Professor Michael Driscoll during the last year. However, it is expected that this work will be phased out in the next year. Trace element studies in geochemistry, using neutrons from the MITR-II, were intensified by Professor Frederick A. Frey.

A new N.R.L. project related to fundamental studies of radiation effects of future fusion reactors was initiated by Professors Otto Harling and Kenneth Russell. This work is directed toward developing techniques for the simulation, in a fission reactor, of the unique fusion
reactor environment. The initial irradiation testing will be done in the MITR-II. As part of another radiation effects project, Professor Harling's students completed an in-core irradiation and subsequent tensile testing of stainless steel specimens which were subjected to a simulated fusion reactor environment. The capabilities developed in this project should permit further development of irradiation damage research projects.

The irradiation positions available in and around the MITR-II have been characterized for fast and slow neutron radiation fields. Very respectable fast neutron and slow neutron fluxes up to $10^{14}$ neutrons/cm²-sec are available for a variety of experiments. Various other research projects which relate to the characterization, operation, or rebuilding of the MITR were also used by students to satisfy thesis research requirements.

The trace analysis and radiochemistry group of Dr. Morteza Janghorbani participated, sometimes in a key manner, in research projects with the Departments of Chemical Engineering, Nutrition and Food Science, and Earth and Planetary Sciences. A new Sea Grant sponsored project was also initiated at the N.R.L. Support in nuclear trace analysis also was provided for a number of non-M.I.T., principally university, scientists.

Reactor utilization for service irradiations, especially medical isotopes, increased significantly. This area is expected to expand further.

Reactor operation activities included a major effort to develop better reactor physics codes to permit optimum fuel management in the relatively sophisticated MITR-II core. This work will be continued for some time. A new reactor fuel supplier for university research reactors has begun supplying fuel. The N.R.L. was instrumental in the efforts to assure supplies of research reactor fuel and continuing government support for this type of fuel. The N.R.L. hosted the annual meeting of Research Training and Testing Reactors at the Institute.

Project development activities continued to be aggressively pursued. A number of small and several major proposals were prepared and submitted for funding during the last year.

OTTO K. HARLING

Patent and Copyright Office

The Patent and Copyright Office seeks to serve the M.I.T. community by protecting and promoting the traditional academic freedom of the Institute's staff and students in matters of publication, and promoting the progress of science and the useful arts by utilizing the benefits of the established patent system in a manner consistent with the public interest.

Organization

Two staff changes were made this past year as a result of the reorganization of the patent, licensing, and marketing operation directed by Dr. Thomas F. Jones. Attorney Diane Thilly was appointed Assistant Counsel to Arthur A. Smith, Jr., Esq. in August 1977 to assist him as licensing director and general legal advisor to the Office of Sponsored Programs (O.S.P.). Dr. Bruce D. Wedlock, while continuing as Director of the Lowell Institute School, has accepted a position in the Office of the Vice President for Research to provide an expanding marketing capability. In order to provide for close communication between the marketing
and licensing operations, office and conference space has been obtained adjacent to the Patent and Copyright Office.

**Licensing**

During the past fiscal year, 144 invention disclosures were received, 65 US patent applications filed, and 54 US patents issued. Additionally, 56 patent applications were filed in foreign countries corresponding to 16 US applications. Gross royalty income from patent and copyright licensing totaled $1,215,693. This represents an increase of 24 percent over the past year's gross income.

During this past fiscal year, the Patent and Copyright Office has expanded its interaction with the Industrial Liaison Program (I.L.P.) to improve and augment the dissemination of information on licensable inventions to I.L.P. member companies. Effective this past year, the I.L.P. receives abstracts of all newly filed patent applications for inclusion in their Monthly List of Publications. In addition, efforts have been made to increase contacts with foreign countries and licensing agents. An experimental program also has been initiated under a research agreement with Control Data Corporation for the inclusion of abstracts of all of the Institute's inventions into CDC's TECHNOTEC technology data base. TECHNOTEC has participants worldwide who routinely search the data base for new technology. It is hoped that this additional exposure should generate new licensees for M.I.T.'s patentable inventions. As part of the experiment, the Patent and Copyright Office also is participating in a feasibility study as to the legal implications of attempting to license the Institute's unpatentable technology.

**Patents**

The emphasis and direction of the patent program at M.I.T. continues to be heavily dependent on the direction and volume of government-sponsored research and on the patent policies of the various government agencies. After considerable study by inter-agency committees, a uniform Government Institutional Patent Agreement was finally promulgated in the Federal Register. Implementation of this uniform policy has been delayed pending a series of hearings presently being conducted by a Congressional subcommittee under the chairmanship of Senator Gaylord Nelson. Dr. Jones testified before this subcommittee in support of institutional patent agreements on behalf of the Institute, the Association of American Universities, the American Council of Education, the American Association of State Colleges and Universities, and the National Association of State Universities and Land Grant Colleges; the grounds were that these arrangements with universities are of value to the nation as a whole because they represent effective instruments for technology transfer.

**Copyrights**

As the result of the passage of the new Copyright Law Title 17 of the United States Code on January 1, 1978, the Patent and Copyright Office has spent considerable time in reviewing the ramifications of the new law for the Institute's traditional posture towards publication, fair-use copying, and copyright equity considerations. The Institute's Copyright Policy, dated March 1, 1974, is being modified to ensure its conformity with the new law while maintaining the intent of M.I.T.'s original copyright policy. Guidelines for copyrighting of theses have been formulated by an ad hoc committee comprised of representatives from the Patent and Copyright Office, the Libraries, the Graduate School Office, O.S.P., and the Academic Council.

ARTHUR A. SMITH, JR.
The Research Laboratory of Electronics (R.L.E.)

The Research Laboratory of Electronics established at the end of World War II as the Institute's first interdepartmental laboratory, was organized to encourage interactions between teaching research in the Departments of Electrical Engineering and Physics. In the years since, the Laboratory has sponsored projects involving participants from as many as a dozen academic departments. The research groups, which currently number approximately 30, work in three broad areas: general physics, plasma dynamics, and communication sciences.

Research in R.L.E. is primarily conducted by faculty members, postdoctorals, and students. Approximately 75 members of the faculty are affiliated with the Laboratory, working with about 250 graduate students and 130 undergraduates. The research covers many topics, thus providing opportunities for a wide variety of student theses. During the past year, work done in the Laboratory provided the basis for 19 doctoral, 3 engineer's, 20 master's, and 23 bachelor's theses.

Major support for the research is provided by the Joint Services Electronics Program of the Army, Navy, and Air Force, as well as other agencies of the Departments of Defense and Energy, the National Science Foundation, the National Institutes of Health, and the National Aeronautics and Space Administration.

GENERAL PHYSICS

The area of general physics is comprised of such fields as solid state, atomic physics, quantum electronics, and electromagnetics. The Laboratory's research in this area involves studies of atoms, molecules, and condensed matter. A few of the research topics in this area are as follows:

The development of Molecule Microscopy by Professor John G. King and his associates requires continuing work in apparatus development, sample preparation, and data acquisition and analysis. Dr. Dusan G. Lysy has recently been using these tools to study, as a function of temperature, the desorption of water from hamster embryo cells, provided by Dr. Phillips W. Robbins, before starting experiments to investigate the spatial variation in desorption. Dr. Lysy finds that the desorption curves for cells are complex and is presently trying to interpret them.

In another direction, Dr. Peter W. Stephens has found a notable difference, depending on whether He$^3$ or He$^4$ is used, in the appearance curve of helium dimers and higher polymers as a function of pressure in a source which generates a supersonic beam from which the polymers condense. Dr. Stephens has found evidence that $^4$He dimers exist in the beam and play a role in the formation of higher polymers, whereas the lighter $^3$He dimer does not bind at all because of its greater zero point energy.

During the past year, Dr. John W. Coleman and his students obtained images of carbon on gold, and gold on carbon, using the Auger Electron Microscope (AEM) in the secondary electron mode. These images were unstable due to electrical micro-discharges between
electrodes, caused by dielectric residues from oil-diffusion pumps in the vacuum systems. Funds were sought and received to switch to oil-free systems, and these modifications are currently under way. Samples for research have been made from Si-Al on Si, Si-Al on Ta, and P-glass on Si, and are ready for use. The main interest, however, still centers on Si and GaAs, and in particular on the following questions: 1) sharpness of boundaries separating low-refractive-index components from high-refractive-index components in integrated optic devices, and regions of different doping in integrated electronic circuit structures; 2) semiconductor-encapsulant profiles at interfaces. Studies such as these will help determine the effects of anneal-producing defects on the optical and electrical properties of the semiconductor material.

The study of weakly bound diatomic molecules by Professor David E. Pritchard and his group has been advanced by the application of supersonic molecular beam and tunable dye laser techniques to measure the molecular absorption spectrum of NaNe. The molecules are created by free expansion of a high pressure gas (~150 atmospheres) into a vacuum, which results in cooling to temperatures on the order of one degree Kelvin, low enough to result in the formation of weakly bound NaNe molecules. The approximately 300 spectral lines observed have been used to determine the three lowest potential curves of NaNe.

Alkali-rare gas molecules are the prototype of weakly bound one electron molecules, and the NaNe potential curves have been the focus of numerous theoretical investigations using both pseudopotential and ab initio techniques, partly because of Professor Pritchard’s experimental work. The progress of the pseudopotential calculations has been dramatic: all calculations prior to 1975 gave potential well depths too low by factors of 10 or so, the latest pseudopotential calculations show less than 10 percent error.

Other potentials for NaNe have been determined from scattering experiments and from spectral line-broadening experiments -- they all disagree with the present results in some important respect. Reconciliation of these differences should lead to better theoretical understanding of those processes, and may have important implications for line-broadening diagnostics of plasmas and stellar atmospheres.

The structure of atoms in very high magnetic fields has been of interest since it was realized that fields on white dwarf stars and neutron stars could be thousands of millions of times larger than the strongest man-made fields. The binding forces on such atoms are dominantly magnetic and their properties are quite different from those of conventional atoms. Such "magnetic atoms" have now been observed in the laboratory by Professor Daniel Kleppner and his colleagues. Rather than attempting to create super high field, the experiment employs highly excited atoms in which the electric forces are weak. This stratagem permits achievement of the high field regime with a conventional superconducting solenoid. The experiments are important in testing the theory which has so far been developed, and in stimulating the creation of a comprehensive theory of atoms in magnetic fields. The experimental techniques, which involve lasers and an atomic beam, have been developed during the past year, and a study has been carried out in the "low field" regime where the diamagnetic interaction is larger than the term separation of the coulombic states, though still small compared to the total electrostatic energy of the atom.

Professor John D. Joannopoulos is performing studies of electronic and vibrational excitations at surfaces of semiconductors and insulators. The effects of adsorbed molecules and semiconductor-metal and semiconductor-insulator interfaces also are being investigated. A new theory has been developed to account for defects and disorder at surfaces and interfaces.

Professor Hermann Haus, Visiting Professor Erich Ippen from Bell Laboratories, and graduate students Ping-Tong Ho and Lance Glasser succeeded in modelocking a semiconductor laser, producing pulses of 23 psec duration at a 3 GHz rate. The shortness of the pulses, the
convenient rate of repetition, and the simplicity of the system make it very attractive for high data rate communications. The system has stimulated interest in other laboratories and industry. In another project, surface acoustic wave grating guides and resonators are being studied with a view to developing compact new filters.

Professor Jin Au Kong and his students have pursued a number of projects in electromagnetic wave propagation and radiation, including 1) geophysical subsurface probing and communication with dipole antennas, 2) microwave remote sensing of the earth and 3) fiber optics and integrated optics. Eight journal articles, two symposium articles, and several technical reports have been published in the past year.

Professor Bernard F. Burke and his students continued their research efforts on interstellar water masers, using the Haystack Radio Observatory plus other radio observatories throughout the world as a long baseline network of interferometers. Water vapor masers vary in time, and an interesting event was discovered in the source W30H. The complete sequence of turning on and decay was observed for an interstellar maser and a theoretical explanation was developed. An enormous amount of energy, of the order of $10^{40}$ ergs, appears to have been released in a very small volume of space. It is conjectured that in the process of star formation magnetic field line recombination can occur resulting in a solar flare-like phenomenon but with an energy release several million times greater.

A coordinated set of observations, involving X-ray, optical, and radio investigations, was carried out on the X-ray galaxy NGC 2110. Professor Burke's group, using the Very Large Array (VLA) of the National Radio Astronomy Observatory (NRAO) was able to measure the radio characteristics of the galaxy showing that its position coincided accurately with the X-ray and optical positions and further that the source showed a slight extension of a few arc seconds. The galaxy appears to be an active one of a new type; further investigations are proceeding.

An extensive series of observations at the hydrogen line frequency was carried out with both the 300 ft. telescope of the NRAO, and the 1000 ft. Arecibo telescope. The objective of this work was to study line effects, in which cold hydrogen clouds on a galactic scale could be studied against bright continuum radio sources. Several new examples were discovered including two well-known Seyfert galaxies, Markarian-6 and NGC 1068. The observed absorbing clouds do not naturally fit into conventional models of galactic structure and since they appear in Seyfert galaxies, they provide additional information on the expulsion of large quantities of matter in these systems.

During the past year, Professor Philip C. Myers and graduate students have continued their radioastronomical studies of the interstellar medium while Professor Alan H. Barrett was on sabbatical leave. A mapping study of the Ophiuchi dark cloud complex in microwave spectral lines of H, CO, OH, and H$_2$CO established that the atomic and molecular emission in this complex has a very wide range of spatial scales, from ~0.1 to ~6 pc. The spectral line widths are correlated with their spatial extents, suggesting that the lines are Doppler-broadened primarily by systematic motion, and most probably by contraction. A compilation of observed interstellar gas cloud temperatures and densities was completed, indicating that for dense molecular clouds the mean temperature and density are correlated: molecular clouds are hotter when they are denser. This trend is consistent with equilibrium between cooling by molecular line emission and heating by a combination of gravitational collapse, collisions with warm grains, and the slip of ions past the cloud magnetic field. A survey of nearby hot O and B stars for continuum emission at 6 GHz was conducted at the National Radio Astronomy Observatory to determine the fraction of these stars which have associated dense gas. This fraction is significantly greater than that determined from optical studies, probably because the optical studies are more limited by obscuration. The result implies that fewer photons are available to ionize the intercloud medium than was expected previously. An observational
study was begun of the remarkable long-chain molecules (cyanopolyenes) in the nearby Taurus dark cloud complex. A map was made at the Haystack Radio Observatory of emission from the HC$_5$N molecule, which shows extremely small velocity dispersion of only ~200 m/s, and extremely small spatial extent of only ~0.08 pc. These HC$_5$N properties show a striking similarity to those of NH$_3$.

Professor Myers and his group have also continued work on the application of microwave radiometers to the safe, noninvasive detection of subsurface temperature anomalies in the human body. These local warm regions can be associated with cancerous tumors. Clinical studies of breast cancer detection have been carried out at Faulkner Hospital, Boston, with radiometers operating at 1.3 and 3.3 GHz. Current equipment detects about 70 percent of the cancers. When combined with infrared thermography, this method can detect about 90 percent of the cancerous tumors. Thus it appears that microwave thermography may be a useful, safe supplement to the X-ray detection of breast cancer.

Remote sensing research has focused on the interpretation of passive microwave spectral data obtained from earth-orbiting satellites. A team including Professor David Staelin, Research Associate Philip Rosenkranz, and Ph.D. candidate William Ledsham used passive microwave sensors to map the temperature, humidity, and wind fields associated with hurricanes, and also demonstrated the utility of Kalman filtering in the estimation of atmospheric temperature and humidity fields.

Professor Ralph H. Staley and his group are investigating the effects of chemical surface modification on photoemission properties of semiconductors. During the past year, band bending in p-type silicon crystals was studied for samples with organic cations covalently attached to the surface. For sufficiently large band bending, negative electron affinity photoemission effects are expected. A new technique for characterization of surface chemistry, photoacoustic spectroscopy, is being developed and used in this project.

Professor F. Read McFeely and his group have recently completed construction of their angle resolved photoemission spectroscopy apparatus. Testing of the instrument is currently in progress, with the initial results being quite encouraging. In addition, a high resolution electron monochromator has been designed to operate in conjunction with this system. The monochromator will allow Professor McFeely to perform high resolution electron energy loss experiments in order to study the vibrational properties of molecules absorbed on the surface. Thus they will be able to study both the electronic and vibrational properties of the surface species simultaneously.

Professor McFeely's other major effort has been in the theoretical interpretation of angle-resolved photoemission at high (X-ray) energies. The results have shown that the primary spectral features arise from the electronic density of states and do not require thermal crystalline disorder, as had previously been supposed. These results have further suggested new approaches to the study of surfaces by photoemission.

Professor Frederic R. Morgenthaler and his colleagues have continued their work on magnetoically-tunable high-Q microwave filters that employ bulk single crystals or thin films of yttrium iron garnet (YIG). Of special interest has been the development of a theory that describes the two-dimensional resonance modes of a thin film disk, magnetized normal to its plane, by a magnetic field having a radial variation that is an even power of the radius. Solutions were found for two types of modes: resonance edge modes of a uniformly magnetized disk with frequencies, mode patterns, and velocities of energy circulation perturbed by the radial field gradient, as might be expected; and a radically different type in which the gradient causes the pole distribution to concentrate near some critical radius within the interior of the disk. Such a radius forms a "virtual-surface" or "track" that localizes and guides the mode energy. Therefore, there is solid theoretical justification for the earlier predictions of the
"track" concept, and both frequencies and mode patterns have been enumerated. A doctoral thesis is currently under way to study such modes by means of combined microwave and optical detection.

Professor Clifton G. Fonstad and his group have developed their own techniques for fabricating low loss, sputtered glass waveguides and are now perfecting the production of gratings (surface corrugations) on these guides. A pulsed nitrogen pumped dye laser, having adequate resolution for use in characterizing these filters, has been assembled and the test facility is now largely complete. Measurements of filter characteristics, just now beginning, are planned first on conventional (no phase shift) distributed feedback (DFB) filters, and then on gratings containing phase shifts. In a companion program to develop DFB lead-tin telluride lasers, grating fabrication and liquid phase epitaxy on gratings is being pursued. Conventional DFB lasers will be fabricated by fall 1978 and gratings with phase shifts may be incorporated in later devices.

Professor Shaoul Ezekiel and his group are developing a new laser inertial rotation sensor using a passive ring cavity. The demonstrated performance is close to the limit set by the signal-to-noise ratio. A larger and more sensitive rotation sensor is being designed for earth wobble measurement. In addition, Professor Ezekiel's group has continued its research in atom-field interaction, development of I$_2$ multi-frequency secondary standards and stimulated emission spectroscopy using nonlinear interactions.

Professors Dirk J. Muehlner, Peter A. Wolff, Dr. Andrew Wood, and graduate students have made measurements of the valley-orbit Raman cross-section of donors in Ge using four-wave mixing of CO$_2$ laser beams. Their results indicate that laser action in n-Ge via stimulated Raman scattering should be possible. Attempts to observe stimulated scattering using both CO$_2$ and Far Infrared (FIR) laser pumps have been frustrated by pump intensity dependent effects such as photolionization of the donor atoms. This particular effect is presently under study at CO$_2$ wavelengths using both absorption and four-wave mixing measurements. Resonant four-wave mixing of CO$_2$ laser beams has also been observed in Si:P at the valley-orbit energy and in HgCdTe where the resonance is at the spin-flip energy. In HgCdTe several very sharp resonances are seen, details varying with position on the crystal. Further study is in progress. Finally, a new program aimed at achieving phase matching between two 5ω beams and their FIR difference frequency by periodic modulation of the doping of n-InSb is under way. The ultimate goal of this program is to generate continuously tunable FIR radiation via the electron spin nonlinearity. This work is being done in collaboration with Professor August Witt.

**PLASMA DYNAMICS**

The goal of the plasma dynamics program is a broad understanding of basic phenomena occurring in plasma regimes that are of interest to controlled fusion, space physics, and astrophysics. The research includes methods of producing highly ionized plasmas by electron beam injection, high-power lasers, microwaves, and low-pressure arcs. Plasma diagnostic techniques involve measurements in several portions of the electromagnetic spectrum including the microwave, millimeter wave, infrared, and optical regions.

Professors Bruno Coppi and Ronald R. Parker and their associates have achieved new record values for the combined particle density and energy confinement time of thermonuclear plasmas produced in the Alcator A device.
In addition, having learned a method to avoid the onset of disruptive instabilities, it has been possible to produce well confined plasmas with record low values of the so-called "safety factor" against macroscopic instabilities. This result has important implication for the possible development of toroidal confinement devices into power producing thermonuclear reactors.

During the past year, the construction of the new Alcator C device was completed and the machine was formally dedicated in April 1978. The Alcator experiments have been a joint venture of R.L.E. and the Bitter National Magnet Laboratory.

Professor George Bekefi and his group have continued their work on Versator II, a research tokamak constructed by this group. It is primarily being used to investigate various radio frequency heating schemes of the tokamak discharge. It was originally designed to operate at a peak magnetic field of 8 kG. To make these studies as versatile as possible, the machine was upgraded to allow operation at 15 kG magnetic field levels. The modifications have now been completed and rf heating studies are about to begin. The next year will be devoted to studies of lower hybrid heating at a frequency of 800 MHz and at a power level of 200 kW. The lower hybrid experiments are being carried out in collaboration with the Princeton Plasma Physics Laboratory which is supplying the high power Klystron. Later, electron-cyclotron heating experiments will be made in cooperation with the Naval Research Laboratory which will be providing a novel 200 kW gyrotron.

The Reactor confinement device, originally developed in a collaboration between Professors Coppi and Robert Taylor, has been reconstructed and brought to new quarters. Meanwhile, the machine has been provided with new diagnostic systems that make it one of the few experimental facilities to explore the still unknown confinement properties of toroidal plasmas with non-circular cross section.

Professor Abraham Bers and graduate students have continued their theoretical studies related to heating of tokamak-type plasmas with high-power microwave sources. These studies have indicated a new way in which the microwave power could generate a steady-state current in the plasma, thus leading to the possibility of a steady-state fusion power reactor. The group's work on nonlinear wave phenomena in plasmas is also closely related to proposed experiments for heating the plasmas in Alcator A and C, in Versator II.

Magnetic-mirror confined plasmas are subject to a specially disturbing type of instability when the plasma is highly ionized and relatively collisionless -- the drift-cyclotron-loss-cone (DCLC) mode. It can be stabilized by a constant injection of cold plasma to maintain a Maxwellian distribution. However, this procedure cools the electrons, which is undesirable. Research Assistant Robert E. Klinkowstein and Professor Louis D. Smullin have shown that the DCLC can be stabilized by a small percentage (~one percent) of hot electrons. These electrons are produced by the collective interaction between the mirror trapped plasma and an axially injected electron beam of some 5-10 KeV, 3-10 amps. As a result of this work, a grant of $300,000 has been received from the Department of Energy, Division of Magnetic Fusion Energy for the continuation of the study of hot-electron stabilization techniques, and for the construction of a larger mirror confinement system, Constance II.

Studies of nonlinear interactions between particles and waves in a plasma are continuing. Professor Peter Politzer and graduate student Teymour Boutros-Ghali have modified the electron plasma facility to permit measurement of the time evolution of the electron velocity distribution in two dimensions, rather than one. This facility is now being used to measure velocity space diffusion of electrons induced by a controlled spectrum of externally applied turbulence to test the predictions of strong turbulence theory. The strong turbulence model has been applied to the question of stabilization of instabilities in magnetic mirror traps. The calculations yield good agreement with several r.f. stabilization experiments.
Professor Thomas Dupree and Research Associate David J. Tetreault have continued work on the theoretical study of fluctuations in turbulent plasma. Particular emphasis is placed on fluctuations which cause significant particle or heat transport. A computer code is being developed to test and guide the theoretical work. The relationship of plasma turbulence to other areas of stochastic and statistical theory is being studied.

COMMUNICATION SCIENCES AND ENGINEERING

Research in communication sciences and engineering deals with fundamental studies of signals and systems, and such applications as speech and picture transmission, seismic detection, and optical communication. Much of the effort is related to the life sciences. A combined program of research and training in communications bioengineering includes communications biophysics, neurophysiology, cognitive information processing, and speech communication. Much of this work concerns the sensory or perceptual mechanisms. A related program in linguistics seeks to improve our understanding of languages, which form the basis for communication.

The research of Professors Robert S. Kennedy, Jeffrey H. Shapiro, Dr. Horace P. Yuen, and their students, is concerned with the extension of communication theory to optical frequencies. It involves a variety of new issues related to the characteristics of communication channels and optical devices. The spatial and quantum mechanical behavior of optical fields are particularly important in these investigations. For example, the fundamental questions of detection, estimation, and modulation are found to be questions of quantum state generation and quantum measurement. Abstract studies of these questions have led to theoretically optimum systems. Also, newly developed statistical characterizations for optical propagation through random communication channels, such as the turbulent and the turbid atmosphere, have been used to determine the way in which the space-time variations of the received optical field should be processed by a receiver. This work has led to some potentially useful receivers that adaptively compensate for the spatial and temporal field variations caused by the channel.

Professor Ian T. Young and his colleagues have continued studies of the application of a variety of image processing techniques to problems of biological and medical importance. Professor Young, Research Associate Dr. Stephanie Sher, and Dr. Charles Carpenter and Dr. Terry Strom of Peter Bent Brigham Hospital and Harvard Medical School are studying the use of stains specific to newly synthesized DNA in order to determine tissue compatability. Such a stain will then permit assaying the histocompatability of donors and recipients in kidney transplants. Professor Young, Dr. Sher, Professor Eugene Bell of the Department of Biology, and Donald Levinstone, a graduate student in the Department of Electrical Engineering and Computer Science, are studying the morphological, social, and biochemical properties of human fibroblast cells in clonal colonies as a function of cell age. These studies should help elucidate the nature and character of cellular aging.

Professors William F. Schreiber, Donald E. Troxel, and their students are developing several systems for the application of computer-assisted image processing techniques to the graphic arts. Significant savings in cost and time as well as improvements in quality are expected.

Professor Jonathan Allen and his co-workers have improved the quality of synthetic speech by introducing new algorithms for pitch and duration. These changes have been motivated by fundamental studies, as well as direct comparison of the values predicted by the algorithms with those derived from human speech. In addition, a high performance circuit which serves as a resonance model of the vocal tract has been built and utilized within the overall system for conversion of text to speech.
Professors Alan V. Oppenheim, James H. McClellan, and Arthur B. Baggeroer, with several graduate students, have developed a number of new digital signal processing techniques, and applied them to speech processing and seismic data processing. New algorithms for fast computation of Fourier transforms have been studied and implemented. The speech processing work is directed towards low-cost speech compression and enhancement of degraded speech -- as experienced, for example, on a faulty communication channel. The seismic data processing studies have led to new techniques potentially useful for exploration seismology.

Research on speech communication, under the direction of Professor Kenneth N. Stevens, has continued to examine the acoustical attributes of speech sounds as they occur in words and sentences, the physiological activity that gives rise to these sounds, and the perception of the sounds by listeners. Objectives of this work are to gain an understanding of how the human speech production and perception systems impose constraints on the classes of sounds that are used in speech communication, and to develop models of speech production and perception. In addition, Professor Stevens' group has been investigating the properties of speech produced by deaf persons, the acoustical attributes of cries of newborn infants, and relations between the anatomical development of children's vocal tracts and the acoustical properties of the speech sounds they produce.

Research by Steven Colburn, Nathaniel Durlach, Adrian Houtsma, and Professor Louis Braida continues to focus on intensity perception and loudness, binaural interaction, pitch perception, and aids for the deaf. In the first area, they have extended their evaluation of a new theory of loudness comparisons to a wider variety of stimulus types, and to loudness comparisons between normal and impaired ears for the same stimulus type. In the second, they have further developed a unified theory of binaural interaction based on auditory nerve data and initiated studies of binaural interaction in impaired listeners. In the third, they have evaluated a number of current models of central pitch processing and begun to explore certain pitch anomalies in impaired listeners. In the fourth, they have completed an evaluation of multiband amplitude compression for people with reduced dynamic range, initiated a systematic study of the effects of nonuniform frequency lowering for listeners with severe losses at high frequencies, developed a theoretical model to help guide the choice of frequency-gain characteristic in hearing aids, and explored a number of encoding and display schemes for the tactile communication of speech.

The results of work in the R. L. E. Neurophysiology Group during the past year are as follows:

Dr. Edward R. Gruberg and Professor Jerome Y. Lettvin have shown that the axons of the collicular neurons have a different activity from that of the cell bodies, and that cell-body firing, therefore, cannot be used as an indication of what information processing is done by the colliculus. They also have shown that the nucleus isthmi of the frog is exclusively fed by the ipsilateral colliculus, that it projects back to both colliculi, and that it is the source of the second eye complement for binocular representation in the colliculi. They have shown that nucleus isthmi fibers have been mistakenly identified as type II optic nerve fibers in two decades of papers on visual processing in the frog.

Bradford Howland has developed a new set of eye-testing charts that are now being proposed for clinical use, using the modulation transfer function in which average luminosity stays constant over the field so that form discrimination has a steep cut-off. His method for discovering refractive error in children and animals from a distance is now being used in a variety of clinical research. Mr. Howland has completed the development of a method for measuring higher-order spherical aberration of the human eye, and a new, more compact instrument is now being constructed.
Dr. Stephen G. Waxman and his colleagues have demonstrated a structural differentiation of the axon membrane at nodes of Ranvier, and have shown abnormalities in the axon membrane of mice in which myelin is genetically absent. They also have examined, using computer simulations, the prerequisites for unimpeded conduction in demyelinated axons.

Professor Lawrence S. Frishkopf has continued to study mechanisms of transduction in vertebrate labyrinthine organs. Research in the past year has focused on attempts to identify the afferent synaptic transmitter substance and on anatomical studies of the cupula and receptor cell cilia in the semicircular canal organ of elasmobranch fish. A paper on cupula mechanics in this organ, jointly authored with Professor Charles M. Oman, has been accepted for publication. A comparative study on the composition of labyrinthine fluids in several species, coauthored by Scott Peterson, Professors Oman and Thomas F. Weiss, and Dr. Claude Lechene of Harvard Medical School, is in press.

Study of the physiology of signal transmission in the auditory system has continued in cooperation with the Eaton-Peabody Laboratory at the Massachusetts Eye and Ear Infirmary. Professors Weiss and William T. Peake, Drs. Nelson Y. S. Kiang, John J. Guinan, Jr., and Terrance R. Bourk, and students have worked on the ear and central nervous system with both scientific and clinical goals.

As in years past the work of the R.L.E. linguistics group has dealt with a broad range of topics focused on the nature of human language.

Professor John R. Ross's research has had four foci in the past year: 1) ionicity in language (i.e., more or less direct relationships between meaning and sound); 2) the study of formal devices that are used in poetry; 3) the various constraints, syntactic and otherwise, that surround the use of words like "like" (as in "Stan's like way into surfing topless, like"); and 4) the nature of gramaticality — what it may mean to say that two people speak "the same language," given the staggering diversity among their intuitions about which strings of words are sentences of their language(s).

Because of the linguistics group's long-standing interest in American Indian languages, the group has frequently had among its members native speakers of American Indian languages. In the academic year just concluded, two of these, Laverne Jeanne and Paul Platero, completed their doctoral dissertations and were awarded Ph.D.s in linguistics. This was an especially noteworthy event as they were the first American Indians ever to receive doctorates in linguistics.

In the spring of 1978, the book Linguistic Theory and Psychological Reality edited by Professors Morris Halle, Joan W. Bresnan, and George A. Miller was published by the MIT Press. The volume contains papers that were written in the course of a series of workshops conducted during 1975-77 under a special grant to M.I.T. from American Telephone and Telegraph in celebration of the centennial of the invention of the telephone.

Six doctoral dissertations in linguistics which dealt with problems in syntax, semantics, and phonology were completed during the past year.

PETER A. WOLFF
For the past year, Lincoln Laboratory has continued in its role as a Federal Contract Research Center for advanced electronics, with agencies of the Department of Defense -- the Air Force, Army, Navy, and DARPA (Defense Advanced Research Projects Agency) -- supplying 90 percent of the Laboratory's budgetary support. The size of the Laboratory has also remained essentially constant. In fiscal year 1978 the operating budget was $108 million, supporting the efforts of 795 professional staff -- 67 percent of whom hold advanced degrees. The level of staffing for defense work has now been fixed by agreement between Congress and the Department of Defense, and it is expected to remain stable through the next few years at least.

Since its inception Lincoln has been involved with problems of radar surveillance. Initially, concern was with the detection and tracking of aircraft. More recently, Laboratory projects have focused on systems for the detection and tracking of earth satellites and ballistic missiles. In the past year there has been encouraging progress on a new airborne radar system that is designed to detect and track slowly moving surface vehicles over wide areas in the presence of intense ground clutter.

The name Multiple Antenna Surveillance Radar (MASR) suggests how the system operates. In principle, two identical antennas are mounted on the side of an aircraft, at some distance from one another, and pointed to produce exactly parallel beams. A pulse is transmitted from the first antenna, and a second, identical pulse is then transmitted from the second antenna. The time interval between the pulses is set to match the time required for the aircraft to move forward so as to put the second antenna at the exact location from which the first antenna transmitted the first pulse. Thus the same target area is illuminated by the two pulses, separated in time. In processing the returns from each pair of pulses, signals from stationary targets and ground clutter that are identically illuminated are cancelled out; residual signals represent returns from targets that have moved during the time interval between the pulses.

Instead of using a pair of individual antennas, the MASR system uses two sets of precisely matched elements of a single displaced-phase-center array antenna mounted along the side of the aircraft. The beam pattern of each set of elements is controlled by tapering the amplitudes of signals fed to the elements. The direction of the beams can be controlled by changing the phase of the signals, thus permitting the system to scan back and forth to obtain coverage over a substantial area of the terrain visible from the aircraft. Signals from the MASR are processed on board the aircraft and transmitted to an instrumentation van for display, analysis, and evaluation.

Initial tests of the MASR system, carried out with stationary (non-scanning) beams, have confirmed the capability of the signal processing system to suppress clutter and detect signals from slowly moving surface vehicles. The MASR has demonstrated clutter reduction approximately 100 times greater than is realized by other airborne moving-target radars. The second phase of tests, using scanning beams, is nearing successful completion.
A very different radar is represented by the LITE (Laser Infrared Tracking Experiment) 1.06 micrometer laser radar which began engineering test operations at the Kwajalein missile range in December 1977, culminating two years of design, development, and testing at the Lexington laboratory. The system will be used to gather laser signature data on reentry vehicles fired from the Vandenberg Air Force Base in California, and will afford an opportunity to gain experience with the use of laser systems operated in the field.

The transmit/receive system of the radar consists of a repetitively pulsed Nd:YAG laser mounted on a Nike-Ajax mount along with a 58-centimeter aperture receiving telescope and a narrow-field-of-view tracking television system. The transmitter has a peak power of 50 megawatts and a beamwidth of 100 microradians. The radar is controlled by a small computer and is capable of being pointed by the KREMS radars to aid in initial target acquisition. After acquisition in angle by the television system and range by the laser system, the radar will operate in a self tracking mode. It is designed to have a three-meter range and a 15-microradian angular resolution. The system also includes a wide-field-of-view (variable from 2.5 degrees to 25 degrees) surveillance television system boresighted with the laser and tracking TV systems.

Initial operational testing has been quite successful. Targets have been acquired in angle at altitudes up to 65 kilometers and have been tracked to altitudes of approximately 5 kilometers. To date, laser returns have been obtained at altitudes up to 40 kilometers.

The two Lincoln communications satellites, LES-8 and LES-9, which were put into synchronous orbit in March 1976, have continued to function successfully, and on October 1, 1977 they were made available to the Air Force for operational use. Meanwhile, the Laboratory has been considering requirements for the next generation of military satellite communications systems, particularly the need to service a large number of terminals of different types including those that are relatively small, simple, and mobile.

To meet this requirement it appears that it will be necessary to employ some form of signal processing, other than conventional hard-limiting repeaters, on board the satellite. The technology of satellite signal processing has been the subject of extensive investigation by a working group from our Communications Division. While it is too early for final detailed design decisions to be made, the broad outlines of what will be required and what is feasible are taking shape.

The basic concept is that the satellite should accept a large number of simultaneous, uncoordinated uplink signals, which will arrive at different frequencies and with different power levels. These inputs are to be down-converted to a number of low-pass signals which can contain either one wideband signal or a number of lower rate frequency-division-multiplexed (FDM) signals. These are demodulated, and the resulting bit stream is routed, under direction of the system controller, to the downlink processors where the data bits are assembled into time-division-multiplexed downlinks for the satellite downlink transmitters.

The demodulators, which must handle a wide variety of modulations and data rates, are a particularly critical element in this scheme and have received intensive study. This has culminated in the construction of a practical, digital multichannel demodulator that will handle up to 16 closely-packed FDM signals without coordination of relative timing or power levels. The successful operation of this equipment also demonstrated the practicability of a particularly bandwidth-efficient form of modulation called "phase-comparison sinusoidal frequency-shift-keying." This was a gratifying result because efficient use of bandwidth minimizes both processor speed and frequency requirements.
While on-board signal processing comes at a price in added weight, power, and complexity for the spacecraft, this is compensated for by the fact that demodulating and remodulating decouples the effects of noise and interference on the uplink from that on the downlink. This means that the effective radiated power of the satellite is not being used to retransmit noise and, therefore, less power is required to support the same data rate.

This decoupling permits separate optimization for whatever forms of radio frequency interference, multipath or terminal constraints each link must face; equally important, it makes possible dynamic allocation of system resources, including the interconnection of different terminal types. These are powerful capabilities, and with increased understanding of the advantages and relatively low cost of on-board signal processing, the more attractive these systems appear.

Radar and communications systems have always been in the mainstream of Lincoln interest. In the past year, there also has been significant progress in two new areas—solar photovoltaics and submicrometer structures.

On July 28, 1977, testing began at Mead, Nebraska, on the first of a series of experimental photovoltaic (PV) power systems that the Laboratory is building under contract with the Department of Energy. The purposes of the Solar Photovoltaic Field Tests and Applications Project are: to establish technical credibility for solar photovoltaic energy systems; to identify and eliminate technical and institutional constraints to their widespread acceptance; and to provide data for economic modeling of solar PV systems.

A variety of both large and small experimental PV systems have been and are being built at Lincoln for use in several application areas. In keeping with the engineering character of the Project, the test systems are heavily instrumented and are regularly monitored to detect changes induced by exposure to the elements and to the operating environment.

The system at Mead is installed at the University of Nebraska's Agricultural Research Station, where it is being used to investigate the suitability of PV for a variety of agricultural applications. Lincoln interests focus on the collection of data regarding solar insolation, the performance of the large array (120,000 individual solar cells), battery storage and power conditioning equipment for this 25 kilowatt peak hour system. Sensors and data logging equipment accumulate the data automatically and transmit them to the Laboratory, in Lexington, on a daily basis.

The use of photovoltaics for very small (subkilowatt) water pumping systems is also of considerable interest because of the potentially large market provided by the need of developing countries for alternatives to muscle-powered pumping systems. The energy costs incurred by irrigators using animal (and human) power in countries such as India are extremely high by US standards, ranging from $2 to $50 per kilowatt hour. Small diesel-powered systems also might be supplanted by PV systems in these regions with direct operating advantages accrued through elimination of logistics problems associated with fuel delivery and engine maintenance and repair. Finally, the use of PV in developing countries is attractive because these countries do not have utility grids, and the modular character of PV permits it to be used in a dispersed manner.

A prototype micro-irrigation system is under development at Lincoln with solar panels mounted on a metal wheelbarrow frame for ease in transporting to the small agricultural plots where it typically would be used.
A number of other systems are in various stages of planning or construction. The most ambitious is a 100-kilowatt peak power system for the Natural Bridges National Monument in southeastern Utah. It is expected to provide all of the electric power for the Park, including two rangers' residences, water pumping, a visitors' center, and various maintenance shops. Turn-on of the Natural Bridges power system is scheduled to take place in the summer of 1979.

Another important application for PV is for dispersed usage in residential electric power systems. Lincoln has worked with the Energy Laboratory over the past two years on technical, economical, and institutional issues relating to this potentially very large market. On the basis of recent economic studies by the Energy Laboratory, it appears that residential PV power will be attractive at PV module prices near $1 per peak watt, which could be achieved by industry in the next five years.

Accordingly, Lincoln is constructing a systems test facility which will be used to investigate a wide range of residential systems configurations. This facility is expected to be operational in the fall of 1978. Additional tests will be carried out in subsequent years at other test sites located in different climatic regions of the country.

At the present time, photovoltaic power is economically attractive only under very special circumstances; it is reasonable to suppose, however, that as demand is generated the basic cell costs can be brought down sufficiently to make PV systems a viable competitor to more conventional power sources for applications such as the above. The data that are being accumulated here and the experience that is being acquired concerning systems design and operating costs should contribute significantly toward the early availability of commercial PV power.

Since 1968 Lincoln Laboratory has been a major contributor to the technology of fabricating two-dimensional surface microstructures. The driving force for this has been the support of various device development programs, including silicon integrated circuits, surface acoustic wave, superconducting, integrated optical, and discrete semi-conductor devices. With some notable exceptions, minimum linewidths in such devices have been above one micrometer.

Very recently, techniques have been developed for fabricating certain simple types of surface microstructures having linewidths of 0.1 micrometer and less. These new techniques have an obvious importance in efforts to shrink the size and improve the performance of micro-electronic devices. Additional motivation for their use and further development also comes from entirely new applications, such as the control of thin film orientation, the creation of two-dimensional molecular assemblies, and the alignment of liquid crystals.

In the summer of 1977 the Laboratory established a Submicrometer Technology Program under the direction of Dr. Henry I. Smith, with special laboratory space set aside to house facilities for electron beam lithography, X-ray lithography, holographic lithography, photolithography, ion beam etching, reactive ion etching, and various types of chemical processing and analytical work. Concurrently, planning was begun for a campus Submicrometer Structures Laboratory, also under the direction of Dr. Smith, that would complement the Lincoln facility and other facilities available at R.L.E. and the Center for Materials Science and Engineering. Through this means it is hoped to encourage interdisciplinary research in areas, such as the manipulation and control of organic molecules, that are outside of Lincoln's mission and immediate competence.

It is expected that this closely coupled venture between the Campus and Lincoln Laboratory will constitute a unique educational, as well as research capability in a very exciting new area of technology.

WALTER E. MORROW, JR.
Vice President, Resource Development

The following introduction to Resource Development's 1978 Annual Report was being reviewed by General James B. Lampert at the time of his death on July 10, 1978. In view of General Lampert's extraordinary efforts on behalf of M.I.T., I believe that it is important to record here the comments of Chairman Howard Johnson and President Jerome Wiesner.

Mr. Johnson: It was my privilege to work with General Lampert and to come to know and appreciate deeply his first-rate qualities of intellect, personality, and character. He was in every sense a noble man, and a gentle man, who led his staff to high accomplishment by the example of his own high standards, hard work, and human caring. He will be most sorely missed by the Institute.

Dr. Wiesner: M.I.T. was General Lampert's second career. He brought to M.I.T. -- and to each of us here -- vigorous and effective leadership coupled with profound reserves of strength, of wisdom, and of humanity that I am sure also underlay his superb accomplishments in the United States Army. He was deeply committed to public service, and the whole-hearted way in which he made this commitment so much a part of his daily life here enriched us all. We will deeply miss his unfailing kindness, his quiet humor, his gentle words of good counsel, and his enduring faith in the Institute. He was a devoted alumnus, an enlightened leader, and a humane friend. He often said he was proud to serve M.I.T. We were proud to have him with us.

NELSON C. LEES

INTRODUCTION

The past year marked the third anniversary of the five-year $225 million M.I.T. Leadership Campaign, which stood at $167 million at the end of June. In the midst of continuing economic uncertainties and severe inflationary pressures this strong showing has been encouraging to everyone associated with this massive effort.

Throughout the year there was strong emphasis on meeting Campaign goals, both in terms of commitments made and continuing actions needed to bring the drive to a successful conclusion. The leadership of the Campaign continues to be provided by the Council on Resources of the Institute, the Chairman and the cochairmen of the Campaign, and the Campaign Steering Committee. I am happy to report that J. Kenneth Jamieson, Class of 1931, was named a cochairman of the drive during the year. I also note the active role played by members of the Executive Committee of the Corporation in meeting with the Campaign cochairmen and members of the Campaign staff to discuss a wide range of plans and actions.
The principal efforts of the Campaign were directed toward approaches to major prospects, and the identification and evaluation of new ones. These were the primary concern of the visits by senior officers and the many members of the Corporation and Corporation Development Committee who helped in arranging and participating in calls. At the same time, strong progress was made in our approaches to industry through the Industrial Liaison Program which continued its strong growth under the able direction of Dr. Samuel A. Goldblith, and through the efforts of the National Business Committee, led by Richard L. Terrell, Class of 1958, and effectively supported by Dean Irwin W. Sizer and Robert Hagopian. The Volunteer Leadership Appeal, under the direction of Donald P. Severance, continued its extensive program of solicitations by volunteers throughout the country. Direct support was provided to me and the leadership of the Campaign by Nelson C. Lees who also oversaw the overall Campaign support efforts. Under the leadership of D. Hugh Darden, a variety of efforts directed toward the encouragement of planned giving were carried forward. I want particularly to note the support of Professor Lawrence E. Beckley who, working with Mr. Severance, took principal responsibility for this year's faculty solicitation aimed at the establishment of a young faculty career development award.

Within the overall thrust of the Campaign, special efforts were made to seek commitments for endowed professorships and student aid, a new athletics and special events center, a major new facility for the visual arts as the first phase of a larger program of new buildings for the arts broadly, the Energy Laboratory, and special expendable funds for the School of Engineering and the Division of Health Sciences and Technology.

We all go into the coming year with confidence that the goal of the Campaign will be reached on schedule -- and exceeded.

PRIVATE SUPPORT

Total private support of M.I.T. during the past year was $34.4 million, comprising $31.3 million in gifts, grants, and bequests and $3.1 million in support through membership in corporate liaison programs (discussed elsewhere in this report). This total is a five-year high, compared with $29.4 million received in 1977, $23.9 million in 1976, $21.7 million in 1975, and $22.7 million in 1974. The increased total for 1978 clearly reflects the impact of the M.I.T. Leadership Campaign.

Sources of gifts for fiscal year 1978 were: alumni, $8.1 million; non-alumni friends, $1.7 million; corporations, corporate foundations, and trade associations, $9.1 million; foundations and charitable trusts, $12.4 million; others, $.05 million. Included in the totals for alumni and friends are gifts of $.1 million made to the William Barton Rogers Pooled income Fund, which was inaugurated in the fall of 1975. Total income for corporate liaison programs was $3.1 million, a 20 percent increase over the total for fiscal year 1977.

Donors designated expendable and endowed funds as follows: unrestricted, $6.9 million; departments, $6.6 million; faculty salaries, $3.9 million; graduate scholarships and fellowships, $1.0 million; undergraduate grants, awards, and loan funds, $1.3 million; building construction funds, $9.0 million; other funds, $2.6 million.
M.I.T. LEADERSHIP CAMPAIGN

Campaign Progress

At the end of the year, total commitments to the M.I.T. Leadership Campaign stood at $167 million, an increase of $35 million over last year's total, and 74 percent of the Campaign's $225 million goal. This total of $167 million included the nucleus fund of $43 million accumulated between January 1, 1974 and the announcement of the official beginning of the Campaign in April 1975.

Senior officers, together with Campaign cochairmen, concentrated on contacting top individual, foundation, and corporate prospects with the capacity to make large commitments over a five-year period. Of special importance to the Campaign this year were commitments of $1 million from General Motors, including $800,000 for the M.I.T. Leadership Campaign and $200,000 for the Sloan School; $1 million from an anonymous corporate donor for the Whitaker College of Health Sciences, Technology, and Management; $1 million from Gulf Oil Foundation, including $500,000 for endowment for energy policy research, $250,000 for combustion research, and $250,000 for the Center for Energy Policy Research; and $1 million each from the Andrew W. Mellon Foundation and the Alfred P. Sloan Foundation, and a grant of $500,000 from the William and Flora Hewlett Foundation, all for the prospective College of Science, Technology, and Society.

The Volunteer Leadership Appeal (discussed elsewhere in this report) completed organization of 40 areas, brought the total of assigned prospects to more than 2,400, and completed initial solicitation visits to more than 1,900 prospects.

Endowed commitments toward the overall goal of $100 million increased from year-end totals of $30.7 million in 1977 to $37.0 in 1978, including additional endowed professorships.

Campaign Organization and Staffing

Howard W. Johnson, Chairman of the M.I.T. Corporation, continued as Chairman of the Campaign. J. Kenneth Jamieson, Class of 1931, joined William B. Murphy, Edward O. Vetter, Class of 1942, and Paul F. Hellmuth, Class of 1947, as cochairmen of the Campaign. (The detailed organization was described in the 1974-75 Annual Report.) The Council on Resources of the Institute continued to oversee the Campaign in conjunction with the Campaign Steering Committee (discussed below). General James B. Lampert, Vice President, Resource Development, served as Campaign Director throughout the year.

Campaign Planning Meetings

During the year, senior officers, Campaign cochairmen, and members of the Campaign Steering Committee and the Corporation Executive Committee met in several special Campaign planning sessions. Participants reviewed overall Campaign strategy, discussed specific prospects and approaches to them, and considered plans for the next several months.

Special Solicitation Efforts

The activities of the National Business Committee (discussed elsewhere in this report) expanded substantially, in accordance with the original plan for the Committee at its inception.
Vice President, Resource Development

in 1976. Special efforts were made to support solicitations for a new athletics and special events center; a major new funding program for facilities for the arts, coordinated by the Council for the Arts (discussed elsewhere); and funding for the School of Engineering, the Energy Laboratory, the Center for Energy Policy Research, the Harvard-M.I.T. Division of Health Sciences and Technology, and a number of special professorships.

CORPORATION DEVELOPMENT COMMITTEE

The Corporation Development Committee continued to support the Leadership Campaign through identification of prospects and approaches to them, solicitations, evaluations of Campaign strategy, and other voluntary efforts.

The Committee's Annual Meeting, attended by approximately 70 members, was held on campus on November 3, 1977. Gerald P. Dineen, Assistant Secretary of Defense for Communications, Command, Control, and Intelligence, addressed the meeting. "Endowment at Work" -- reports from holders of Chairs established during the Leadership Campaign -- and "Feedback from the Field" -- comments by Committee members serving on the Volunteer Leadership Appeal and the National Business Committee -- preceded the luncheon. Following the luncheon, D. Reid Weedon, Class of 1941, was presented with the Marshall B. Dalton Award. "Key Issues in Energy Policy" was the subject of the afternoon panel discussion. The day concluded with dinner for members of the Executive Committee.

Between annual meetings, most of the 160 members of the Committee, including 32 members of the Corporation, were actively involved in specific assignments relating to the Leadership Campaign, and contributed to other M.I.T. committees.

The Committee regrets the deaths of George C. Halstead, Class of 1940; Geza E. Neuman de Vegvar, Class of 1942; and Howard D. Williams, Class of 1911.

VOLUNTEER LEADERSHIP APPEAL

This year, the Volunteer Leadership Appeal, under the direction of Donald P. Severance, comprised 500 solicitors representing 40 organized areas. Individually, with senior officers, or with other volunteers, these solicitors made at least one solicitation visit to 1,900 of the 2,400 assigned individual prospective Leadership donors and to many companies and foundations.

Particularly noteworthy were the Leadership efforts of the four chairmen and their associates, who exceeded their area goals: William H. Mills, Class of 1934 (Tampa/St. Petersburg, Florida); Thornton W. Owen, Class of 1926 (District of Columbia); Wylie S. Robson, Class of 1956 (Rochester, New York); William D. Walther, Class of 1950 (Dayton, Ohio).

Kevin J. Kinsella, district officer for the West and the West Coast since September 1975, resigned this winter. In March, Gordon W. Moore, Class of 1960, assumed Mr. Kinsella's responsibilities. Mr. Moore, a management consultant and native of Denver, now works for the Campaign on a part-time basis.

Although district officers and volunteers concentrated on soliciting individual Leadership prospects and assisting senior officers this year, they also became increasingly involved in working with the National Business Committee on identifying and cultivating foundations and corporations, and participating in visits to these prospects.
In cooperation with the Office of Planned Giving and Legal Affairs, solicitors arranged several meetings with alumni interested in establishing trusts and bequest programs for the benefit of M.I.T.

**RESOURCE PLANNING**

Under the direction of Nelson C. Lees, Resource Planning continued to assume principal responsibility for support and planning functions for the Leadership Campaign. Highlights of the year's activities are summarized below.

**Development Office**

Directed by Dr. Michael F. Luck, the Development Office continued to provide support for the Institute's overall development effort and for the senior officers' Campaign work. The Office, which maintains the central data bank for development at M.I.T., identified and evaluated major donors and prospects; researched and developed funding strategies; made major visit recommendations; coordinated development contacts by senior officers, deans, faculty, and Resource Development staff; and responded to dozens of weekly queries from sources inside and outside the Institute. Over the year, the Development Office initiated extensive contact with faculty to assist them with their funding priorities.

In July 1978, Dr. Luck will leave M.I.T. to assume the post of President of the Rutgers University Foundation. Donald B. Johnson, formerly Associate Director, will succeed Dr. Luck as Director of the Development Office. As Associate Director over the year, Mr. Johnson continued to oversee fund-raising efforts directed at foundations. Richard W. Keefe, Assistant Director, continued to carry additional special responsibilities as Special Liaison to the President. Roberta A. Carrara succeeded Anne K. Mengler as Assistant to the Director.

**Proposals and Publications**

Proposals for private support and M.I.T. Leadership Campaign publications continued to be the major responsibilities of the Proposals and Publications Office. The four staff writers continued to be involved in the preparation of proposals in support of the fund-raising activities of the senior officers, as well as those of faculty members and Campaign staff. A number of new and updated publications detailing Campaign goals were produced.

Joseph G. Carr, who joined Resource Planning in 1972 and became Manager of Proposals and Publications in 1976, left the Institute in March to assume the post of Director of Development Communications at Tulane University. In October 1977, Associate Staff Writer Patricia M. Maroni left M.I.T. to become Assistant Director of Public Affairs for the Massachusetts Port Authority.

Deborah J. Cohen succeeded Mr. Carr as Manager of Proposals and Publications. Ms. Cohen is joined by Ellen N. Hoffman, who was promoted to Associate Staff Writer in October 1977; Katharine C. Jones, who joined the group as Associate Staff Writer in January 1978; and D. Steven Blum, who was appointed Assistant Staff Writer in May 1978.
Resource/Alumni Data Systems

The Resource/Alumni Data Systems group, managed by Victor M. Maslov, completed its mission of refining and expanding systems and programs in support of the M.I.T. Leadership Campaign. In accordance with the Campaign plan, the R/ADS group was phased out at the end of the year, and the operation of most of the Campaign reports was turned over to Administrative Computing Services. Certain other programs will continue to be operated through the Campaign Room, in conjunction with Information Processing Services. A special tribute is appropriate for the remarkable work of the R/ADS group in support of the Campaign.

Donor Relations

On behalf of senior officers and others, Barbara V. Zeilenga and Martha L. Bertrand drafted approximately 1,900 letters of acknowledgment and cultivation. The section pursued its efforts to foster good relations between donors and the Institute by reporting on the use of previous gifts, including endowment funds; encouraging appropriate interaction between staff and donors; and ensuring that reporting requirements of foundations and corporations were accurately and promptly fulfilled.

Campaign Room

Under the direction of Jurate J. Barnes, the Campaign Room continued to expand the operation of the Central Prospect Control System (C.P.C.S.). By year-end, the System contained the names of approximately 6,000 individuals, foundations, and corporations -- an increase of 2,400 over last year's listing.

The Campaign Room provided district officers and other staff with regular computer-based reports on the C.P.C.S. and on other systems run in conjunction with Resource/Alumni Data Systems. Statistical analyses of Campaign data were performed for a variety of special and standard reports.

INDIVIDUAL GIVING

Gifts, grants, and bequests from alumni and friends totaled $8,905,258 this year. The Planned Giving Program, which encourages outright current gifts, gifts in trust, and plans for bequests through individual programs of giving, generated over 49 percent of this total. The following table details the results of the Program.

<table>
<thead>
<tr>
<th>Donors</th>
<th>Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outright gifts generated by Program</td>
<td>25</td>
</tr>
<tr>
<td>Separately invested unitrusts</td>
<td>4</td>
</tr>
<tr>
<td>William Barton Rogers Pooled Income Fund</td>
<td>11</td>
</tr>
<tr>
<td>Receipts from bequests, testamentary, and other trust arrangements</td>
<td>64</td>
</tr>
<tr>
<td>TOTAL</td>
<td>104</td>
</tr>
</tbody>
</table>

*Includes $230,000 given by a family foundation.
Vice President, Resource Development

As of June 30, 1978, there were on record with the Institute 1,098 records or notifications of irrevocable trusts in which the Institute now has a vested future interest or plans for future gifts through bequests. During the year, 21 estates and outside trusts were closed and fully distributed (see table above). Irrevocable trusts totaled 189 (see following table).

<table>
<thead>
<tr>
<th>Number</th>
<th>Dollars (Current Market Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trusts held by M.I.T.</td>
<td>79</td>
</tr>
<tr>
<td>Trusts held outside M.I.T.</td>
<td>110</td>
</tr>
<tr>
<td>TOTAL</td>
<td>189</td>
</tr>
</tbody>
</table>

During the year, five trust funds held by the Institute totaling $105,000 were closed and transferred over free of trust for Institute purposes.

The year was marked by numerous opportunities to assist donors, senior officers, faculty, and administrative staff, especially Resource Development and Alumni Association staff, in developing or concluding gift arrangements.

Nine meetings were held at different locations across the country to develop prospects for the life income plans program, particularly the William Barton Rogers Pooled Income Fund. Further meetings have been scheduled in additional locations. The meetings have yielded several gifts to the Pooled Income Fund and a number of promising discussions involving substantial gifts. This effort will continue, with particular emphasis on reaching 40th and 50th Reunion classes. Early in 1978, the Office of Planned Giving conducted another in its series of mailings, distributing Tax Reform and Your Estate Plan to over 22,500 alumni more than 25 years graduated. To date, approximately 250 reply cards have been returned indicating current estate plans that include M.I.T. or requesting further information. Among those replying, several individuals have been designated for special follow-up.

Continuing attention was given to those proposed changes in the Federal tax law or regulatory rules that could affect the Institute adversely, especially in the area of gift support.

The Office continued to advise and counsel on a wide variety of legal matters concerning gift arrangements, institutional management, and other matters relating to the Institute's operation.

In September, Thomas R. Henneberry joined D. Hugh Darden, Director of Planned Giving, as Assistant Director of Planned Giving. Mr. Henneberry's efforts have substantially improved the overall capabilities of the Office, and have contributed significantly to program plans for an increased level of activity.

FOUNDATION SUPPORT

Staff responsibility for foundation matters in Resource Development remained in the Development Office, under the direction of Donald B. Johnson. Mr. Johnson continued and substantially expanded his close contact with the Provost and many faculty members in recommending, planning, and carrying out visits to foundations in support of academic programs.
NATIONAL BUSINESS COMMITTEE

The National Business Committee was substantially expanded in the summer of 1977. Chaired by Richard L. Terrell, Class of 1958 and Vice Chairman of General Motors, the Committee's original membership of 15 was increased to 48. Members of the Committee this year were: Joseph F. Alibrandi, Class of 1952; Bennett Archambault, Class of 1932; Victor K. Atkins, Class of 1947; William S. Brewster, Class of 1939; Louis W. Cabot; Jerry A. Cogan, Jr., Class of 1958; Thomas F. Creamer, Class of 1940; Ralph E. Cross, Class of 1933; James M. Ewell, Class of 1937; Daniel J. Fink, Class of 1948; Roger M. Freeman, Jr., Class of 1944; Stanley M. Freeman, Class of 1936; Joseph G. Gavin, Jr., Class of 1941; Max E. Gellert, Class of 1948; John H. Gerstenmaier, Class of 1952; Robert C. Gunness, Class of 1934; John F. Hennessy, Jr., Class of 1951; Henry A. Hill, Class of 1942; Charles K. Holmes, Jr., Class of 1949; Cuthbert C. Hurd, Class of 1959; J. Kenneth Jamieson, Class of 1931; Howard H. Kehri, Class of 1960; George M. Keller, Class of 1948; Semon E. Knudsen, Class of 1936; Michael M. Koerner, Class of 1949; Ralph Landau, Class of 1941; John Lawrence, Class of 1932; Floyd A. Lyon, Class of 1942; Wilfred D. MacDonnell, Class of 1934; John C. Martin, Class of 1947; Denman K. McNear, Class of 1948; F. Richard Meyer, III, Class of 1942; Frank R. Milliken, Class of 1934; Thomas F. Morrow, Class of 1935; Carl M. Mueller, Class of 1941; William B. Murphy; Guy W. Nichols, Class of 1961; Will F. Nicholson, Jr., Class of 1950; Alfred E. Perlman, Class of 1923; Charles E. Reed, Class of 1937; Arch C. Scullock, Class of 1943; Cecily C. Selby, Class of 1950; Charles H. Smith, Jr., Class of 1942; Louis E. Stahl, Class of 1938; George R. Vila, Class of 1933; Edward B. Walker III, Class of 1944; William J. Weisz, Class of 1948.

Concurrently, the internal staff support was also strengthened. Irwin W. Sizer, Dean Emeritus of the M.I.T. Graduate School and Consultant to Resource Development, assumed executive responsibility for overall internal operations. Robert Hagopian was appointed Director of Corporate Relations, with principal operational responsibility for all operations. Mr. Hagopian was assisted by James T. King, Project Officer; Robert H. Bliss, District Officer; and Alice W. Tripp, Administrative Assistant for Special Projects. J. Francis Reintjes, Professor Emeritus in the Department of Electrical Engineering and Computer Science, provided part-time assistance in various areas, including liaison with faculty.

Committee members evaluated prospects, provided introductions to corporate officers, participated in visits, and helped to guide proposals. A total of 78 visits were made. Comprehensive lists of corporate prospects were developed and reviewed, including the Fortune Double 500 Industrials and the nation's 100 largest privately owned companies. Committee members accepted a total of 124 assignments. In addition, 24 alumni who are not members of the Committee accepted 62 assignments, giving a total of 186 assigned companies.

Special luncheons of local Committee members, chaired by Mr. Terrell, were held in New York City and San Francisco; the San Francisco luncheon also included officers of prospective companies.

CORPORATE LEADERSHIP AWARD

This year, 16 alumni who are top officers in major United States corporations were selected to receive the Corporate Leadership Award, which was established in 1976. Most of the recipients received their awards in December, at a luncheon at the Chicago Club. For those unable to attend the luncheon, the awards were personally presented over the year by senior officers and other representatives of the M.I.T. Corporation.
INDUSTRIAL LIAISON

Under the direction of Samuel A. Goldblith, Director of Industrial Liaison and Underwood-Prescott Professor of Food Science, the Industrial Liaison and Associates programs showed continued growth this year. Industrial Liaison Program income increased from $1,484,087 in 1976, to $2,302,710 in 1977, to $2,845,701 in 1978.

The Industrial Liaison Program in Japan continued to develop at a modest rate. The Tokyo Office is now directed by George K. Sankey, an American citizen who had previously lived and worked in Japan and is fluent in Japanese. In July, the Industrial Liaison Program planned and coordinated a major symposium in Tokyo, "M.I.T. -- A Force for International Progress." M.I.T. participants were: James B. Lampert, Vice President for Resource Development; Walter A. Rosenblith, Provost and Institute Professor; William F. Pounds, Dean of the Sloan School of Management; Paul E. Gray, Chancellor; Charles P. Kindleberger, Professor Emeritus, Department of Economics; and Professor Goldblith.

Industrial Liaison Program membership in Europe grew to 23 companies. Hugh Parker, Class of 1943, provided invaluable support on introductions to English firms. In January, the Industrial Liaison Program conducted five courses for European member companies. Three courses were held in London: "Management of Research, Development, and Technology-Based Innovation" (attendance: 48); "Fermentation Technology" (attendance: 61); and "Advances in Food Research" (attendance: 28). Two courses were held in Zurich: "Mini/Micro Computer Systems: A Close Look at Minicomputers/Microcomputers and Their Applications to Real World Problems" (attendance: 45); and "Modern Control Engineering" (attendance: 34).

The Industrial Liaison Program held 16 symposia/seminars at M.I.T., including four two-day meetings and two three-day meetings; five additional seminars were held in various locations around the country. Average attendance at the meetings was 103; two meetings attracted especially large attendance: "Management of Human Resources: New Issues and Challenges" (attendance: 210); and "Office Automation: What the Future Holds" (attendance: 243). "Uncertain Exchange Rates: Implications for International Business" -- a seminar sponsored jointly by the Sloan School of Management, the Department of Economics, and the Industrial Liaison Program -- attracted over 70 chief financial officers from member companies.

New Industrial Liaison Program services were initiated and are described in The Industrial Liaison Program at M.I.T.: A Guide for Member Company Personnel, a recently printed guide for member companies to encourage more effective use of the Program.

The Industrial Liaison Program continued to work toward attracting additional qualified Liaison officers and increasing faculty visits to member companies.

Associates Program income increased from $204,000 in 1976, to $221,500 in 1977, to $289,500 in 1978.

The Program looked to enhanced cost-effectiveness through increased membership, both in New England and in other areas which now have several member companies, and furthered its plans for expanded and improved benefit offerings.

Much of the success of Industrial Liaison, both the Industrial Liaison Program and the Associates Program, can be attributed to the splendid and willing cooperation of senior officers, faculty, and Industrial Liaison staff. The support of the National Business Committee, under the leadership of Mr. Terrell, Dean Sizer, and Mr. Hagopian, resulted in a number of new Liaison Program members.

JAMES B. LAMPERT
Financial Statements

The financial statements summarize the finances of the Institute during the fiscal year 1977-78 and at the close of the year on June 30, 1978.

Schedule A
The Statement of Revenues and Funds Used to Meet Expenses of Current Operations for the year ended June 30, 1978 with comparative totals for 1977 displays the expenses and the revenues and funds used, categorized as either unrestricted or restricted, and shows the sources of the additional unrestricted revenues and funds needed to meet operating expenses.

Schedule B
The Investment Income for Distribution to Funds for the year ended June 30, 1978 with comparative totals for 1977 reports the year’s investment income and other activity in that fund, and details the distribution to funds both in the general investments and in separately invested funds.

Schedule C
The Balance Sheet at June 30, 1978 with comparative totals at June 30, 1977 summarizes the assets, liabilities and fund balances in the major fund categories.

Schedule D
The Condensed Statement of Changes in Financial Position for the year ended June 30, 1978 with comparative totals for 1977 illustrates the changes in total resources resulting from additions, applications, or appropriations during the year, classified between current funds — unrestricted and restricted — and all other funds.

Schedule D-1
The Statement of Changes in Financial Position for the year ended June 30, 1978 with comparative totals for 1977 details the changes in total resources summarized in Schedule D, showing all of the major fund categories.

Schedule E
The Summary of Changes in Invested Fund Balances for the ten years ended June 30, 1978 summarizes the sources and uses of funds each year for the last decade.

Schedule F
The Highlights: A Decade in Review summarizes the several important factors which demonstrate the overall financial position during the last ten years.

Glossary

The background description of fund accounting emphasized in last year’s report, and so important in understanding college and university finances, has been repeated in this report and can be found following the Glossary.

Operations (Schedule A)
Total operating expenses in 1977-78 were $319,356,000, an increase of 15.3 percent over the 1976-77 total of $276,912,000. Total operating revenues and funds used to meet these expenses rose to $313,481,000, an increase of 15.6 percent over the 1976-77 total of $271,111,000. The additional need for unrestricted revenues and funds required to bring operations into balance was $5,875,000 in 1977-78 compared to $5,801,000 in 1976-77. This requirement in 1977-78 was met entirely from current year revenues of $1,433,000 from the net Use of Facilities Allowances derived from sponsored research programs, $810,000 from Patent Revenues and $3,700,000 from Unrestricted Gifts, Grants and Bequests. These sources totaled $5,943,000 and all amounts received in these categories were availed of to meet expenses, except for:

(1) $68,000 which was the excess of unrestricted funds received over the funds required to balance, and

(2) $335,000 of additional Use of Facilities Allowances which was reserved for continuing capital needs, primarily in the area of utility plant renewal and the expansion of utility distribution lines for air-conditioning and heating.

It is significant that no Funds Functioning as Endowment or Other Fund Balances were required to bring operations for the year into balance. In addition, the full investment income on the Research Reserve was added to principal for the first time in several years.
The trend of annual improvement in operating results continued into 1977-78; however, the rate of improvement has slowed. Budget reductions are becoming increasingly more difficult to achieve and changes in student enrollment patterns are putting heavy pressure on Unrestricted Funds, particularly in the School of Engineering. A large stream of gifts and continued increases in all sources of income appears to be the answer to financial well-being and stability. Research revenues were strong in 1977-78, with campus research increasing by 15.8 percent and Lincoln Laboratory by 18.2 percent. While much of those increases were due to increased subcontracting, the funds available for research were gratifying. Tuition and other related income was up 9.0 percent. Gifts, investment income and other receipts availed of were up 23.3 percent and this included the results of the Industrial Liaison Program which continued to expand rapidly from $2,303,000 in 1976-77 to $2,845,000 in 1977-78. However, endowment income available for operations was up only 3.6 percent, which continues to illustrate our need for help in building the capital base for existing programs.

On the expense side, instruction and unsponsored research increased by 9.1 percent from 1976-77 to 1977-78. Research expenses generally matched the increase in research funds available and the increase in research administration and general expense reflects major improvements in providing care for research animals. Of the expenses jointly applicable to instruction and research, Medical appears to have declined, but this results from an accounting change which now records that portion of Medical Department costs applicable to employees as an employee benefit which is then applied through the employee benefit rate to non-student salaries and wages wherever they occur. Plant operation and maintenance increased 23.2 percent and this reflects primarily the major program of building renewal and renovations which was started in the previous year and which results from the demands for additional space from the sponsored research activities. Student services also shows a large increase of 20.5 percent and this is due to a major increase in the College Work-Study Program of the Federal government and higher interest costs to fund the borrowings from outside sources for the Student Loan Program. The large increase in undergraduate scholarships reflects increasing need for help in the college budgets of our students and this need continues to grow as the charges for tuition, dining, housing, and other expenses react to inflationary pressures.

A five-year history of the additional need for unrestricted revenues and funds to bring operations into balance, and the source of the funding used to meet the need is shown in the following table. This table presents the years 1974 through 1976 on a comparable basis with the results for 1977 and 1978 shown at the bottom of Schedule A.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional need for unrestricted revenues and funds</td>
<td>$9,503</td>
<td>$9,005</td>
<td>$6,493</td>
<td>$5,801</td>
<td>$5,875</td>
<td>$36,677</td>
</tr>
<tr>
<td>Use of facilities allowances</td>
<td>$1,202</td>
<td>$1,351</td>
<td>$1,220</td>
<td>$1,308</td>
<td>$1,433</td>
<td>$6,514</td>
</tr>
<tr>
<td>Patent revenues</td>
<td>931</td>
<td>431</td>
<td>457</td>
<td>629</td>
<td>810</td>
<td>3,258</td>
</tr>
<tr>
<td>Current gifts, grants and bequests</td>
<td>1,991</td>
<td>2,032</td>
<td>2,216</td>
<td>3,738</td>
<td>3,700</td>
<td>13,677</td>
</tr>
<tr>
<td>Total additional current revenues</td>
<td>$4,124</td>
<td>$3,814</td>
<td>$3,893</td>
<td>$5,675</td>
<td>$5,943</td>
<td>$23,449</td>
</tr>
<tr>
<td>Less: Funds available for future operations</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>68</td>
</tr>
<tr>
<td>Net additional current revenues used</td>
<td>4,124</td>
<td>3,814</td>
<td>3,893</td>
<td>5,675</td>
<td>5,875</td>
<td>23,381</td>
</tr>
<tr>
<td>Other fund balances</td>
<td>5,379</td>
<td>2,581</td>
<td>1,201</td>
<td>126</td>
<td>0</td>
<td>9,287</td>
</tr>
<tr>
<td>Funds functioning as endowment</td>
<td>0</td>
<td>2,610</td>
<td>1,399</td>
<td>0</td>
<td>0</td>
<td>4,009</td>
</tr>
<tr>
<td>Additional need for unrestricted revenues and funds met from:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

552
Gifts

Gifts, grants, and bequests in 1977-78 and in 1976-77 were as follows:

<table>
<thead>
<tr>
<th></th>
<th>1977-78</th>
<th>1976-77</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gifts for endowment</td>
<td>$6,420,000</td>
<td>$7,137,000</td>
</tr>
<tr>
<td>Gifts for buildings</td>
<td>$8,918,000</td>
<td>$4,855,000</td>
</tr>
<tr>
<td>Gifts for current and future use—invested</td>
<td>$7,249,000</td>
<td>$5,163,000</td>
</tr>
<tr>
<td>Other gifts for current use</td>
<td>$5,649,000</td>
<td>$5,889,000</td>
</tr>
<tr>
<td>Total gifts to funds</td>
<td>$28,236,000</td>
<td>$23,044,000</td>
</tr>
<tr>
<td>Grants-in-aid</td>
<td>$3,051,000</td>
<td>$3,855,000</td>
</tr>
<tr>
<td>Total</td>
<td>$31,287,000</td>
<td>$26,899,000</td>
</tr>
</tbody>
</table>

The total of $31,287,000 is a 16.3 percent increase above the previous year and is 54.3 percent above the total of three years ago.

This increase in gifts resulted from the efforts of the M.I.T. Leadership Campaign despite the adverse effect of lower market prices for gifts of securities. Major gifts were received for buildings and important funding was received for endowed professorships and academic programs.

The increase in the gifts for buildings included funds for the construction of facilities for the Whitaker College of Health Sciences, Technology, and Management and to provide for the Health Services. There were important gifts for the Steinbrenner Stadium, the renovation of Huntington Hall, and continued funding for the Sherman Fairchild Building.

The gifts for current and future use—invested include unrestricted gifts of $3,700,000, of which $1,054,000 was in bequests. A bequest of $1,144,000 was also received from the Estate of Frank S. MacGregor.

The gifts reported by the Alumni Fund totaled $4,972,000, a new high, and are included in the various categories of gifts listed above as received. The other gifts for current use include gifts restricted as to purpose used primarily for academic programs and student aid. Grants-in-aid include support for designated sponsored research activities and declined from the previous year.

Funds

The book value of the funds was $548,976,000 on June 30, 1978 as compared to $529,010,000 on June 30, 1977.

<table>
<thead>
<tr>
<th></th>
<th>1977-78</th>
<th>1976-77</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endowment and similar funds:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income for unrestricted purposes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endowment</td>
<td>$48,909,000</td>
<td>$47,262,000</td>
</tr>
<tr>
<td>Funds functioning as endowment</td>
<td>$30,307,000</td>
<td>$30,168,000</td>
</tr>
<tr>
<td>Income for restricted purposes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endowment</td>
<td>$93,072,000</td>
<td>$87,399,000</td>
</tr>
<tr>
<td>Funds functioning as endowment</td>
<td>$62,247,000</td>
<td>$61,285,000</td>
</tr>
<tr>
<td>Investment income for distribution to funds</td>
<td>$10,000,000</td>
<td>$10,000,000</td>
</tr>
<tr>
<td>Net realized gains from investments</td>
<td>$29,346,000</td>
<td>$33,542,000</td>
</tr>
<tr>
<td>Total endowment funds</td>
<td>$273,881,000</td>
<td>$269,656,000</td>
</tr>
<tr>
<td>Building and expendable funds</td>
<td>$67,100,000</td>
<td>$53,996,000</td>
</tr>
<tr>
<td>Expended plant funds</td>
<td>$169,856,000</td>
<td>$169,654,000</td>
</tr>
<tr>
<td>Investment income for distribution to funds—current invested</td>
<td>$10,710,000</td>
<td>$9,582,000</td>
</tr>
<tr>
<td>Other funds</td>
<td>$27,429,000</td>
<td>$26,122,000</td>
</tr>
<tr>
<td>Total funds</td>
<td>$548,976,000</td>
<td>$529,010,000</td>
</tr>
</tbody>
</table>

The increase of $19,966,000 in funds resulted primarily from the increase in gifts to endowment and similar funds and the gifts to building and expendable funds which are being held for investment and future expenditure. This increase in funds was the largest since 1970-71 and reflects a substantial improvement in the Institute's financial position.

There was a decline of $4,196,000 in the cumulative net realized gains from investments as investment transactions resulted in more losses than gains relative to book values. Although there was a decline in the reserve of net realized gains from investments and the unrealized appreciation as described under Investments, these declines were modest as compared to the declines experienced in the general stock and bond markets during the year.

The Other Funds total increased because of a further increase in student loan funds. Agency funds and funds subject to life interests in income declined slightly. Gifts to life income plans are often in the form of marketable securities which were generally at lower levels during the past year.
The expansion and upgrading of the Institute’s educational plant continued at a rapid pace in 1977-78 and the momentum is expected to carry into the next several years.

A listing of the major projects completed during the year is impressive. It includes the following: the new Alumni Center in Building 10, the reconstruction of Huntington Hall (10-250), the Henry G. Steinbrenner Stadium, a new combustion facility in Building 31 and other major renovations in Buildings 12 and 20 to support Energy Laboratory activities, the interim animal care facility on Vassar Street, and the provision for new space and the improvement of present space to accommodate the requirements of the National Magnet Laboratory and the Plasma Fusion Center on Albany Street.

A large tract of land was cleared on the East Campus to provide for the new Whitaker College of Health Sciences, Technology, and Management and new Health Services facilities, and a planning study has been initiated for the entire East Campus. Plans are already underway for a new chilled-water facility in that area and a major steam line was acquired from a local utility during the year. A further development on the east campus was the transfer from investment real estate to educational plant of the Suffolk Building at 292 Main Street in the Kendall Square area to house organizational elements of the Energy Laboratory, the headquarters of the Sea Grant Program, the Center for International Studies, and the Center for Computational Research in Economics and Management Science. That building should be fully occupied within the next year. Major renovations are about to begin in the Webster Building to meet the additional requirements of the Energy Laboratory.

The Institute also added Random Hall on Massachusetts Avenue to the housing resources for undergraduates, and the real estate at 351-355 Massachusetts Avenue was renovated for use by undergraduate independent living groups. Renovations to both acquisitions are being financed in part with low-interest loans from the U.S. Department of Housing and Urban Development’s College Housing Program.

Finally, it was a year in which chilled-water distribution lines were constructed in the main plant area to further expand our capability to accommodate the air-conditioning needs of that major complex, needs which cannot be met all at once without a tremendous infusion of new resources but which can be met in the long run by doing something every year. The year also saw a concentrated effort to upgrade the many constant temperature rooms.

The book value of educational plant was $205,992,000 at June 30, 1978, up from $203,340,000 on June 30, 1977.

Total mortgage indebtedness at June 30, 1978 was $31,199,000 consisting of $10,064,000 of Federal government loans, $20,850,000 financed through the Massachusetts Health and Educational Facilities Authority, and $285,000 of other loans.

Investments

The year-to-year change in the endowment and other investments is shown in the following table:

<table>
<thead>
<tr>
<th></th>
<th>June 30, 1978</th>
<th></th>
<th>June 30, 1977</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Book</td>
<td>Market</td>
<td>Book</td>
<td>Market</td>
</tr>
<tr>
<td>General investments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed income</td>
<td>$152,845,000</td>
<td>$142,690,000</td>
<td>$146,703,000</td>
<td>$140,010,000</td>
</tr>
<tr>
<td>Equities</td>
<td>129,535,000</td>
<td>209,042,000</td>
<td>119,172,000</td>
<td>192,175,000</td>
</tr>
<tr>
<td>Real estate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For present or future use</td>
<td>10,220,000</td>
<td>10,220,000</td>
<td>13,437,000</td>
<td>13,437,000</td>
</tr>
<tr>
<td>Other real estate</td>
<td>31,047,000</td>
<td>31,789,000</td>
<td>31,465,000</td>
<td>31,696,000</td>
</tr>
<tr>
<td>Total</td>
<td>$323,647,000</td>
<td>$384,741,000</td>
<td>$309,777,000</td>
<td>$377,318,000</td>
</tr>
<tr>
<td>Separately invested</td>
<td>24,834,000</td>
<td>24,787,000</td>
<td>22,929,000</td>
<td>23,778,000</td>
</tr>
<tr>
<td>Total</td>
<td>$348,481,000</td>
<td>$409,528,000</td>
<td>$332,706,000</td>
<td>$401,096,000</td>
</tr>
</tbody>
</table>

1 At cost
2 At values determined by professional appraisers
3 This table excludes student notes receivable and amounts due from Educational Plant Funds.

There was an increase of $8,432,000 in the market value of the portfolio in 1977-78 as compared with an increase of only $90,000 in 1976-77. The book values increased more than market values because the increase in invested funds was greater than the relatively modest decline in the prices of fixed income securities and equities in the portfolio. The transfer of investment real estate to educational plant in the east campus area reduced the overall increase in total investments during the year, but had no effect on investment returns.
There was an increase in the amount invested in common stocks and other equity investments during the year due to net purchases and the retention of some common stocks received as gifts. This increased investment was greater than the modest realized loss and decline in unrealized appreciation for equities during the year. As a result, there was an increase in both the book and market values of equities held.

The portfolio of fixed income securities increased because of the investment of new gifts retained for future expenditure, primarily unexpended educational plant funds. Within this category, the portion of fixed income investments held in short-term securities increased significantly during the year because of the maturity and net sales of long-term bonds and the investment of new building and expendable funds in short-term securities.

The investment income received during the year, after administrative expenses, was $22,441,000 as compared with $19,783,000 in 1976-77. This increase of 13.4 percent resulted primarily from the substantial rise in the interest rates earned on short- and long-term fixed income securities, increased dividends on common stocks, and the increase in funds available for investment. The total income from other real estate, held primarily for investment purposes, increased by 46 percent because of increased income from new leases and renewals. In addition, there was a 313 percent increase in the rental income from external sources on property held for present or future Institute use. These increases resulted in part from changes in real estate management operations.

The investment income received exceeded the income distributed to funds, which increased by 8.8 percent. As a result, the reserve of investment income for distribution to funds increased to $20,710,000 from $19,582,000 at the end of the previous year. This reserve has increased by $1,316,000 in the past two years and has replaced more than two-thirds of the $1,931,000 reduction in this reserve during the 1975-76 and 1974-75 years.

The 13.4 percent increase in investment income received was the largest increase in eleven years. This rate of increase is not sustainable and the expected growth rate of investment income on existing assets is still below the expected rate of inflation. As a result, new gifts must be retained for investment just to meet the rising cost of existing academic programs. Any proposed reallocation of assets to higher yielding investments just to increase income in the near future may not improve the longer-term returns, as such high income investments often provide little or no income growth to offset future inflation. As a result, the investment objective of the Institute is to maximize long-term total investment return consistent with appropriate risk, in a manner which provides a growing stream of investment returns over time. These returns should treat equitably, in inflation adjusted dollars, the present and future needs of the Institute.

There was a merger of Pool B into Pool A of the General Investments early in the year. The creation of a single pool of endowment and similar funds was made primarily for administrative and investment management reasons and the adjustment process for combining the distribution rate to funds in the two Pools is taking place over several years.

During the year, the Investment Committee recommended, and the Corporation of the Institute approved, amendments to the Bylaws of the Corporation which permit investment management by an outside investment manager for all or any portion of the property of the Corporation. The Investment Committee approved an investment management agreement, covering a substantial portion of the securities assets in Pool A of the General Investments, with Thorndike, Doran, Paine and Lewis of Boston, the investment counseling subsidiary of Wellington Management Company. This organization was also retained to provide investment advice to the Treasurer for those investment securities not included in the investment management agreement. The investment manager and the Treasurer perform these functions in accordance with the policies and procedures established by the Investment Committee.

General

The financial results of the past two years and the estimates for 1978-79 show the Institute to be in approximate balance between income and all forms of expenditures. There has also been some rebuilding of financial reserves, though not enough to overcome the effects of inflation. While this is a source of some comfort and satisfaction relative to colleges and universities generally, the annual requirements are increasingly being met with current funds and the need to add capital is as great now as in the past. As the Leadership Campaign enters its final phase in achieving its overall goals, there will be a recurring need for this level of effort in the future to sustain and improve the ongoing activities and to continue the initiation of new programs.

Respectfully submitted,

Stuart H. Cowen
Vice President for Financial Operations

Glenn P. Strehle
Treasurer

August 28, 1978
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
STATEMENT OF REVENUES AND FUNDS USED TO MEET EXPENSES OF CURRENT OPERATIONS
for the year ended June 30, 1978
with comparative totals for 1977
(in thousands of dollars)

Schedule A

OPERATING EXPENSES:

<table>
<thead>
<tr>
<th>Description</th>
<th>Institute or Donor</th>
<th>Unrestricted</th>
<th>Restricted</th>
<th>Total 1978</th>
<th>Total 1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction and unsponsored research</td>
<td>$ 30,636</td>
<td>$ 16,609</td>
<td>$ 47,245</td>
<td>$ 43,311</td>
<td></td>
</tr>
<tr>
<td>Sponsored research (Note A):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct expenses:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departmental and interdepartment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lincoln Laboratory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research administration and general expenses</td>
<td>2,087</td>
<td>10</td>
<td>2,097</td>
<td>1,548</td>
<td></td>
</tr>
<tr>
<td>Total expenses directly attributable to instruction and research</td>
<td>32,723</td>
<td>202,950</td>
<td>235,673</td>
<td>203,166</td>
<td></td>
</tr>
<tr>
<td>Expenses jointly applicable to instruction and research:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Libraries</td>
<td>3,700</td>
<td>184</td>
<td>3,884</td>
<td>3,415</td>
<td></td>
</tr>
<tr>
<td>Medical</td>
<td>2,863</td>
<td>14</td>
<td>2,877</td>
<td>3,603</td>
<td></td>
</tr>
<tr>
<td>Plant operations and maintenance</td>
<td>18,391</td>
<td>3,308</td>
<td>21,699</td>
<td>17,619</td>
<td></td>
</tr>
<tr>
<td>Administration</td>
<td>5,474</td>
<td>115</td>
<td>5,589</td>
<td>5,006</td>
<td></td>
</tr>
<tr>
<td>Fiscal, personnel and other Institute-wide services</td>
<td>10,570</td>
<td>103</td>
<td>10,673</td>
<td>9,566</td>
<td></td>
</tr>
<tr>
<td>General expenses</td>
<td>3,385</td>
<td>936</td>
<td>4,321</td>
<td>4,191</td>
<td></td>
</tr>
<tr>
<td>Other instruction and research support activities</td>
<td>1,152</td>
<td>91</td>
<td>1,243</td>
<td>1,177</td>
<td></td>
</tr>
<tr>
<td>Student services</td>
<td>4,604</td>
<td>2,282</td>
<td>6,886</td>
<td>5,714</td>
<td></td>
</tr>
<tr>
<td>Other expenses</td>
<td>2,666</td>
<td></td>
<td>2,666</td>
<td>2,492</td>
<td></td>
</tr>
<tr>
<td>Scholarships and fellowships:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undergraduate</td>
<td>1,521</td>
<td>4,646</td>
<td>6,167</td>
<td>5,118</td>
<td></td>
</tr>
<tr>
<td>Graduate</td>
<td>632</td>
<td>4,286</td>
<td>4,918</td>
<td>4,725</td>
<td></td>
</tr>
<tr>
<td>Dining and Housing</td>
<td>409</td>
<td>8,073</td>
<td>8,482</td>
<td>7,622</td>
<td></td>
</tr>
<tr>
<td>MIT Press</td>
<td></td>
<td>4,278</td>
<td>4,278</td>
<td>3,498</td>
<td></td>
</tr>
<tr>
<td>Total operating expenses (Schedule D)</td>
<td>$ 88,090</td>
<td>$ 231,266</td>
<td>$ 319,356</td>
<td>$ 276,912</td>
<td></td>
</tr>
</tbody>
</table>

REVENUES AND FUNDS USED:

<table>
<thead>
<tr>
<th>Description</th>
<th>Institute or Donor</th>
<th>Unrestricted</th>
<th>Restricted</th>
<th>Total 1978</th>
<th>Total 1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition and other related income</td>
<td>$ 41,366</td>
<td></td>
<td>$ 41,366</td>
<td>$ 37,939</td>
<td></td>
</tr>
<tr>
<td>Research revenues:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departmental and interdepartment</td>
<td>26,446</td>
<td>$ 89,736</td>
<td>$ 116,182</td>
<td>100,366</td>
<td></td>
</tr>
<tr>
<td>Lincoln Laboratory</td>
<td>7,004</td>
<td>96,595</td>
<td>103,599</td>
<td>87,625</td>
<td></td>
</tr>
<tr>
<td>Endowment income applied to operations (Schedule B)</td>
<td>6,699</td>
<td>4,562</td>
<td>11,261</td>
<td>10,873</td>
<td></td>
</tr>
<tr>
<td>Gifts, investment income and other receipts for:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted purposes</td>
<td></td>
<td></td>
<td>19,100</td>
<td>19,100</td>
<td>15,492</td>
</tr>
<tr>
<td>Scholarships and fellowships</td>
<td>700</td>
<td>8,922</td>
<td>9,622</td>
<td>8,154</td>
<td></td>
</tr>
<tr>
<td>Dining and Housing</td>
<td></td>
<td>8,073</td>
<td>8,073</td>
<td>7,414</td>
<td></td>
</tr>
<tr>
<td>MIT Press</td>
<td></td>
<td>4,278</td>
<td>4,278</td>
<td>3,248</td>
<td></td>
</tr>
<tr>
<td>Total operating revenues and funds used</td>
<td>82,215</td>
<td>231,266</td>
<td>313,481</td>
<td>271,111</td>
<td></td>
</tr>
<tr>
<td>Additional need for unrestricted revenues and funds**</td>
<td>5,875</td>
<td></td>
<td>5,875</td>
<td>5,801</td>
<td></td>
</tr>
<tr>
<td>Total revenues and funds used</td>
<td>$ 88,090</td>
<td>$ 231,266</td>
<td>$ 319,356</td>
<td>$ 276,912</td>
<td></td>
</tr>
</tbody>
</table>

**Additional need for unrestricted revenues and funds met from:

<table>
<thead>
<tr>
<th>Description</th>
<th>Institute or Donor</th>
<th>Unrestricted</th>
<th>Restricted</th>
<th>Total 1978</th>
<th>Total 1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of Facilities Allowances</td>
<td>$ 1,433</td>
<td></td>
<td>$ 1,433</td>
<td>$ 1,308</td>
<td></td>
</tr>
<tr>
<td>Patent Revenues</td>
<td>810</td>
<td></td>
<td>810</td>
<td>629</td>
<td></td>
</tr>
<tr>
<td>Current gifts, grants, and bequests</td>
<td>3,700</td>
<td></td>
<td>3,700</td>
<td>3,738</td>
<td></td>
</tr>
<tr>
<td>Total additional current revenues</td>
<td>5,943</td>
<td></td>
<td>5,943</td>
<td>5,675</td>
<td></td>
</tr>
<tr>
<td>Less: funds available for future operations</td>
<td>68</td>
<td></td>
<td>68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net additional current revenues used</td>
<td>5,875</td>
<td></td>
<td>5,875</td>
<td>5,675</td>
<td></td>
</tr>
<tr>
<td>Other fund balances</td>
<td></td>
<td></td>
<td></td>
<td>126</td>
<td></td>
</tr>
<tr>
<td>Funds functioning as endowment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$ 5,875</td>
<td></td>
<td>$ 5,875</td>
<td>$ 5,801</td>
<td></td>
</tr>
</tbody>
</table>

The accompanying notes are an integral part of the financial statements.
# MASSACHUSETTS INSTITUTE OF TECHNOLOGY

## INVESTMENT INCOME FOR DISTRIBUTION TO FUNDS

for the year ended June 30, 1978

with comparative totals for 1977

(in thousands of dollars)

### Schedule B

<table>
<thead>
<tr>
<th>General Investments</th>
<th>Separately Invested Funds</th>
<th>Total 1978</th>
<th>Total 1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>$19,582</td>
<td>20,948</td>
<td>$19,582</td>
<td>$19,394</td>
</tr>
<tr>
<td>$1,493</td>
<td></td>
<td>22,441</td>
<td>19,783</td>
</tr>
<tr>
<td><strong>Total before distribution</strong></td>
<td></td>
<td><strong>42,023</strong></td>
<td><strong>39,177</strong></td>
</tr>
</tbody>
</table>

### Distribution:

**Income distributed:**

- From current year’s earnings: $19,820
- From prior years’ earnings: (1,493)

*Total distribution to funds*: $21,313

### Investment income for distribution to funds, balance end of year:

<table>
<thead>
<tr>
<th>General Investments</th>
<th>Separately Invested Funds</th>
<th>Total 1978</th>
<th>Total 1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>$20,710</td>
<td></td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>10,710</td>
<td></td>
<td>10,710</td>
<td>9,582</td>
</tr>
</tbody>
</table>

*Total distribution to funds:*

Endowment funds:

- Used for operations (Schedule A): $11,248
- Used for scholarships and fellowships: 2,440
- Used for other charges: 171
- Added to principal: 8
- Added to unexpended balances of endowment income: 27
- Transferred to other funds: 3,905

Other funds:

- Agency funds: 36
- Life income funds: 18
- Student loan funds: 14
- Building funds: 725
- Other expendable funds: 1,228

*Total distribution to funds:*

<table>
<thead>
<tr>
<th>General Investments</th>
<th>Separately Invested Funds</th>
<th>Total 1978</th>
<th>Total 1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>$19,820</td>
<td>1,493</td>
<td><strong>21,313</strong></td>
<td><strong>19,595</strong></td>
</tr>
</tbody>
</table>

Balances include:

- Funds functioning as endowment: $10,000
- Current invested funds: 10,710

*Total distribution to funds (Schedule C):*
## MASSACHUSETTS INSTITUTE OF TECHNOLOGY

### BALANCE SHEET

at June 30, 1978

with comparative totals at June 30, 1977

(in thousands of dollars)

#### Schedule C

<table>
<thead>
<tr>
<th>Assets</th>
<th>Current Operating Funds</th>
<th>Current Invested Funds</th>
<th>Student Loan and Similar Funds</th>
<th>Educational Plant Funds</th>
<th>Life Income and Agency Funds</th>
<th>Total 1978</th>
<th>Total 1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>$152</td>
<td>$—</td>
<td>$—</td>
<td>$—</td>
<td>$—</td>
<td>$152</td>
<td>$2,600</td>
</tr>
<tr>
<td>Unrestricted</td>
<td>2,466</td>
<td>—</td>
<td>350</td>
<td>—</td>
<td>2,816</td>
<td>4,465</td>
<td></td>
</tr>
<tr>
<td>Accounts receivable</td>
<td>11,406</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>11,406</td>
<td>8,493</td>
<td></td>
</tr>
<tr>
<td>Students' notes receivable</td>
<td>—</td>
<td>26,727</td>
<td>—</td>
<td>—</td>
<td>26,727</td>
<td>24,554</td>
<td></td>
</tr>
<tr>
<td>Contracts in progress, principally U.S. Government</td>
<td>8,442</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>8,442</td>
<td>4,991</td>
<td></td>
</tr>
<tr>
<td>Deferred charges, inventories and other assets</td>
<td>14,512</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>14,512</td>
<td>13,493</td>
<td></td>
</tr>
<tr>
<td>Investments, at cost (Note B)</td>
<td>—</td>
<td>47,788</td>
<td>273,878</td>
<td>19,784</td>
<td>7,030</td>
<td>348,480</td>
<td>332,706</td>
</tr>
<tr>
<td>Receivables (payables) arising from investment transactions</td>
<td>—</td>
<td>—</td>
<td>(347)</td>
<td>—</td>
<td>(347)</td>
<td>273</td>
<td></td>
</tr>
<tr>
<td>Due from other M.I.T. funds</td>
<td>6,438</td>
<td>5,276</td>
<td>—</td>
<td>—</td>
<td>11,714</td>
<td>8,719</td>
<td></td>
</tr>
<tr>
<td>Land, buildings, and equipment, at cost</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>202,471</td>
<td>—</td>
<td>200,358</td>
<td></td>
</tr>
<tr>
<td>Construction in progress</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>3,521</td>
<td>—</td>
<td>3,521</td>
<td></td>
</tr>
<tr>
<td>Total assets</td>
<td>$43,416</td>
<td>$53,064</td>
<td>$26,727</td>
<td>$273,881</td>
<td>$7,030</td>
<td>$629,894</td>
<td>$603,515</td>
</tr>
</tbody>
</table>

| Liabilities and Fund Balances | | | | | | | |
| Liabilities: | | | | | | | |
| Accounts payable and accruals | $23,905                    | $—                      | $—                            | $—                      | $—                           | $23,905    | $21,847    |
| Withholdings, deposits and other credits | 5,389                      | —                      | —                             | —                       | 5,389                       | 5,070      |            |
| Advances and unexpended grants for sponsored research: | | | | | | | |
| U.S. Government | 2,366                        | —                      | —                             | —                       | 2,366                       | 1,127      |            |
| Private sources | 356                        | —                      | —                             | —                       | 356                         | 54         |            |
| Due to other M.I.T. funds | —                        | 6,438                  | 339                           | 4,937                   | 11,714                       | 8,719      |            |
| Borrowings—Mortgage bonds and notes payable (Note E) | —                        | —                     | 5,989                         | 31,199                  | 37,188                       | 37,688     |            |
| Total liabilities | $32,016                    | $6,438                 | $6,328                        | $36,136                 | $80,918                      | $74,505    |            |

| Fund Balances: | | | | | | | |
| Expendable: | | | | | | | |
| Unrestricted purposes | —                        | 68                     | —                             | —                       | 68                           | —          |            |
| Restricted gifts and other receipts available for current expenses | 11,400                    | —                      | —                             | —                       | 11,400                       | 11,134     |            |
| Restricted purposes | —                        | 31,278                 | —                             | —                       | 31,278                       | 26,810     |            |
| Unexpended endowment income for restricted purposes | —                        | 4,570                  | —                             | —                       | 4,570                        | 4,529      |            |
| Investment income for distribution to funds (Schedule B — Note C) | —                        | 10,710                 | 10,000                         | —                       | 20,710                       | 19,522     |            |
| Student loan funds (Note D) | —                        | 20,399                 | —                             | —                       | 20,399                       | 19,052     |            |
| Endowment and similar funds | | | | | | | |
| Income for unrestricted purposes: | | | | | | | |
| Endowment | —                        | 48,909                 | —                             | —                       | 48,909                       | 47,262     |            |
| Funds functioning as endowment | —                        | 30,307                 | —                             | —                       | 30,307                       | 30,168     |            |
| Income for restricted purposes: | | | | | | | |
| Endowment | —                        | 93,072                 | —                             | —                       | 93,072                       | 87,399     |            |
| Funds functioning as endowment | —                        | 62,247                 | —                             | —                       | 62,247                       | 61,285     |            |
| Net realized gain from investments | —                        | 29,346                 | —                             | —                       | 29,346                       | 33,542     |            |
| Educational plant funds: | | | | | | | |
| Unexpended | —                        | —                      | —                             | 19,784                  | 19,784                       | 11,523     |            |
| Expended | —                        | —                      | —                             | 169,856                 | 169,856                      | 169,654    |            |
| Funds subject to life interests in income | —                        | —                      | —                             | 6,338                   | 6,338                        | 6,415      |            |
| Agency funds | —                        | —                      | —                             | 692                     | 692                          | 655        |            |
| Total fund balances | 11,400                    | 46,626                 | 20,399                        | 273,881                 | 189,640                      | 548,976    | 529,010    |
| Total liabilities and fund balances | $43,416                 | $53,064                | $26,727                       | $273,881                | $225,776                     | $629,894   | $603,515   |

558
### Schedule D

**Current Funds**

<table>
<thead>
<tr>
<th>Institute or Donor</th>
<th>Unrestricted</th>
<th>Restricted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td><strong>Current Funds</strong></td>
<td><strong>Endowment, Plant, and Similar Funds</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1978</strong></td>
<td><strong>1977</strong></td>
</tr>
</tbody>
</table>

**Current Year:**

- Revenues, other additions, and borrowings: $89,105, $239,565, $328,670, $16,858, $345,528, $302,940
- Operating expenses (Schedule A): $88,090, $231,266, $319,356, $-2, $319,356, $276,912
- Other deductions and repayment of borrowings: $(8), $(2,994), $(3,002), $(3,704), $(6,706), $(7,308)
- Net increase (decrease) before appropriations: $1,007, $5,305, $6,312, $13,154, $19,466, $18,720
- Appropriations among funds: $(939), $598, $341, $341, $- , $-

**NET INCREASE (DECREASE) FOR THE YEAR**

<table>
<thead>
<tr>
<th></th>
<th><strong>1978</strong></th>
<th><strong>1977</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Year:</td>
<td>$68</td>
<td>$57,958</td>
</tr>
<tr>
<td></td>
<td>$57,958</td>
<td>$58,026</td>
</tr>
<tr>
<td></td>
<td>$528,138</td>
<td>$586,164</td>
</tr>
<tr>
<td></td>
<td>$566,698</td>
<td>$566,698</td>
</tr>
</tbody>
</table>

**BALANCES, END OF YEAR**

<table>
<thead>
<tr>
<th></th>
<th><strong>1978</strong></th>
<th><strong>1977</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Year:</td>
<td>$68</td>
<td>$57,958</td>
</tr>
<tr>
<td></td>
<td>$58,026</td>
<td>$528,138</td>
</tr>
<tr>
<td></td>
<td>$586,164</td>
<td>$566,698</td>
</tr>
</tbody>
</table>

**BALANCES, END OF YEAR INCLUDE:**

<table>
<thead>
<tr>
<th></th>
<th><strong>1978</strong></th>
<th><strong>1977</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fund balances:</td>
<td>$68</td>
<td>$57,958</td>
</tr>
<tr>
<td></td>
<td>$58,026</td>
<td>$490,950</td>
</tr>
<tr>
<td></td>
<td>$548,976</td>
<td>$529,010</td>
</tr>
<tr>
<td>Outstanding borrowings:</td>
<td>-</td>
<td>-</td>
</tr>
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<td>$37,688</td>
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<table>
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<th>Total</th>
<th>$68</th>
<th>$57,958</th>
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<tr>
<td></td>
<td>$58,026</td>
<td>$528,138</td>
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This condensed schedule should be examined in conjunction with the detailed Statement of Changes in Financial Position (Schedule D-1) which follows.
**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**

**STATEMENT OF CHANGES IN FINANCIAL POSITION**

for the year ended June 30, 1978

with comparative totals for 1977

(in thousands of dollars)

**Schedule D-I**

<table>
<thead>
<tr>
<th>Schedule D-I</th>
<th>Current Funds</th>
<th>Institute or Donor Funds</th>
<th>Total Current Funds</th>
<th>Student Loan Funds</th>
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<td>$ —</td>
<td>$ 52,055</td>
<td>$ 52,055</td>
<td>$ 24,587</td>
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<td><strong>REVENUES, OTHER ADDITIONS AND BORROWINGS:</strong></td>
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<td></td>
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<tr>
<td>Tuition and other related income</td>
<td>41,366</td>
<td>—</td>
<td>41,366</td>
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<tr>
<td>Research revenues</td>
<td>35,219</td>
<td>186,331</td>
<td>221,550</td>
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<tr>
<td>Fees, services and miscellaneous receipts</td>
<td>1,119</td>
<td>9,596</td>
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<td>Investment income</td>
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<td>Net realized gain or (loss) on investments</td>
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<td>8,021</td>
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<td>Government support for construction</td>
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<td>—</td>
<td>—</td>
<td>—</td>
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<td>Dining and Housing</td>
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<td>8,073</td>
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<td>MIT Press</td>
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<td>4,278</td>
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<td>—</td>
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<td><strong>Total revenues, other additions and borrowings</strong></td>
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<td>$ 239,565</td>
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<td><strong>EXPENDITURES, OTHER DEDUCTIONS AND REPAYMENT OF BORROWINGS:</strong></td>
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<td>Operating expenses (Schedule A)</td>
<td>$ 88,090</td>
<td>$ 231,266</td>
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<td>Other deductions</td>
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<td>2,994</td>
<td>3,002</td>
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<td>Repayment of borrowings</td>
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<td>—</td>
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<td><strong>Total expenditures, other deductions and repayment of borrowings</strong></td>
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<td>$ 234,260</td>
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<td><strong>APPROPRIATIONS AMONG FUNDS:</strong></td>
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<td>Fund balances to unrestricted (Schedule A)</td>
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<td>—</td>
<td>—</td>
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<td>Funds functioning as endowment to unrestricted (Schedule A)</td>
<td>—</td>
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<td>—</td>
<td>—</td>
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<tr>
<td>Appropriations for buildings added to educational plant</td>
<td>(95)</td>
<td>(107)</td>
<td>(202)</td>
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<td>Expendable funds used to support related expenses</td>
<td>—</td>
<td>1,500</td>
<td>1,500</td>
<td>(594)</td>
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<tr>
<td>Other appropriations</td>
<td>(844)</td>
<td>(795)</td>
<td>(1,639)</td>
<td>(62)</td>
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<td><strong>Total appropriations among funds</strong></td>
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<td>598</td>
<td>(341)</td>
<td>(656)</td>
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<td><strong>NET INCREASE (DECREASE) FOR THE YEAR</strong></td>
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<td><strong>BALANCES, END OF YEAR</strong></td>
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<td><strong>BALANCES, END OF YEAR INCLUDE:</strong></td>
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<td>$ 57,958</td>
<td>$ 58,026</td>
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<td><strong>Total</strong></td>
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<td>$ 57,958</td>
<td>$ 58,026</td>
<td>$ 26,388</td>
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<td>Endowment and Similar Funds</td>
<td>Educational Plant</td>
<td>Life Income and Agency Funds</td>
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<td>Total 1977</td>
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<tr>
<td></td>
<td>Used for</td>
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<tr>
<td></td>
<td>Educational Plant</td>
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<td>$269,899</td>
<td>$ 11,523</td>
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<td>$ 7,070</td>
<td>$566,698</td>
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<tr>
<td>193</td>
<td>579</td>
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<td>47</td>
<td>221,550</td>
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<td>(3,981)</td>
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<td>393</td>
<td>22,441</td>
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<td></td>
<td>(217)</td>
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<td>(4,872)</td>
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<td>8,918</td>
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<td></td>
<td>468</td>
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<td>345,528</td>
<td>302,940</td>
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<td>2,634</td>
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<td>537</td>
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<td>319,356</td>
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<td>1,816</td>
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<td>380</td>
<td>326,062</td>
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<td>2,391</td>
<td>10,034</td>
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<td>(1,816)</td>
<td>19,466</td>
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<tr>
<td></td>
<td>(1,105)</td>
<td></td>
<td>1,307</td>
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</tr>
<tr>
<td></td>
<td>(906)</td>
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<td>(126)</td>
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<td>(1,773)</td>
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<td>(509)</td>
<td>(40)</td>
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<td>$273,881</td>
<td>$ 19,784</td>
<td></td>
<td>$201,055</td>
<td>$586,164</td>
</tr>
</tbody>
</table>

$273,881 $ 19,784 $169,856 $ 7,030 $548,976 $529,010

$273,881 $ 19,784 $31,199 $ 7,030 $37,188 $37,688

$273,881 $ 19,784 $201,055 $ 7,030 $586,164 $566,698
### Schedule E

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Sources of funds:</td>
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<tr>
<td>Gifts and bequests (Note A)</td>
<td>$28,236</td>
<td>$23,044</td>
<td>$18,528</td>
<td>$16,782</td>
</tr>
<tr>
<td>Investment income (Note C)</td>
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<td>19,783</td>
<td>18,532</td>
<td>18,332</td>
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<td>Net gain or (loss) on sales or exchanges of investments</td>
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<td>(4,872)</td>
<td>(2,610)</td>
<td>443</td>
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<td>Royalties received net of related costs</td>
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<td>663</td>
<td>459</td>
<td>455</td>
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<td>Receipts from foundations and agencies for student aid</td>
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<td>Government grant for student loans</td>
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<td>975</td>
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<td>Fees, services and other receipts</td>
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<td>9,535</td>
<td>9,884</td>
<td>6,636</td>
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<td><strong>Total</strong></td>
<td>$72,762</td>
<td>$55,978</td>
<td>$53,111</td>
<td>$50,839</td>
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</table>

| Use of funds:                    |        |        |        |        |
| Endowment investment income (Note C) | $11,261| $10,873| $10,301| 10,506 |
| Gifts, investment income and other receipts | 24,975 | 21,293 | 21,503 | 18,602 |
| Scholarship and fellowship awards for tuition and stipends | 10,615 | 9,580  | 8,550  | 8,285  |
| Additions to educational plant    | 1,307  | 1,179  | 3,729  | 5,867  |
| Operating expenses recorded in direct expenses of the Office of Sponsored Programs | 230    | 399    | 1,093  | 673    |
| Other charges to funds not related to current operation | 4,609  | 2,941  | 3,199  | 5,963  |
| **Total**                        | 19,765 | 9,713  | 4,736  | 943    |

| Net increase in funds            |        |        |        |        |
| Fund balances at end of year     | $379,121| 359,356| 349,643| 344,907|
| Less gifts and other receipts available for current expenses | 11,400 | 11,134 | 10,454 | 10,743 |
| **Total invested funds**         | $367,721| $348,222| $339,189| $334,164|

*This schedule has not been revised to correspond to Schedules A through D-1, however, the data is comparable for the years presented.*
### Schedule E (Continued)

<table>
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<tbody>
<tr>
<td>$</td>
<td>$342,058</td>
<td>$335,318</td>
<td>$328,247</td>
<td>$302,901</td>
<td>$290,598</td>
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<td>$18,215</td>
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<td>963</td>
<td>1,772</td>
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<td>92</td>
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<td>290,598</td>
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**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**

**HIGHLIGHTS: A DECADE IN REVIEW** *(in thousands of dollars)*

**Schedule F**

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<td>Investment Income</td>
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<td>$18,532</td>
<td>$18,332</td>
</tr>
<tr>
<td>Total Gifts, Grants and Bequests</td>
<td>$28,236</td>
<td>$23,044</td>
<td>$23,328</td>
<td>$16,782</td>
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<tr>
<td>For Endowment</td>
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<td>For Buildings</td>
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<td>$239,248</td>
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<td>Current Funds</td>
<td>$58,026</td>
<td>$52,055</td>
<td>$75,566</td>
<td>$76,097</td>
</tr>
<tr>
<td>Book Value of Educational Plant</td>
<td>$205,992</td>
<td>$203,340</td>
<td>$201,823</td>
<td>$197,513</td>
</tr>
<tr>
<td>Investments, at Cost</td>
<td>$348,481</td>
<td>$332,706</td>
<td>$319,878</td>
<td>$313,624</td>
</tr>
<tr>
<td>Investments, at Market</td>
<td>$409,528</td>
<td>$401,096</td>
<td>$401,006</td>
<td>$376,061</td>
</tr>
<tr>
<td>Borrowings by M.I.T.</td>
<td>$37,188</td>
<td>$37,688</td>
<td>$30,520</td>
<td>$30,122</td>
</tr>
<tr>
<td>Undergraduate Students ***</td>
<td>$4,506</td>
<td>$4,422</td>
<td>$4,358</td>
<td>$4,048</td>
</tr>
<tr>
<td>Graduate Students ***</td>
<td>$3,824</td>
<td>$3,774</td>
<td>$3,603</td>
<td>$3,468</td>
</tr>
<tr>
<td>Library, printed volumes and microforms (thousands of volumes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuition Rate (in dollars)</td>
<td>$4,350</td>
<td>$4,000</td>
<td>$3,700</td>
<td>$3,350</td>
</tr>
</tbody>
</table>

* Where appropriate the data for the years 1969-1975 have been reclassified for comparison purposes.
** Draper Laboratory divested as of July 1, 1973
*** Full time enrollment
## Schedule F (Continued)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$233,442</td>
<td>$279,061</td>
<td>$245,127</td>
<td>$223,222</td>
<td>$225,169</td>
<td>$224,649</td>
</tr>
<tr>
<td></td>
<td>33,711</td>
<td>29,449</td>
<td>26,976</td>
<td>27,918</td>
<td>25,134</td>
<td>23,665</td>
</tr>
<tr>
<td></td>
<td>139,980</td>
<td>192,849</td>
<td>161,630</td>
<td>140,386</td>
<td>149,292</td>
<td>157,339</td>
</tr>
<tr>
<td></td>
<td>39,747</td>
<td>37,745</td>
<td>37,835</td>
<td>36,751</td>
<td>33,917</td>
<td>28,368</td>
</tr>
<tr>
<td></td>
<td>7,912</td>
<td>8,108</td>
<td>8,344</td>
<td>8,074</td>
<td>7,582</td>
<td>7,363</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$162,372</td>
<td>$219,447</td>
<td>$187,715</td>
<td>$163,429</td>
<td>$171,294</td>
<td>$176,206</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>27,004</td>
<td>24,571</td>
<td>22,512</td>
<td>21,548</td>
<td>19,036</td>
<td>18,109</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$19,099</td>
<td>$18,321</td>
<td>$16,942</td>
<td>$15,498</td>
<td>$15,523</td>
<td>$14,579</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$18,215</td>
<td>$16,919</td>
<td>$17,081</td>
<td>$34,186</td>
<td>$14,230</td>
<td>$23,468</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3,904</td>
<td>2,127</td>
<td>2,680</td>
<td>3,863</td>
<td>1,853</td>
<td>4,595</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5,553</td>
<td>5,450</td>
<td>2,415</td>
<td>2,514</td>
<td>3,918</td>
<td>2,540</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$500,925</td>
<td>$488,240</td>
<td>$469,050</td>
<td>$452,558</td>
<td>$420,305</td>
<td>$403,361</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>234,551</td>
<td>229,327</td>
<td>221,827</td>
<td>216,364</td>
<td>189,901</td>
<td>169,854</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>81,476</td>
<td>84,693</td>
<td>85,341</td>
<td>80,505</td>
<td>85,352</td>
<td>101,568</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>190,029</td>
<td>182,063</td>
<td>157,651</td>
<td>143,120</td>
<td>136,926</td>
<td>127,521</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>318,321</td>
<td>318,513</td>
<td>312,288</td>
<td>303,287</td>
<td>278,454</td>
<td>265,469</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>365,631</td>
<td>420,104</td>
<td>425,402</td>
<td>382,539</td>
<td>308,091</td>
<td>354,155</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>29,369</td>
<td>30,782</td>
<td>20,720</td>
<td>17,408</td>
<td>14,501</td>
<td>11,699</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4,018</td>
<td>4,105</td>
<td>4,054</td>
<td>4,058</td>
<td>4,002</td>
<td>3,907</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3,358</td>
<td>3,328</td>
<td>3,250</td>
<td>3,296</td>
<td>3,395</td>
<td>3,274</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,995</td>
<td>1,879</td>
<td>1,733</td>
<td>1,566</td>
<td>1,437</td>
<td>1,305</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$3,100</td>
<td>$2,900</td>
<td>$2,650</td>
<td>$2,500</td>
<td>$2,150</td>
<td>$2,150</td>
</tr>
</tbody>
</table>
NOTES TO FINANCIAL STATEMENTS

A. ACCOUNTING POLICIES

BASIS OF PRESENTATION

The accompanying financial statements have been prepared on the accrual basis. In order to ensure observance of limitations and restrictions placed on the use of the resources available to the Institute, the accounts of the Institute have been maintained in accordance with the principles of "fund accounting". This is the procedure by which resources for various purposes are classified for accounting and reporting purposes into funds that are in accordance with activities or objectives specified.

SPONSORED RESEARCH

Revenue associated with contracts and grants is recognized as related costs are incurred. Grants and contracts normally provide for a use allowance, in lieu of depreciation, which is reflected as unrestricted revenue. The Institute has recorded reimbursement of indirect costs relating to Government contracts and grants at the authorized billing rates for the fiscal years ended June 30, 1978, and 1977, which are subject to final negotiation after Government audit.

LAND, BUILDINGS, AND EQUIPMENT

Land, Buildings and Equipment, are shown at cost. As is customary for educational institutions, depreciation has not been recorded on buildings and equipment. When expended, costs associated with the construction of new educational facilities are shown as construction in progress until such projects are completed.

GIFTS

Gifts are recognized upon receipt. Gifts other than cash are recorded at their fair market value when such values are determinable as of the date of contribution.

VACATIONS

The Institute accrues vacation expense earned by certain research related employees. Other vacations are expensed as taken.

INTERFUND BORROWINGS

Interfund borrowings by Educational Plant Funds include short-term advances of $259,000 as well as $4,678,000 of borrowings from current invested funds (at 6%, and 8% interest) related to the temporary funding of certain buildings.

B. INVESTMENTS

Total market value of investments approximated $409,528,000 and $401,096,000 at June 30, 1978 and 1977 respectively. Such amounts include market values of certain real estate which were determined by professional appraisers. The Institute records bond interest as received and does not accrue discount. See the schedule of investments which appears on page 8 of the Treasurer's Report for further details.

C. INVESTMENT INCOME FOR DISTRIBUTION TO FUNDS

At June 30, 1978 and 1977, the Institute had reserved $20,710,000 and $19,582,000 (captioned "Investment Income for Distribution to Funds") representing fund income in excess of amounts distributed to funds in prior years. This reserve was increased by $1,128,000 in 1978 and by $188,000 in 1977 as a result of the difference between income earned and income distributed to funds (see Schedule B).

D. STUDENT LOAN FUNDS

National Direct Student Loan Funds of $12,420,000 and $11,213,000 at June 30, 1978 and 1977, respectively, are ultimately refundable to the United States Government.
E. BORROWINGS — MORTGAGE BONDS AND NOTES PAYABLE

Borrowings — Mortgage Bonds and Notes Payable consist of the following at June 30, 1978 and 1977:

<table>
<thead>
<tr>
<th>Bond Description</th>
<th>1978</th>
<th>1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.I.T. Construction and Consolidation Bonds of 1968:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Series A, 3 1/2%, due 1978-2003</td>
<td>$4,618,000</td>
<td>$4,738,000</td>
</tr>
<tr>
<td>Series B, 3 3/4%, due 1978-2015</td>
<td>3,611,000</td>
<td>3,656,000</td>
</tr>
<tr>
<td>Series C, 3%, due 1978-2018</td>
<td>1,550,000</td>
<td>1,570,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>1978</th>
<th>1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dining facilities bonds, 3 3/4%, due 1978-1999</td>
<td>$285,000</td>
<td>294,000</td>
</tr>
<tr>
<td>Mortgage notes payable, 5 1/4%, due 1978-1979</td>
<td>59,000</td>
<td>173,000</td>
</tr>
<tr>
<td>Mortgage notes payable, 5 1/4%, due 1978-1981</td>
<td>226,000</td>
<td>301,000</td>
</tr>
<tr>
<td>Residential facility lease purchase obligation (note F)</td>
<td>5,075,000**</td>
<td>5,153,000**</td>
</tr>
<tr>
<td>Mortgage notes payable, 5-6 1/2%, due 1978-2003</td>
<td>9,630,000</td>
<td>9,800,000</td>
</tr>
<tr>
<td>Mortgage notes payable, 5-7%, due 1978-2006</td>
<td>6,145,000</td>
<td>6,225,000</td>
</tr>
</tbody>
</table>

Total related to educational plant                      | **$31,199,000** | **$31,910,000** |

Notes payable, 6%, due 1978                               | 243,000            |

Notes payable to bank, 7 1/2%-8 1/4% due 1978 and 1979 for student loans | 5,250,000 | 4,800,000 |

Notes payable to bank, 7 3/4%, due 1978 for
Faculty and Staff Educational Loan Fund                  | 200,000            |

Notes payable to U.S. Government, 6 1/4%-8 1/2%, due 1978-1992, for student loans | 539,000 | 585,000 |

Total                                                 | **$37,188,000** | **$37,688,000** |

*At June 30, 1978 the Institute had pledged securities with a market value of $11,238,000 annual unrestricted operating revenue of $2,120,000, and certain other project revenue to comply with the terms of the bond indentures.

**The Institute receives interest supplements from the Department of Housing and Urban Development with respect to these issues.

F. COMMITMENTS

1. Annual payments under a thirty-year residential facility lease purchase obligation payable to the Massachusetts Health and Educational Facilities Authority approximate $350,000. Annual rentals for Utility Facilities, which are being leased for their estimated 25-year useful lives from the Massachusetts Health and Educational Facilities Authority, approximate $400,000 and are being charged to plant operations as incurred.

2. The Institute is committed under real estate leases to a gross annual payment of $1,101,000 in 1979. Certain leases expiring in 1978 are subject to renewal or may be renewed.

3. The Institute is committed under a lease for certain computer equipment to a gross annual payment of $922,000 in fiscal 1979 and 1980 and $692,000 in fiscal 1981. Upon its expiration in 1981, the lease is subject to renewal at a rate of $143,000 annually.

4. The Institute is committed under a long-term noncancellable lease relating to real estate. The rental under this lease is $120,000 in fiscal 1979 and each succeeding fiscal year thereafter through fiscal 2003.

G. RETIREMENT FUNDS

The Institute's retirement plans, which cover substantially all employees, are under the supervision of trustees. Plan assets are not included in the Institute's financial statements. Current service costs of the plans are funded as incurred. Pension expense charged to operations was $10,103,000 and $9,180,000 in fiscal 1978 and 1977 respectively. As of July 1, 1977, a change in actuarial methods and assumptions resulted in an unfunded past service liability of $1,480,000 which is being amortized over fourteen years. The retirement plans have been operated in conformity with the Employee Retirement Income Security Act of 1974 since January 1, 1976, and have received notification of continued qualification from the Internal Revenue Service.
AUDITOR'S REPORT

TO THE AUDITING COMMITTEE OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY:

We have examined the following financial statements of Massachusetts Institute of Technology:


Our examination was made in accordance with generally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. We previously examined and reported upon the financial statements of the Institute for the year ended June 30, 1977.

In our opinion, the financial statements referred to above present fairly the financial position of Massachusetts Institute of Technology at June 30, 1978, the revenues and funds used to meet expenses of current operations and the changes in financial position for the year then ended, and the summarized changes in invested fund balances for the ten years ended June 30, 1978 in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

COOPERS & LYBRAND

Boston, Massachusetts, September 8, 1978
GLOSSARY FOR FINANCIAL STATEMENTS

Agency Funds — funds held as custodian or fiscal agent for affiliates such as alumni and student organizations.

Appropriations Among Funds — authorized transfer of resources between fund groups.

Auxiliary Activities — refers to the operations of Dining and Housing and MIT Press.

Borrowings — represent mortgage bonds and notes payable to external agencies, institutions and others.

Current Invested Funds — expendable resources which have been invested to produce income.

Current Operating Funds — uninvested resources held for meeting current restricted or unrestricted expenses.

Endowment and Similar Funds — encompasses both endowment funds and funds functioning as endowment. Endowment funds are gifts and bequests where the donor has stipulated, as a condition of the gift, that the principal is to remain inviolate in perpetuity and is to be invested for the purpose of producing present and future income. Funds functioning as endowment are gifts, bequests and other receipts which had no restrictions as to the expenditure of principal which the Institute elected to add to endowment funds.

Educational Plant Funds — funds invested (expended) and those available for investment (unexpended) in educational plant, as well as applicable mortgage bonds and notes payable.

Fund — an entity consisting of assets, liabilities and fund balance. The assets and income must be invested or spent in accordance with the designated purpose of the fund.

General Investments — assets of funds which have been pooled for investment purposes.

Life Income Funds — gifts for investment with income payable to one or more beneficiaries during their lives. Upon the termination of life interests, the principal becomes available for Institute purposes which may be designated by the donor.

Permanent Funds — funds designated by the donor or the Institute as unexpendable.

Plant Funds — see Educational Plant Funds.

Quasi Endowment Funds — see funds functioning as endowment in Endowment and Similar Funds.

Restricted — resources, the use of which have been designated (restricted) by a donor or the Institute.

Separately Invested Funds — funds held by the Institute and maintained in separate portfolios for investment purposes.

Student Loan Funds — resources loaned to students or available for such loans.

Unrestricted — resources which are available for the general purposes of the Institute, and are not restricted as to use.

Use of Facilities Allowances — represents the portion of sponsored research program revenues received in lieu of depreciation on facilities used for such programs.
University Fund Accounting

University finances, not unlike the rest of the world in which we live, have grown more complex as the organizations themselves have grown. At the same time, the demands for more and better information from both inside and outside the institutions have increased, often with differing objectives. Colleges and universities have tried to be responsive to these demands by improving financial reports, but there are two basic differences between corporate accounting and university finances which make it difficult to understand the financial statements of an educational institution.

What follows is a brief explanation of these two basic differences — the fund accounting concept and the availed of method of accounting:

a) The concept of fund accounting, and the commonly used terms such as restricted, unrestricted, general, designated, true endowment, funds functioning as endowment, and permanent funds which all sound like very sharp and distinct categories in which funds are recorded, are often misunderstood. In addition, the use of funds can differ substantially from the narrow definition implied by the name given to a particular category. For example, a restricted fund may be drawn upon to support an activity which had been budgeted for unrestricted support in the Institute's annual budget process if the activity being supported qualifies under the restriction which governs the use of that particular fund. Used in that way, a restricted fund can fulfill a need for unrestricted funds.

b) The availed of method of accounting makes a distinction between the recording of new resources such as investment income or gifts at the time they are added to funds, and the subsequent use of these funds when applied to meet expenditures. The following description of fund accounting and the availed of method of accounting is taken from the 1973 M.I.T. Report of the Treasurer.

"M.I.T., in common with other educational institutions, reports its operations and financial conditions using fund accounting, with the financial resources of the Institute called 'funds.' An accounting standards committee has defined a fund as 'a sum of money or other resources segregated for the purposes of carrying on specific activities or obtaining certain objectives in accordance with special regulations, restrictions and limitations.' Accounting for the funds of the Institute provides information on the assets, liabilities, revenues and expenses of each fund and defined group of funds, and for the funds of the Institute in total. The fund itself, however, in all of its parts including income and principal, remains a definite unit with its use for designated objectives or general Institute purposes.

"Unrestricted funds are resources received by M.I.T. for its general purposes but are not restricted as to their use. By action of the President and Executive Committee of the Corporation, they can be applied to support operating expenses, student aid, plant construction, or to the creation of endowment. Restricted resources are contributed by donors or provided by outside sponsors for defined purposes such as scholarships, professorships, plant construction, or for specific research or educational programs.

"The flow of revenues and funds reflects the 'availed of' method of accounting. Funds accumulated from prior years as well as revenues or funds received within a fiscal year may be used for operations in that year, or set aside as endowment or for other purposes in that year, or deferred for some operating or other use in a subsequent fiscal period. Tuition revenues, net research revenues, and most of the income from investments are used within the year received, but gifts, grants, bequests and other receipts of a given year are often expended later. Current expendable restricted gifts or grants are frequently received in one year but expended over more than one fiscal period, and only the amount 'availed of' in any given year is reported as revenue."
Secretary 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 under the chairmanship of Howard W. Johnson.

CORPORATION MEMBERSHIP

At the year's end the record total of 95 Members of the Corporation included 71 Active Members, 17 Life Members Emeriti, and one Member-Elect due to assume office at the October 6, 1978 Annual Meeting of the Corporation. There were 22 individuals whose membership status changed during 1977-78 in an active year for the Membership Committee.

At its October 7, 1977 Annual Meeting, the Corporation elected Katrina M. Wootton, Class of 1977 to complete the term vacated by David R. Wilson, Class of 1973, who resigned to return to the Institute as a doctoral candidate in the Department of Mechanical Engineering. Ms. Wootton’s term ends on June 30, 1979.

The Corporation lost through death on October 16, 1977 its eldest member, Irving W. Wilson, at the age of 87, Life Member Emeritus and former Chairman of the Board of the Aluminum Company of America, who had served for nearly 28 years; and on May 15, 1978, at the age of 87, its Life Member Emeritus, Ralph Lowell, former Chairman of the Board and President of Boston Safe Deposit and Trust Company, who had served for 29 years. Their wisdom and friendship towards the Institute were expressed in many ways over years of exemplary service.

At its June 5, 1978 Meeting, the Corporation elected the following two Members to Life Membership effective July 1, 1978: Louis W. Cabot, Chairman of the Board, Cabot Corporation and Richard L. Terrell, Class of 1958, Vice Chairman, General Motors Corporation.

At its June Meeting the Corporation further elected the following seven Members to five-year terms, effective July 1, 1978: W. H. Krome George, Class of 1940, Chairman and Chief Executive Officer, Aluminum Company of America; Paul Hotte, Class of 1942, Vice President, Investor Relations, P. R. Mallory & Co. Inc.; Ellmore C. Patterson, Chairman of the Executive Committee, Morgan Guaranty Trust Company; I. M. Pei, Class of 1940, Principal, I. M. Pei & Partners; Stanley M. Proctor, Class of 1943, Founder and President, Stanley M. Proctor Company, Inc.; Edward O. Vetter, Class of 1942, Corporate Director and Consultant; and Emily L. Wick, Class of 1951, Dean of the Faculty and Professor of Chemistry, Mount Holyoke College. Brian G. R. Hughes, Class of 1977, a student at the Graduate School of Business Administration, Harvard University, was elected a Member at the same Meeting to a five-year term, effective October 6, 1978.
In addition, Joe F. Moore, Class of 1952, President, Bonner and Moore Associates, assumed an ex-officio position in the Corporation by virtue of his election as the 1978-79 President of the Alumni Association. In that position, he succeeded Norman B. Leventhal, Class of 1938, effective July 1, 1978.

Two life Members transferred to Emeritus status during the year -- Crawford H. Greenewalt, Class of 1922, Member of the Finance Committee and a Director of E. I. du Pont de Nemours & Company, Inc., with nearly 26 years of service; and Edward J. Hanley, Class of 1924, Chairman of the Finance Committee, Allegheny Ludlum Industries, Inc., with nearly 22 years of service.

Both of these retiring Life Members have served in several Visiting Committees and the Standing Committees of the Corporation. Mr. Greenewalt held Visiting Committee chairmanships in 17 of the years he served as an active Member. Mr. Hanley served a total of 12 years in the Investment Committee, and 10 years in the Executive Committee. Both are continuing their service on Visiting Committees, and Mr. Hanley continues on the Auditing Committee.

Expiration of term membership has cost the Corporation the formal services of Angus N. MacDonald, Class of 1946, President, Angus MacDonald & Company, Inc.; Charles B. McCoy, Class of 1932, Director and Chairman of the Finance Committee, E. I. du Pont de Nemours & Company, Inc.; Laurence Storch, Class of 1971, Attorney in the Office of the Legal Advisor, Department of State; and James E. Turner, Class of 1933, Retired Group Vice President, Textron, Inc. These retiring Corporation Members continue their association with the Corporation in many ways as members of various Corporation and Institute committees.

Under the Bylaws of the Boston Museum of Fine Arts, the President of M.I.T. annually appoints a representative from M.I.T. to serve on the BMFA Board of Trustees. During the past year the Institute's representative has been Professor Phyllis A. Wallace of the Sloan School of Management. Several Corporation Members also serve as BMFA Trustees. Dr. Johnson continued his service as President of the Museum of Fine Arts.

**M.I.T. LEADERSHIP CAMPAIGN**

Following a discussion at the fall meetings of the Executive Committee and at the December 2, 1977 Meeting of the Corporation, President Jerome B. Wiesner announced that he planned to concentrate his personal efforts on the Leadership Campaign between then and the fall of 1978. He further announced that during this period of time he would continue as chief executive officer but that Chancellor Paul E. Gray would assume the academic and administrative responsibilities for the operation of the Institute. This unprecedented action by a major university president was taken at a time when the Leadership Campaign total stood at $147 million and was ahead of schedule. Nevertheless, President Wiesner said that he and Dr. Johnson had come to the conclusion that further personal involvement of the President and commitment of more of his time in the months ahead to the development of Institute resources, would be an important investment to enhance the strength and quality of future M.I.T. programs.
By the June Meeting of the Corporation, the reported totals of gifts, grants, and pledges to the M.I.T. Leadership Campaign rose to $164.5 million -- close to a quadrupling of the $43 million nucleus fund originally reported at the April 22, 1975 public announcement of the $225 million, five-year Campaign -- or nearly 73 percent of the total sought was in hand or pledged.

The pattern of positive responses from individuals, corporations, and foundations in the third public year of the Campaign was a source of very great encouragement to the Campaign Steering Committee. With the total amount just over the two-thirds point of the $225 million Campaign, at the March 3, 1977 Meeting, Dr. Johnson announced that J. Kenneth Jamieson had agreed to serve as Co-Chairman of the Campaign, joining Paul F. Hellmuth, W. B. Murphy, Edward O. Vetter and himself in that capacity for the last third of the Campaign.

Corporation Members serving on the Campaign Steering Committee, in addition to Dr. James R. Killian, Jr., President Wiesner, and Chancellor Gray are: Paul M. Cook, Class of 1947, Luis A. Ferre, Class of 1924, Robert C. Gunness, Class of 1934, Cecil H. Green, Class of 1923, J. Kenneth Jamieson, Class of 1931, Breene M. Kerr, Class of 1951, Ralph Landau, Class of 1941, Carl M. Mueller, Class of 1941, Clint W. Murchison, Jr., Class of 1944, W. B. Murphy, D. Reid Weedon, Jr., Class of 1941, and John J. Wilson, Class of 1889. Paul V. Keyser, Class of 1929 is continuing his service in the Campaign Steering Committee following his completion of seven years of Membership in the Corporation in 1977.

The report on behalf of the staff organization for the Campaign, is included elsewhere. At the same time, no account of trusteeship would be complete without mentioning the crucial Campaign role the Corporation has assumed as Co-Chairmen, members of the Campaign Steering Committee, Area Chairmen, Corporation Development Committee, and Alumni Fund Board. In addition, many Members of the Corporation have headed or are heading National Sponsoring Committees for particular projects and have made historical gifts on their own. For example, Edward O. Vetter has agreed to head a national committee to emphasize the importance of endowed Professorships to the endowment object of the Campaign. Breene M. Kerr served as National Chairman of the Sponsoring Committee for the Building 10 drive to renovate Huntington Hall, Room 10-250, and to fund the new Alumni Center on the first floor of the Building 10 area of the Maclaurin Buildings under the Great Dome. Clint W. Murchison, Jr. continued as Chairman of the $7.5 million drive for a new Athletics and Special Events Center. A $1 million anonymous gift by a Member of the Corporation brought the total raised for the Center near the half-way mark. Richard L. Terrell continued as Chairman of the National Business Committee seeking major grants from US and foreign corporations. Luis A. Ferre continued as Chairman of the Council for the Arts at M.I.T., Gregory Smith continued as Chairman of the Arts Council's Development Committee and I. M. Pei is Chairman of the Arts Facilities Sponsoring Committee as the Council joined in merging its efforts with the Leadership Campaign. In Japan, Yaichi Ayukawa continued to serve as a central figure in organizing support by Japanese industry for the Leadership Campaign. The naming and establishment of the Whitaker College of Health Sciences, Technology, and Management honoring Mr. and Mrs. U. A. Whitaker was a high point of the year. The Health Sciences Fund, Inc. was also renamed The Whitaker-Health Sciences Fund, Inc. in their honor. Our Member D. Reid Weedon, Jr., received the 1977 Marshall B. Dalton Award of the Corporation Development Committee "in recognition of conspicuous and sustained service in the enhancing of M.I.T.'s financial independence." Altogether, these leadership responsibilities and actions by the Corporation constitute an unprecedented commitment by the Institute's governing body to secure the necessary resources for M.I.T.'s continued independence and strength. We are deeply grateful to the above named and to the Corporation as a whole.
MEETINGS

As a matter of record, the Corporation held four meetings during the year. At a time of continued financial stringency, Chairman Johnson, President Wiesner, and Chancellor Gray called upon all segments of the Institute community to continue the budget reductions needed to pull together in planning for a future balanced budget. In addition, through its various committees the Corporation played a key role in communicating with students, faculty, alumni, and the general public on the range of questions and issues before M.I.T.

Special thanks are due once again to the Ad Hoc Committee on Shareholder Responsibility, under the chairmanship of George W. Thorn, and to the Corporation Joint Advisory Committee on Institute-wide Affairs, under the chairmanship of Gregory Smith, for their continuing assistance to the Executive Committee and to the Corporation respectively. Walter L. Milne, Assistant to the President and the Chairman of the Corporation, served again as Secretary to the Committee on Shareholder Responsibility, in a year in which the Institute's investments in South Africa were the focal issues.

Additional thanks are due the Corporation Screening Committee, under the chairmanship of Laurence Storch, and the staff of the Alumni Association for the effort required to conduct the special alumni election needed to fill a vacancy in the membership category of younger Members. Under the leadership of Mr. Storch, the Corporation voted to amend the Bylaws again on June 5, 1978 to strengthen the nomination of Corporation Members under this category of membership; the composition of the Corporation Screening Committee was altered to include other than the five youngest Members.

In notable actions the Corporation voted to amend the Charter at the Annual Meeting to permit the Institute to enter into limited partnership in real estate trusts; amend the Bylaws on December 2, 1977 to give the new Investment Manager discretionary authority to make investments; and amend the Bylaws on June 5, 1978 to enlarge the Auditing Committee from three to five members. The establishment of the Whitaker College of Health Sciences, Technology, and Management has already been noted. Other important votes were taken to expand the Corporation Visiting Committees from 27 to 29 to establish new Visiting Committees for Whitaker College and for the Department of Athletics. Two new degree programs were also approved in the Department of Architecture -- a new Master of Science Degree in Visual Studies, a new Master of Science Degree in Architecture Studies -- and the Master of Architecture in Advanced Studies was discontinued. The Corporation further voted to approve a new Bachelor of Science in Political Science: Public Policy, in the Department of Political Science -- all in accordance with recommendations of the faculty.

Finally, under President Wiesner's leadership, discussions continued at the quarterly Meetings of the Corporation and in the meetings of the Executive Committee, Council on Resources of the Institute (C.R.I.), Corporation Development Committee (C.D.C.), and the M.I.T. Resource Development staff regarding a plan to develop a membership arrangement for non-alumni of the Institute, which would help to augment and strengthen the network of friends at M.I.T.

CORPORATION JOINT ADVISORY COMMITTEE ON INSTITUTE-WIDE AFFAIRS (C.J.A.C.)

Under the chairmanship of Gregory Smith, this Joint Advisory Committee to the Corporation completed its ninth year of operation. The Committee held slightly more meetings than during
the previous year and spent less of its time searching for appropriate agenda topics. Academic issues and the quality of life at M.I.T. represented the principal thrust of the Committee during the year. Chancellor Paul E. Gray headed a star-studded cast of faculty members who made presentations to C.J.A.C. These included Professors Robert I. Hulsizer, Richard M. Douglas, Thomas J. Greytak, Kenneth Hoffman, and Sherry R. Turkle on Committee on Educational Policy (C.E.P.) issues, Admissions, Committee on Academic Performance (C.A.P.) issues, government intelligence activities, and the quality of life, respectively. We acknowledge their presentations with deep gratitude. The writer wishes to emphasize once again the valuable contribution C.J.A.C. has made in building respect and mutual understanding within the M.I.T. community, despite the reduced level of Committee activity. Particular credit is due the chairman, Gregory Smith, for his skillful leadership of C.J.A.C. The Committee was assisted in its deliberations by the brilliant and devoted volunteer staff support of Martha L. Bertrand. Without her donated assistance, this office could not have provided staff support to C.J.A.C. We are deeply indebted to her.

DEDICATIONS AND SPECIAL FUNCTIONS

The Corporation continued to carry prime responsibility for dedications of major facilities. Notable ceremonies this year included the public announcement of the naming of the Whitaker College of Health Sciences, Technology, and Management at the Corporation Luncheon on October 7, 1977 following the Annual Meeting. Dr. George W. Thorn was the principal speaker. Dr. Wiesner and Dr. Johnson expressed appreciation to Mrs. Helen F. Whitaker, our Corporation Member and her late husband, U. A. Whitaker, for their generosity and foresight in making it possible to establish Whitaker College. Mrs. Whitaker was presented with a commemorative scroll containing the resolutions of the Corporation on the naming of Whitaker College and its establishment at M.I.T. In a closely related development, the Joint Harvard-M.I.T. Program in Health Sciences and Technology was granted the status of a Joint Division with its M.I.T. component rooted in Whitaker College. Dr. Irving M. London was subsequently appointed Director of both the Whitaker College and the Joint Division.

Also on October 7, 1977, Drs. Wiesner and Gray headed a group of speakers at a ceremony to dedicate and name four of the six Houses in the New West Campus Houses, a residence for undergraduate students at 471-476 Memorial Drive. Honored by these actions were William A. Coolidge, our Life Member Emeritus; Thomas C. Desmond, Class of 1909; our late Life Member Leonard D. Lawrence, Class of 1928; and Jonathon (Class of 1923) and Blanche Ballard. Later that same day, the new Alumni Center and associated Margaret Hutchinson Compton Gallery and courtyard were dedicated in the renovated Huntington Hall, at the opening of the 1977 Alumni Officers Conference. Mrs. Compton was unable to be present for the opening but was honored again at the December Corporation Luncheon, when a portrait of her was unveiled and later hung permanently at the Gallery Entrance; and the first exhibition, The Compton Years, was opened in the Gallery. Messrs. Breene M. Kerr and Edward O. Vetter planted ceremonial trees in the adjacent courtyard on October 7, and it was subsequently designated in honor of Alumni Association Presidents by the Executive Committee and the Corporation.

Other notable ceremonies and events during the year were: the distribution of Corporate Leadership Awards to a second group of 16 Awardees at a Corporation Luncheon in Chicago on December 16, 1977 at the Chicago Club, Robert C. Gunness acting as host and Drs. Johnson and Wiesner serving as speakers; the official opening of the Interim Care Facility for Laboratory Animals on Vassar Street on March 3, 1978; the dedication of ALCATOR-C plasma fusion machine on April 7, 1978, Dr. Albert G. Hill presiding and President Wiesner joining as a speaker with faculty members and representatives of the US Department of Energy; an
April 12, 1978 dinner at the River Club of New York City for the M.I.T. Corporation and the Council for the Arts in connection with a Lincoln Center performance of the M.I.T. Symphony Orchestra, Angus N. MacDonald serving as host; the dedication of the Henry G. Steinbrenner (Class of 1927) Stadium on April 30, 1978, Dr. Johnson presiding and Chancellor Gray, Professor Ross H. Smith, and members of the Steinbrenner family speaking; the dedication of a plaque on the exterior wall of New England Mutual Life Insurance Company at 501 Boylston Street in Boston, on May 30, 1978, commemorating the Rogers Building, M.I.T.'s first permanent home, Dr. Gray joining Abraham T. Collier, president of the company as co-speakers; and the observance of the Tenth Anniversary of the Wellesley College-M.I.T. Exchange Program, with President Barbara W. Newell of Wellesley College marching in the June 5, 1978 Commencement as a guest of honor.

CORPORATION VISITING COMMITTEES

1977-78 was a year of sharply increased activity for the Corporation Visiting Committees. Compared with 14 of the 27 Committees which met during the 1976-77 year, 20 meetings were scheduled in 1977-78. Two of these meetings involving the Visiting Committees for Sponsored Research and the Department of Political Science had to be cancelled because of the Blizzard of 1978, but they have been rescheduled for the fall of 1978. In all, 17 Visiting Committees held meetings in 1977-78, including an initial meeting of the newly established Athletics Visiting Committee on February 15 and 16 under the Chairmanship of Irenee du Pont, Jr. One of the 17 Visiting Committees, that for the School of Architecture and Planning, held separate subcommittee meetings for the two Departments of the School.

These 18 meetings involved roughly half of the total Visiting Committee membership which now exceeds 500 members with the addition of an Athletics Visiting Committee. This actual level of Visiting Committee activity was somewhat higher than expected. This was due to a buildup of unsatisfied demand for meetings during 1976-77 following a guideline set by the Corporation during 1975-76 to reduce the frequency of meetings for Visiting Committees. Thus, although the number of meetings dropped from 18 to 14 in the first year of operation of the new policy, the number climbed back to 18 meetings in 1977-78 and would have been higher were it not for the two storm cancellations.

The rationale for fewer meetings is sound in the light of the increased outreach activities of the Institute during the intensive period of off-campus campaigning under the current capital drive. In addition, the turnover among Department Heads, in recent years averaging around 20 percent, has mitigated the demand for meetings somewhat, as Visiting Committee Chairmen have tried to recognize the need for new Department Heads for adequate time to develop their plans.

We are still hoping to settle in at a level of about 15 or 16 meetings a year, evenly divided as between the fall and spring semesters. The calendar for 1978-79 is headed in this direction, with eight of the Visiting Committees already scheduled to meet during the first semester. I want to recognize the dedicated work of Ellen W. Reinhard of this Office in the arduous task of scheduling these meetings.

Several features of the meetings which have proved successful in the past were continued by the Committees this year. All 18 meetings, save one, included dinner at which the Committee members were brought together informally with members of the faculty and administration and in a few cases with students. 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 junior 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. Five of the Departments visited were headed by new Department Heads, which lent an additional element of importance to those meetings. Virtually all of the Departments visited continued to show budget strains. Those in the School of Engineering reflected the additional problems posed by the dramatic shift of enrollments towards the School of Engineering.

Attendance by members of the Visiting Committees has been outstanding this year. The 18 meetings had an average of 14 members per meeting. In addition, 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. Warm thanks are due Provost Walter A. Rosenblith for his continued energetic participation both in the meetings and in the selection of new Committee members, and to the more than 300 faculty members who participated in the sessions of the Visiting Committees.

Of the Committees meeting in 1976-77, all but one of the Chairmen have now reported orally to the Corporation, and all but one have submitted written reports. 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 M.I.T. The Academic Council now 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.

We are still handicapped by reduced staffing of the Visiting Committee operation due to budgetary considerations. The search for volunteer assistance with Visiting Committee arrangements continues in order to help fill a staff vacancy. In this interval, Jerilyn K. Edmondson, Ellen W. Reinhard, and the writer are sharing the overload.

Finally, in this period of reduced support services throughout M.I.T., I wish to thank Rosemary Carpenter of the M.I.T. Alumni Association for her exceptional support of the nomination of alumni to the Visiting Committees and for her assistance to the Corporation Screening Committee for younger alumni. The smooth operation of the special election of younger alumni as nominees to the Corporation has been due in no small measure to her dedicated service and cheerful helpfulness at all times.

VINCENT A. FULMER
The 1977-78 year was highlighted by the Alumni Association's move into the new Alumni Center in Building 10. A gift of the alumni to the Institute, along with the complete refurbishing of Huntington Hall (10-250), the new location impacted positively on alumni, student, and faculty programs, commencing in the fall with the Alumni Officers Conference (A.O.C.). The Conference opened on Friday, October 7 with a reception in the then unfinished office area and the newly completed Margaret Hutchinson Compton Gallery, a gift of the Class of 1938. The Gallery featured an exhibit of "The Compton Years." The next morning Frank Press, Science Advisor to President Carter and former Chairman of the Department of Earth and Planetary Sciences, officially opened Huntington Hall by presenting the first Robert H. Richards Alumni Lecture to 450 Alumni Officers and their guests. In January the entire staff moved into the Center and, in February 600 faculty, alumni, and guests attended an Open House honoring Professor Harold E. Edgerton, Class of 1927 in conjunction with the opening of an exhibit of his work in the Gallery. During Technology Day another 400 alumni attended a reception featuring a Gyorgy Kepes Exhibit, "The M.I.T. Years: 1945-1977."

During the year, the Association continued working toward its goal to build a national alumni volunteer organization with national breadth and penetration. The strategy continues to be that of working at the local level, through Regional Directors as staff, to set, area by area, local goals, strategies, and tactics.

A second prime goal has been to significantly increase the level of annual gift income to the Institute through the Alumni Fund. The Alumni Fund Board set as a goal for the Fund the achievement of a $6 million annual giving level to be reached by the end of the Leadership Campaign in 1980. The results of the current (1977-78) Fund year of $4,969,076 from 20,849 donors indicates that the $6 million goal is achievable but that a considerable challenge remains in increasing the number of donors.

Two further questions remain on the Fund's performance and organization. First, without the impetus of a Challenge Gift and the Leadership Campaign, both of which have contributed significantly to the success of the Fund during the current year, can and how does the Fund maintain a level of annual giving in excess of $6 million? Second, at the completion of the Leadership Campaign, how does the Volunteer Campaign effort and donor accomplishment merge into the Alumni Fund effort so as to provide a maximum level of annual financial support for M.I.T.? Both of these questions will require the continued attention of the Fund Board and the new Director of the Alumni Fund, Stephen Denker. Dr. Denker moved in April of 1978 to the position of Director from his post as Regional Director for New York.

The Association's goal of broadening and increasing the participation of alumni volunteers was substantially advanced through the efforts of the Association's President, Norman B. Leventhal, Class of 1938. During his tenure, Mr. Leventhal took progressive action to increase the leadership role of the members of the Association National Boards and Committees. Alumni Officers became more involved in setting goals and policy for internal operations, the Fund, Technology Review, and Alumni Relations programs. Mr. Leventhal brought a steady and experienced hand to all aspects of the Association's business and the Association expresses its sincere gratitude, as Mr. Leventhal continues to serve M.I.T. in several capacities. He is succeeded in the presidency of the Association by Joe F. Moore, Class of 1952. Mr. Moore has
recently served the Association as a Vice President and member of its Board of Directors. He has been an active alumnus, both nationally and in Houston, Texas, where he resides. Mr. Moore is President of Bonner & Moore Assoc., Inc. of Houston. His recent intense involvement in the business of the Association and his enthusiasm ensure the Association continued outstanding leadership.

ALUMNI RELATIONS

During the year alumni, faculty, students, and parents visited the Alumni Center and the Gallery in large numbers. For the last five months of the academic year, after the move was completed, nearly 150 meetings, attended by over 6,000 people, were held in the Center's facilities, primarily in the Vannevar Bush Room. Dorothy Adler in her position as secretary to Richard Knight, receptionist for the Center, and Manager of the Bush Room, brought warmth, graciousness, and good management to this role.

A major thrust during the year was directed toward building stronger ties with students. Clearly our new location helped. Thirteen senior dinners, designed to acquaint students with the Association, attracted 350 people. Career seminars and one seminar on "Alumnihood" during I. A. P. attracted 190 students. The senior class worked closely with the Association to produce two newsletters, and, for the first time in many years, a senior gift.

The Host Family Program, a subcommittee of the Committee to Strengthen Alumni Involvement with the Institute, headed by Fagi Levinson, served 120 students, almost double the number of a year ago. Most Association staff members also acted as advisors to freshmen. Clubs also worked with students by conducting meetings over the Christmas holidays with potential, current, and past students; April meetings for admitted students and their parents; and summer social gatherings to which current students were invited. A large number of clubs implemented programs to assist students in finding worthwhile summer employment. The New York Alumni Center hosted the M. I. T. Symphony Orchestra in April at Avery Fisher Hall at a concert which attracted an audience of 2,300 people. Ten Clubs arranged for six performances by the Shakespeare Ensemble which entertained audiences of 860, and four presentations by the Logarhythms drew audiences of 175. Alumni also housed the students on these trips. The Club of Maryland held a reception for the Sailing Team and housed the team twice, first while they were competing in the MacMillan Cup and later when they were competing in the Kennedy Cup Regatta.

Several other student groups began to perceive the Association as a resource. One group, the Lecture Series Committee, donated $2,500 to the Building Ten Fund. In subtle, as well as structured ways, the Center acted as a catalyst in strengthening on-campus ties.

The National Boards and Committees continued to review their roles as they related to the planning cycles and their long-range objectives. Under President Leventhal's direction the Board of Directors played a stronger role in policy decisions. Ad hoc committees of the Board were established to look into issues relating to Technology Review and the internal operations of the Association. The latter group was instrumental in introducing Data Base Management Software on an Institute-wide basis and both promise to be of continued help to Institute as well as Association staff.

The Board awarded 14 Bronze Beaver Citations, the highest award given by the Association to the following alumni for outstanding service: Dwight C. Arnold, Class of 1927, Kenneth S. Brock, Class of 1948, Peter C. Hand, Class of 1948, Charles K. Holmes, Jr., Class of 1949, Norman R. Klivans, Class of 1940, Frederick G. Lehmann, Class of 1951, James K. Littwitz,
Alumni Association


To assist in this most difficult selection process and to further consider means of recognizing alumni service, the Board established an Awards Committee and appointed six past recipients of the Bronze Beaver Citation to serve on the Committee.

The Alumni Council Program and Membership Committee, determined to build a more purposeful organization, continued to involve more active alumni with programs designed to enable alumni to serve the Institute leadership as a knowledgeable forum for long-range issues. President Jerome Wiesner, Provost Walter Rosenblith, Chancellor Paul Gray, and Dean Robert Alberty discussed the complex issues which the administration faces in reaching academic, research, and fiscal policy decisions.

The Committee on Nominations for Corporation Visiting Committees emphasized departmental need even more in their search for nominees. Vincent Fulmer, Secretary of the Institute, in commenting on the role of this Committee and the staff effort required effectively to support the Committee, paid tribute to Rosemary Carpenter "for her exceptional support of (this committee) and for her assistance to the Corporation Screening Committee for younger alumni."

At the recommendation of the Club Advisory Board an attitude survey was sent to a selected sample of alumni. The survey was designed to provide some measure of alumni perceptions of the Institute, current activities, communications, their involvement and our image in their local community. Since the survey was designed to measure trends, time will be required to develop baseline data. In general, however, the results suggest that alumni have positive feelings toward the Institute, although most rate their interest in becoming more involved as moderate to low. The Association plans to continue the survey annually so that over time trends or differences between constituencies may be discerned.

Alumni, stimulated by a stable and seasoned staff, continued to show a high level of interest in M.I.T.-related programs, as the following table indicates:

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<td>18,476</td>
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581
Attendance at Technology Day, essentially a Class Reunion activity, was down slightly due almost entirely to restrictions on floor seats at M.I.T. Night at the Pops, necessitated by much higher reunion attendance and more interest in attending by students and faculty. Although 14 departments held department open houses, they were generally sparsely attended, suggesting that some other type of program may be better suited to building departmental ties. Next year's Technology Day Committee plans to study the objectives and the market strategies for this event. Reunion attendance was at an all-time high -- all 14 quinquennial classes from 70th to 5th held all or part of their reunions on campus with 2,361 alumni and their family members attending. The A.O.C. attracted the largest number of alumni in history. Summer College was a disappointment, resulting in cancelling a session in Hawaii. It is believed that the low interest was due in part to the selection of Hawaii and to the nature of the promotion. The Association plans to continue these programs next year. A Boston Seminar Series, run for the second year, consisted of six evening dinner seminars to which 43 alumni subscribed. The Association plans to repeat this program next year and to run a similar series in New York. Staff support was redirected this year from conferences and seminars to Summer College and student programs, although the Association, in conjunction with the Sloan School and local organizations, sponsored two management seminars, in New York City and in Chicago.

Club activities were at an all-time high, and very likely close to the level which our staff and our alumni can sustain. Fifty-five different clubs held 232 meetings which 15,816 alumni, students, and friends attended -- double the attendance of just four years ago. As previously mentioned, an increasing number of meetings and programs were student oriented -- a trend which we believe will continue. One new club, Ft. Lauderdale, was formed, and clubs in Minnesota, New Haven, and Detroit were reactivated. Our new clubs on Cape Cod, in Palm Beach, and in Princeton continued to have diversified programs and a high level of interest.

Over the year nearly 200 club mailings were sent at least once to approximately 40,000 alumni from local M.I.T. organizations. With encouragement from the Regional Directors the quality of these mailings continues to improve with more clubs moving in the direction of newsletters.

As in the case of mailings, clubs communicated an M.I.T. presence in the local community and they provided a local forum for the M.I.T. faculty. Over the year, 74 members of the M.I.T. faculty and administration spoke to 7,655 alumni and their guests at 80 events organized by 48 different alumni organizations. Of these M.I.T. representatives, 15 addressed more than one M.I.T. organization and the following six spoke to five or more: President Jerome B. Wiesner (7); Dean Emeritus Irwin W. Sizer (7); Provost Walter A. Rosenblith (6); Dean Carola Eisenberg (6); Chancellor Paul E. Gray (6); and Institute Professor Harold E. Edgerton (5).

The Mexican alumni had their 31st Fiesta in Guanajuato at which Dean Eisenberg was the honored guest. In addition to these student and faculty programs, Clubs held many other programs with outside speakers, many of whom were M.I.T. alumni. They held plant tours, career clinics, venture clinics, musical and theatre evenings, museum tours, embassy parties, summer picnics and boat cruises, panel discussions, and business luncheons. In all it was a good year with a wide diversity of programs.

NOMINATIONS AND ELECTIONS

The National Selection Committee met on November 21, 1977 to select the Association's Corporation nominees and national officers as follows: for five-year terms on the Corporation.
Paul Hotte, Class of 1942, Stanley M. Proctor, Class of 1943, and Emily L. Wick CM, Class of 1951; for a one-year term as Association President, Joe F. Moore, Class of 1952; for two-year terms as Association Vice Presidents, Harl P. Aldrich, Jr., Class of 1947, and Charles K. Holmes, Jr., Class of 1949; for one-year term as Association Vice President, George M. Keller, Class of 1948; for two-year terms as Association Directors, District 1, Marvin C. Grossman, Class of 1951; District 2, Emily Wade, Class of 1945; District 4, S. James Goldstein, Class of 1946; and District 5, Robert F. Calman, Sloan Program, Class of 1967.

A ballot was sent to all alumni in April containing the names of 11 alumni nominated by their clubs to serve three-year terms on the National Selection Committee. Dorothy G. Levinson, Class of 1957, Pittsburgh, Pennsylvania; Charles K. Holmes, Jr., Class of 1949, Atlanta, Georgia; and John W. Barriger IV, Class of 1949, Chicago, Illinois, were elected to serve on the Committee.

The response to the ballot this year was 4.58 percent, approximately the same as in previous years.

The Association also supports the election process for membership on the M.I.T. Corporation of a member from the three recent classes 1976, 1977, and 1978. Brian G. R. Hughes, Class of 1977, was nominated from a slate of 10 candidates to serve a five-year term on the Corporation. The ballot response this year was 12 percent, the highest since 1972.

A total of 76 alumni were nominated by the Association's Committee on Nominations for Corporation Visiting Committees to fill vacancies on the Visiting Committees and a new Visiting Committee for the Department of Athletics was established. Twenty-eight alumni were appointed by the Board of Directors to fill vacancies on the Association's seven national Boards.

**ALUMNI FUND**

The year 1977–78 was another extraordinary one for the Alumni Fund. A total of $4,969,076 was received from 20,849 donors. This gift total was up $117,916 from 1976–77. Several components of the Fund continued to contribute to its success. These included volunteer efforts for the regional program with 229 regions now organized, a special gifts program conducted primarily in the fall of each year, Class and Course programs, and telethons through which over 2,000 alumni were contacted.

This year a special emphasis was placed on increasing the participation by recent graduates in the Alumni Fund. A special Young Alumni program was created. This year's program emphasized the revised Challenge 78 rules for Young Alumni, which included matching any increase in an alumnus' gift over his or her last gift, personal solicitation programs, and telethons. Each of the five most recently graduated classes experienced growth. Participation in the Alumni Fund by the Class of 1976 recovered from four percent in 1977 to over 16 percent in 1978. The Class of 1977 achieved over 15 percent during their first year following graduation. The Class of 1978 achieved over 15 percent during their first year following graduation.

A Senior Class Gift program was reinstated after several years. The Class of 1978 raised $822 and achieved over 25 percent participation. These funds are designated to provide for improvements in the lobby of the William Barton Rogers Building.

As compared to dollars, however, donor participation in the Fund for 1977–78 continued to be disappointing. The number of donors decreased by 279 below 1976–77. This represented the
fifth year in which donor participation failed to increase. Although several factors appear to be contributing, much weakness continues in the number of donors from recent classes and by donors who do not contribute from year to year, but irregularly. Although up significantly from last year, the percent participation from younger classes is below that historically experienced by the Fund. Special attention will continue to be given to both problems during the coming year.

The 25th, 40th, and 50th Reunion Classes of 1953, 1938, and 1928 reported five-year reunion gifts of $244,000, $606,851, $1,225,000 respectively. Several special projects of the Fund were also particularly successful. Among these were the Ellen Swallow Richards Professorship which received $41,504 in gifts and earned additional money in Challenge Funds; the Independent Residence Development Fund received $198,490 in gifts and also earned additional Challenge Funds.

The 1978 Fund year has continued to be an outstanding one for the Building Ten Fund. Under the chairmanship of Breene M. Kerr, Class of 1951, the Building Ten Chair Fund and Compton Gallery Fund achieved a total of $468,000 in gifts and pledges in the 1978 Fund year, bringing the project to a total of $1,168,000. In addition, the Class of 1955 has made a pledge which should put the project well over the top. The newly renovated Huntington Hall (10-250) was dedicated at the October 1977 Alumni Officers Conference and the staff of the Alumni Association has been housed in its new Alumni Center since January 1978. The strong appeal of the project and the 10-250 chair opportunity ($2,000 per chair), of which over 200 have been sold to date, has accounted for the extraordinary success of the Building Ten program.

A total of $122,539 was received for undergraduate scholarships; an additional amount was earned from the Challenge pool for this purpose.

In April 1978, Stephen P. Denker, Class of 1959, assumed the position of Director of the Fund. Dr. Denker has served for two and a half years as Regional Director for the mid-Atlantic States. His office was located in the M.I.T. Alumni Center of New York, 50 East 41st Street, New York, N.Y. 10017.

TECHNOLOGY REVIEW

The year 1977-78 brought more change to the business than the editorial aspects of Technology Review.

But the editors make no apologies: Volume 80 is a good one, probably a better editorial product than any of its predecessors. The December 1977 issue was outstanding by any measure, including seven articles by important authorities in the field of archeoastronomy -- "the astronomy of the ancients." It resulted from a seminar series arranged by Professor Kenneth Brecher of the Department of Physics, who collaborated as Guest Editor with Michael Feirtag of the Review's Board of Editors to produce this large and unique magazine.

We are also indebted to Myron A. Exelbert, GM 1963, for his collaboration with the editors in bringing a series of articles on innovation to Volume 80 of the Review. Authors included Professors Edward B. Roberts, Eric A. von Hippel, and Lester C. Thurow of M.I.T.; George R. White, Vice President of Xerox Corp.; Robert N. Noyce, Chairman of Intel; Alan R. Fusfeld of Pugh-Roberts Associates; and William J. Abernathy (Harvard) and James M. Utterback (M.I.T.). Most of these were speakers at a symposium on "The Management of Innovation" arranged in 1976 by a committee of the M.I.T. Alumni Center of New York, of which Mr. Exelbert was Chairman.
Other notable articles of the year have included "Enhanced Radiation Warheads, Alias the Neutron Bomb" by George B. Kistiakowsky (May), "Computer Animation: Snow White's Dream Machine," by Kenneth Kahn and Henry Lieberman (October/November); and "Food Security for the World's Poor," by Lance Taylor et. al. (February).

Sara Jane Neustadtl became Managing Editor early in the year, succeeding Dennis L. Meredith who accepted a new assignment at the California Institute of Technology; and her place was ably taken by Leonard A. Phillips, formerly at Houghton Mifflin. A further change occurred in the spring of 1978 when Deborah McGill was named Assistant Editor at Harper's Magazine; her place (as editor of "columns" reviews, and letters) was taken by Susanne Fairclough, and Ms. Fairclough's responsibilities for the Class News section were taken by Sandra Knight.

Circulation

Evelyn Milardo, who joined the Review as Circulation Manager as the year began, has brought a new level of expertise to our sales and service programs. One result is that the Review's paid circulation has gradually increased through the year, standing at the end of the year close to 24,000. Mailing list rentals have increased, and the renewal rate remains (stubbornly, one may say) in the vicinity of 50 percent. Sixty percent is a reasonable goal, and one purpose during the coming year will be to understand and -- if possible -- improve our performance in this area.

Fulfillment of our non-alumni (paid) subscriptions was transferred during the year to Information Services, Inc., of Babson Park and Whitinsville, Massachusetts. That we weathered with little confusion the transition in these services from M.I.T. to ISI is to the credit of Ms. Milardo and -- especially -- of Dorothy Finnerty, Fulfillment Manager; it is now apparent that the new arrangements are increasing our efficiency and decreasing our overhead.

Advertising

Perhaps the outstanding event of the year was the invitation from The Leadership Network, Inc., to represent Technology Review for national advertising. By accepting the invitation, the Review joined a group sales arrangement including seven other "upscale" magazines, among them Foreign Affairs, Atlas World Press Review, The New Republic, Commentary, and the New York Review of Books. By making a "group" approach to advertisers, The Leadership Network has brought several national advertisers into the Review to whom we could not have sold space individually, and advertising revenue is already significantly increased.

The Review also has benefited from increasing interest from specialized advertisers with messages for science/engineering/management readers, and we close the year with more advertising revenue than in any recent previous years.

To support the efforts of Richard F. Wright, Advertising Manager, in selling the Review, we joined the Audit Bureau of Circulations late in 1977; we are thus audited regularly as a paid-circulation magazine with figures made available regularly to the advertising community by the Bureau.

Surveys

As the year ends, two surveys of Technology Review readers are in process. One, by The Leadership Network, will show how our readers compare with those of other magazines in the Network in loyalty to the magazine, economic status, and professional interests. The other,
Alumni Association

an intensive telephone survey of selected "expert" readers by Management Analysis Center, Inc., of Cambridge, is intended to provide an evaluation of the magazine in terms of the interests of potential readers.

Both of these studies will be helpful in the detailed study of the Review and its service to alumni and the Institute to be made by a committee of the Alumni Association during the coming year.

JAMES A. CHAMPY