

Massachusetts Institute of Technology
Bulletin

Report of the President and the Chancellor Issue
1975-1976

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President and Chancellor

In our Reports of the past several years, four interrelated priorities have been emphasized: the search for a set of operating conditions to insure the long-term fiscal integrity of the Institute; support of the continued development and evolution of M.I.T.'s departments and laboratories; the development of more comprehensive and interrelated educational and research activities that contribute to the understanding of modern society and its humane and effective management; and enlargement of the growing intellectual role that more, and more varied, connections between M.I.T. and other organizations can play in the Institute's educational and research programs. In this Report we would like to discuss these issues explicitly and describe our view of how they affect the Institute and how they are affected by the setting in which the Institute functions.

These priorities are to some degree in conflict. For example, attainment of a stable set of financial operating conditions has required close attention to the growth of expenses and planned reduction of costs in most areas of Institute operations. We fully realize that continuing cost-control efforts can jeopardize the vitality of academic programs and essential support functions, and we have endeavored to maintain an appropriate balance between the intellectual needs of programs and the financial capabilities of the Institute.

Also, in a taut financial climate proposed new programs and existing activities inevitably compete for scarce resources. As a result, new programs are judged by criteria more stringent than those employed in the past, particularly with respect to the programs' ability to attract new resources. While the effect has in many respects been salutary, the shortage of venture capital, which slows down continued development and evolution in every field, tends to affect even the most dynamic and most promising activities. Even when a field happens to receive special national attention and thus somewhat more generous support for relevant research activities, as in the case of the Energy Laboratory, the development of associated new academic programs remains difficult to fund. Prudence clearly dictates an emphasis on the support of the vital core of the Institute. In the present situation we believe that it is necessary to concentrate more of our attention than just a few years ago on maintenance of the outstanding quality and enthusiasm of the faculties of the traditional groups, departments, and laboratories. This often involves the support of new intellectual ventures and we maintain a major commitment to recently-initiated programs, including the Center for Cancer Research, the Energy Laboratory, and the Harvard-M.I.T. Program in Health Sciences and Technology. These centers are now well established and contributing to the intellectual vitality of the Institute, to important national problems, and to the Institute's financial well-being. The Center for Policy Alternatives and the Division for Study and Research in Education are also on course in their development. We shall continue to seek ways to support other emerging, new activities of high quality that will become vital aspects of a future M.I.T.

Our efforts to achieve a satisfactory and lasting balance between operating expenses and revenues have led to the elimination of certain marginal activities, to broadly-based improvements in the efficiency and effectiveness of some operations, and to reductions in the level of activity of some essential support services. At the same time we have undertaken multiple efforts to increase recurring operating revenues. These efforts include a modest expansion

of the size of both the undergraduate and graduate student bodies, increases in sponsored research activities, augmentation of the Industrial Liaison and M.I.T. Associates Programs, and the initiation 18 months ago of the Leadership Campaign.

We expected that cost control and income enhancement efforts, together with a lessening of the rate of inflation and improvement in investment income as the economy recovered from the recession would bring the budget back into balance. Although operating expenses for 1975-76 exceeded recurring revenues from all sources by approximately \$2.6 million, this imbalance was, in fact, approximately 25 percent less than we had anticipated, and about half of the corresponding figure for the preceding year. Our present expectation is that the imbalance in operations will be reduced again in the year now beginning and that the operating budget will be at least in balance in the year that begins in July 1977. This progress has been helped substantially by the early results of the Leadership Campaign which has been gaining momentum over the past year; its success is an essential part of the Institute's economic health.

Our fiscal goal for the future can be stated in two parts. First, we must achieve a financial condition in which current unrestricted gifts will not be committed primarily to support current operations, as they have been for the past four years, but will be available, at least in part, for the initiation of essential new academic programs, for critical renewal of facilities, for additions to endowment, and for other capital purposes. Second, we must achieve a balance between the rates of growth of expenses and revenues so that the financial state of the Institute is reasonably stable. The second objective is the more difficult one, for it requires reasonably steady growth in both investment income and gift revenues, and these in turn depend critically on the state of the economy and on other variables not under our control. In the first stages of our struggle with the budget, broad and general cost control was tolerable, increases in student numbers acceptable and attainable, consolidation of selected academic activities healthy, and increases in research volume generally supportive of academic programs. But such efforts have many pitfalls too, and in order to deal with the financial situation in ways that will strengthen, and not weaken the Institute, we have undertaken a set of in-depth studies to guide future actions.

In this connection, a Committee on Research Structure, led by Professor Frank Press, was appointed to assess the impact of the changing national research climate on the operations of M.I.T. and to recommend appropriate changes in the Institute's style of conducting research. The Committee's Report identifies a series of problems, needs, and opportunities, and culminates in a wide-ranging set of recommendations which will be discussed by the faculty and administration during the coming year. The Committee concentrated on two issues: the Institute's financial situation, especially as it relates to research; and the need to develop new opportunities for young people during the 10-year period ahead when there will be relatively little faculty turnover or growth. The Report concludes that M.I.T.'s intellectual vitality and, indirectly, its educational programs can be enhanced by emphasizing research centers, closely related to departments, as a source of new research and funding opportunities. The Committee recommends that we strengthen these activities by providing a broader range of research career opportunities on the M.I.T. staff. It also identifies a series of steps which would ease the tasks of faculty members engaged in the search for research support.

The nature of the budgeting process in recent years has provided insufficient opportunity for the departments, laboratories, centers, and administrative officers to plan, more than one year at a time, for the best use of the resources that would be available to them and to discuss their opportunities and needs with us and with the Provost. To permit a more sensitive, selective, and effective budget process, we are developing the 1977-78 and the 1978-79 academic budgets simultaneously, and have begun a comprehensive review of programs in the individual Schools and academic departments as well as in some of the major centers. We are finding this process to be helpful in developing a more finely-honed sense of the intellectual opportunities available to the various departments and centers, and we expect that available

resources can be applied strategically to enhance these opportunities. A parallel study of selected administrative units has begun with the hope that opportunities can be found for further economies, consolidation of efforts, and improved services.

During the past year we have had to contend with a new uncertainty of major proportions. The future financial viability of the Institute and the other graduate universities of the nation has been threatened by proposals for major changes in the overhead reimbursement policy of the Federal government. These proposals are now under intensive discussion between university business officers and the government. We hope and believe this year's round of discussions will end in a document which assures that the universities will be reimbursed for fair and reasonable costs. Nonetheless, everyone concerned with the health of the American research establishment or the well-being of the nation's distinguished universities should be aware of this danger.

Since the end of World War II the extraordinary strength and quality of American science has been fostered and primarily supported by far-sighted Federal policies which were manifestations of the belief, shared by the Congress, that an outstanding base in science and technology was a prerequisite for an adequate national defense, a healthy nation, and a prosperous economy. It was a matter of policy to encourage an increase in the volume of fundamental and applied research through the growth of the nation's existing research oriented universities and the support of new centers of excellence. This was done primarily through the mechanism of research grants to individual faculty investigators and by providing financial help with necessary facilities. At a few key institutions, M.I.T. among them, growth was facilitated further by the establishment and support of large research centers such as the Research Laboratory of Electronics, the Laboratory for Nuclear Science, and the Center for Materials Science and Engineering. Because it was recognized that the universities, especially the private ones, had no independent means of funding the additional costs of the substantial growth hoped for, a policy of full cost reimbursement was established. These arrangements, which evolved into a Bureau of the Budget document, Circular A-21, have for years been the basis of negotiations between university business officers and government contract supervisors. The consequences of favorable Federal policies are clearly evident in the preeminent position of U.S. science and technology and in the leadership of U.S. technical education.

The costs associated with research have been rising because of the combined effects of inflation and the increasing sophistication of research that inevitably occurs with the passage of time. For almost a decade Federal support of research has not kept pace with the increase in costs. However, universities have adjusted to this austere climate with only moderate impact on the quality of the research effort. At the same time a more dangerous situation has been developing. A few Federal agencies, under pressure from cost-conscious legislators, and perhaps unaware of the long-standing commitment to full cost reimbursement or the damaging effects of abandoning it, have insisted on a dramatic increase in the level of cost-sharing. Federal funding agencies, acting in response to Congressional urging, are proposing steps to limit or eliminate reimbursement for certain categories of direct research costs such as faculty time committed to research, as well as for the essential and legitimate indirect costs of research activities.

A major change in the policy of full cost reimbursement would cause extreme difficulties for the universities at almost any time. Coming now, after several years of diminished resources and extraordinary inflation, it would cause a serious disintegration of the research efforts at essentially every major university, including M.I.T. Furthermore, as the universities adjusted their allocation of resources to the new situation, all of their programs, non-technical as well as technical, would be affected. Fortunately, it has been possible to establish a responsive dialogue with representatives of the executive and the

legislative branches of the government, to gain an understanding of their concerns, and to explain the complexities and limitations of university research support. We hope that these efforts will contribute to the reestablishment of constructive agreements for the Federal support of the university component of the national R & D effort.

While the Federal government's stance vis-à-vis support of research is of critical financial significance to the Institute, both in terms of the kinds of costs deemed reimbursable and the internal mechanisms which the Institute develops to take best advantage of the configuration of Federal programs (the topic of the Press Report), of equal importance is the intellectual renewal which the Institute derives from its partnerships with other organizations -- among them, government agencies, private foundations, and businesses. Our desire and need for such relationships is not new. M. I. T. people have always drawn much of their stimulation from interactions extending beyond the boundaries of the Institute, but the intensity of those relationships fluctuates and they change in form over time. Organizations with quite different roles in our society share in its problems and this generates a growing mutuality of interest and a search for the ways in which their complementarity can be used to the benefit of all.

Current issues of mutual interest include the role of technology in the society, concerns about adequacy of energy and resource reserves, concerns about the environment, fiscal pressures, alarm about the effects of increasing governmental regulation, and concern for the health and viability of our democratic social system. Basically, these are all questions of adaptation to an ever changing, ever more complex technological society. They are problems involving choice among increasingly unclear options. M. I. T.'s role is to help achieve adequate understanding of the options available. Our links with governmental and industrial groups involve programs of educational renewal; continuous interaction on technical and scientific developments, and shared research interests.

M. I. T.'s continuing education efforts have emphasized two styles of endeavor -- the mid-career programs of the Sloan School of Management and the School of Engineering, and the Summer Session Program's short subjects designed to highlight special topics for the benefit of experts in the field. These activities have been highly successful and will continue to be important M. I. T. efforts, but we are conscious of a growing desire for more extensive continuing education programs. This need is expressed repeatedly by alumni, governmental groups, and industrial organizations, many of which want university assistance in the development of their own advanced training programs. In responding to these needs we must consider two issues: how to be effective in this mode, and how to do it without placing undue burdens on the M. I. T. faculty. New options are being explored throughout the Institute, with special emphasis by the Sloan School and the Center for Advanced Engineering Study of the School of Engineering.

M. I. T.'s technical outreach programs and interactions take many forms, some old, some new. Well-established activities like the M. I. T. Industrial Liaison Program and the M. I. T. Associates Program are attracting an ever-increasing number of participants who, in turn, are making more effective use of the programs than was often the case in the past. Since 1974 the ILP program has grown from 95 companies to 130; the Associates Program from 30 companies to 40. This growth is a reflection of M. I. T.'s growing work on industrially-related technology, and industrial recognition of the importance of the broadest possible basic and applied research base to support corporate developments. Very few companies can afford a corporate research program as extensive as that available at M. I. T. but even those which can, use M. I. T. as a foil for testing the validity of their efforts.

In a complementary direction, many new M. I. T. activities such as those in the Energy Laboratory and the Polymer Processing Program are focused on industrial processes and

therefore need continuing industrial guidance and association. In the Energy Laboratory, an Advisory Board functions well in its intended role, reviewing laboratory activities and serving as a communication link to interested individuals in industrial organizations. In addition, scientists and engineers from several companies have participated in the activities of the Laboratory as visitors, and a number of companies have provided financial support. We are encouraging this style of relationship despite some criticism of undue industrial influence on the Laboratory for we believe that the advantages far outweigh the risks. Everyone involved has been most careful to avoid inappropriate use of this unique set of relationships. Industrial involvement in the Polymer Processing Program is much more formal and intense than in the Energy Laboratory. Participants join the Program, help finance it, and share in its guidance, involve their own staff members in the work as a regular practice, and seek to apply the results.

In addition to such participation on a laboratory or programmatic basis, a growing number of firms is finding specific research activities of individual faculty members or faculty groups of sufficient interest to share in their support. Though such industrial support has always been present, today's congruence of industrial and Institute interests make such help more attractive, from the perspective of both the faculty member and the potential sponsor.

The Institute is highly interdependent, both intellectually and financially, with the world it serves. Actions taken to strengthen the Institute have ripple effects in other organizations; changes in policy on the part of others generate both new opportunities and new constraints for the Institute. Our intellectual and financial policies need to take cognizance of these interdependencies. We are, in effect, trying to solve a set of simultaneous equations -- to bring the Institute into financial equilibrium, to enable its departments to renew themselves at a pace characteristic of the traditions which have made them foremost in their fields, to develop in many parts of the Institute the capacity to focus explicitly on the nature of modern technological society, and to increase the areas of partnership with other organizations, especially industry. Our efforts are iterative and interactive, involving many kinds of activities, many kinds of collegueship; events in one arena will change the constraints and opportunities both for itself and for others. What follows in these pages is a sampled view of the array of activities under way. We hope that their relationships to each other and to our main themes will be apparent.

This year we would like to take note of the 25th anniversaries of three important components of modern-day M.I.T. -- the Lincoln Laboratory, the Sloan School of Management, and the School of Humanities and Social Science. Each has received considerable recognition in its own sphere. Although very different, each has made substantial and unique contributions to the intellectual and educational life of the Institute, as well as to the definition of the kind of science and engineering which the Institute has come to represent to the world at large.

During the 25 years in which these organizations were growing, the Schools of Science, Engineering, and Architecture and Planning also were evolving. Prior to World War II, Karl Compton and Vannevar Bush were leaders in a great strengthening in the engineering disciplines at M.I.T. particularly in regard to the quality and breadth of studies on which they were based. During the past 30 years engineering activities at M.I.T. have been transformed into a group of rapidly evolving, intellectually mobile disciplines with deep roots in science. Under Karl Compton in the 1930s the sciences had been transformed from programs whose primary role was providing service courses for engineering students to important disciplines in their own right which, forged in the crucible of World War II, took their place as eminent disciplines at M.I.T. The School of Architecture and Planning, descendant of the architecture program which was an original part of the Institute and of the

nation's second city planning program founded in 1932, entered its modern period in the early 1940s, and today is one of the strongest and most consistent advocates of a more human environment for all citizens. The Institute of today is made up of all of these, working in partnership. In this Report we would like to highlight the contributions of those Institute units which have just reached the quarter-century mark.

Lincoln Laboratory

The Laboratory was established in 1951 following a request to President James R. Killian, Jr. from General Hoyt Vandenberg, then Air Force Chief of Staff. Shortly before, the Soviet Union had detonated a thermonuclear device -- years before such an event had been anticipated in the United States -- and long-range, high-speed aircraft were already an operational reality. The country could no longer rest its security on geographic isolation, and it had no air defense of any consequence. It was clear that a large and intensive effort would have to be mounted if the technology of aircraft control and warning were to catch up to the rapid developments that had occurred in aeronautics and weaponry. This was what M. I. T. was being asked to do, and there was good precedent for the Institute to respond favorably.

Eleven years earlier a similar appeal from the Microwave Committee of the National Defense Research Council had led to the formation at M. I. T. of the Radiation Laboratory, which was to become the largest wartime university laboratory devoted to technical military problems, the center for American radar development. The Radiation Laboratory required new concepts of management as well as new ways of accomplishing scientific technological developments under great pressure, and this managerial and technical understanding still resided at M. I. T. in the many alumni of the Laboratory who had remained on or returned to the faculty in 1946, particularly in the Research Laboratory of Electronics, the direct descendant of the Radiation Laboratory. Some of these people, Jay W. Forrester, Albert G. Hill, M. M. Hubbard, Louis D. Smullin, George E. Valley, Jr., Jerome B. Wiesner, and Jerrold R. Zacharias, had been among the several groups of scientists who took part in a series of examinations of our air defense capabilities following the Russian atomic test, and had contributed to the early definition of needs and technological possibilities. It was to these and their associates that the Secretary of the Air Force referred in a letter to President Killian in 1952, when he noted how fortunate it was for the Air Force and the country that so many eminent scientists who had made notable contributions during the war were in a position to contribute more.

Lincoln is thus, both technologically and managerially, the direct descendant of the Radiation Laboratory of World War II. There is, however, an important difference. Where the Radiation Laboratory was concerned with the development and exploitation of a new technology -- radar -- Lincoln was established to attack an urgent national problem. This called for a new level of technical conceptualization, the aggregation into a single integrated system of a number of components -- aircraft, radars, computers, telephone networks, and teams of human operators -- each of which, in its own right, represented a system of major technical and organizational complexity.

Success required teamwork among large numbers of individuals with diverse talents, professional backgrounds, and experience. It required the support and cooperation of an important segment of American industry and, perhaps most critically, it required sponsorship that would assure the Laboratory freedom to focus on and follow the problem, to accept the risks inherent in new and developing technologies, and to reject solutions dictated by simple expedience or political consideration.

In any event, it was a successful approach, and by 1958 the first sector of the Semi-Automatic Ground Environment for Air Defense (SAGE) was in operation and the Distant Early Warning Line -- a chain of radar and communications stations stretching from the northwest coast of Alaska to the eastern shore of Baffin Island -- had been installed. The continuing tasks of new weapons integration and the inevitable upgrading and improvement of the original system had been transferred to industry and to the MITRE Corporation, an independent, non-profit organization, newly formed around a nucleus of Lincoln staff.

If the air defense problem had been solved, other problems remained, and the Secretary of the Air Force wrote to President Julius A. Stratton that he regarded the Lincoln Laboratory as a technical resource of great value for the future; he proposed to support at Lincoln on a long-term stable basis "a program of research in air defense electronics and related fields, and in the early development of advanced systems which may emerge from such research. The program would be oriented in content to correspond with M.I.T.'s areas of competence and its responsibilities as an educational institution and would be of substantial size, commensurate with the talent and facilities available."

In succeeding years, the major involvement of the Laboratory has been with the problems of defense against ballistic missiles and the achievement of reliable, world-wide communications. More recently, these broad areas of concern have been expanded to include problems of space and tactical surveillance and civil air traffic control, the latter supported by the Federal Aviation Administration.

None of these programs has led to the massive system implementation effort that was associated with SAGE. In part, this stems from the national decision to maintain a high level of defense research but not to deploy a ballistic missile defense system; in part, it can be attributed to M.I.T.'s view of the role of a university research center in which the governing force is creative thought, and where even the most cherished research projects must, in the later stages of development, be handed over to others. In the early 1950s, when a major revolution in electronic technology was in full swing, there had been few organizations with the capability to take on the production, development, and installation of a system as complex as SAGE. That is no longer true, and the transfer to industry of scientific conceptions and new technology properly occurs much earlier in the research and development cycle.

However, the accomplishments of Lincoln Laboratory, and the rationale for support of a large university research center such as Lincoln, extend beyond the development of specific systems or the solution of specific problems. In addition, such a Laboratory functions as a clinic in which the ideas or discoveries of the larger Institute community can be tested, nurtured, or tempered through exposure to the demanding pragmatism of complex real-world problems. Thus, Lincoln has played an essential role in giving technological substance to those concepts of information and control which were exciting the imagination of many of us 25 years ago and were being prophetically espoused by Norbert Wiener as the advent of the Second Industrial Revolution.

The core memory, invented and put into use at Lincoln, and the high-speed switching transistor, engineered into computers at Lincoln, made the high-speed digital computer a reliable, economic, and ubiquitous device. Digital data transmission techniques have made it possible to "knit" together large data processors and to deliver information efficiently to even the smallest user. Integrated digital circuitry which the Laboratory has developed or sponsored has already brought sophisticated computation and control systems into our homes and daily lives. Equally important has been the variety of applications of these devices and techniques and thereby the stimulation of new invention and new fields of investigation. The use of computers for real-time control of operations is now widely accepted,

continually expanding the field of engineering. It was a radical concept, generally regarded as impractical until it had been demonstrated on a large scale in a number of areas at Lincoln. Computer graphics and computer aided design, large-scale simulation and computer assisted instruction all have roots in the Laboratory.

There is an integrated impact of these efforts that is not conveyed by the listing of specific accomplishments. It represents the achievement of a technological "critical mass" that is derived in part from the size of the effort, in part from investigative freedom, and in part from a happy symbiosis -- not always devoid of internal strains -- between a large organization of problem solvers and builders, and the individualized imagination and creativity that characterize our faculty and students.

If we look towards the future, we can perhaps see represented in the Lincoln/M.I.T. combination an evolving organizational and intellectual competence to deal with complexity and particularly with the expanding problems and opportunities afforded by modern technology. We will certainly need such competence if we are to meet the formidable and already foreseeable challenges of world-wide energy management, environmental control, and social ecology.

Alfred P. Sloan School of Management

The problem of managing modern industrial society involves many tasks we do not yet know how to do or even to think about in an orderly way. We need to encourage innovation and change without permitting society to bear undue risks from new technologies and institutional arrangements. We need to develop fairer societies where the benefits of increased productivity and capital accumulation are widely shared without reducing the motivation of those who are principally responsible for economic development. We need to discover a basis for evaluating the legitimate claims of future generations to resources which might otherwise be irreversibly consumed in the near term. We need to find ways in which complex technical and scientific choices can benefit from broader understanding of those whose lives will be affected. We need new knowledge to understand each of these issues and more new knowledge to understand the trade-offs among them.

The Sloan School was organized at M.I.T. in 1952 because it was recognized that a deep understanding of new technologies would be a necessary ingredient in management systems of the future; that rigorous and analytic methods could be applied in seeking to understand the economic tides, technological developments, and human complexities of contemporary enterprises, public and private. The M.I.T. strategy of students and faculty working together to learn through research and classroom interaction seemed an ideal way to attack these difficult problems.

With the founding of the Sloan School, M.I.T. continued the process of innovation in management education which had begun at the Institute almost 40 years earlier. In 1914, M.I.T. was one of the first major universities to offer management education to undergraduates. Course XV has, over the years, produced some of M.I.T.'s most distinguished alumni, including James R. Killian, Jr. It continues to attract some of M.I.T.'s most able undergraduates. A second major innovation in management education at M.I.T. also preceded the formation of the Sloan School. The Sloan Fellows Program, first offered in 1931, was designed for men and, more recently, women with 10 to 15 years of successful professional experience who were about to undertake more general management responsibilities. This program continues to be unique in the world. It attracts outstanding individuals, from both inside and outside the U.S. and from the public and private sectors, to a 12-month

program leading to an S. M. in Management. It has been referred to as the flagship in the recently proliferating fleet of continuing management education programs.

In 1952, when M.I.T. organized the Sloan School, the process of innovation continued. Prior to that time education of young men and women at the master's level was dominated by so-called M.B.A. programs -- and these programs were dominated by a commitment to a particular pedagogical device -- the case method. While effective for some purposes, programs based on a commitment to this method seemed to have some disadvantages which the Sloan School set out to overcome. The Sloan School looked forward to a world of change -- a world in which new ideas, new technologies, and new forms of organization would have a substantial impact. It, therefore, placed greater emphasis on preparing students for the future than on exposing them to past practice. The Sloan School's new approach to management education required a different faculty and a different student body than were to be found at that time in other schools of business and management. During the years since its founding, the Sloan School approach of balancing new approaches to new problems with an understanding of ongoing institutional arrangements and procedures has evolved into programs which today combine an array of educational methods. Further program innovations at Sloan included the beginning of a program for Senior Executives in 1956, a Doctoral program in 1961, and an Accelerated Master's program in 1971. The Sloan School's departure from prior educational practice has had a substantial effect on the design of programs in other management schools. Shortly after its beginning, the School moved into the leading rank of business and management schools in the country.

The School's faculty also made a series of intellectual contributions which confirmed the hope that the Sloan School could contribute important new ideas to the practice of management. Professor Douglas MacGregor's work on Theory X and Theory Y as self-confirming management styles has substantially influenced organization theory and practice since it was first announced at a Sloan School convocation in 1956. Professor Jay Forrester's early work on Industrial Dynamics has led to the development of a methodology which he and others have applied to some of the most challenging problems in modern society. While this work has produced some controversy, there is no doubt it has constructively stimulated fruitful debate and focused attention on issues of great importance. In the field of finance and capital markets, Sloan School contributions have been central to our new understanding of how such markets work -- how investors, including the Institute, can take advantage of this new understanding, and how regulatory agencies can more effectively serve the public interest. In the field of mathematical modeling and the application of computer technology to important management problems, the Sloan School was an early leader and remains strong to this day. A Center for Information Systems Research recently has been formed in the School to facilitate stronger interaction with industry in this area. Close collaboration of Sloan faculty with those from the Department of Economics and other parts of the Institute through the Energy Laboratory has led to major contributions to our understanding of the issues underlying United States energy policy, and have substantially contributed to the evolution of that policy.

Recognizing health as one of the nation's largest service industries and certainly one with a great need for more effective organization and management, Sloan faculty began 10 years ago to carry out research in this domain. It was during this period that the joint Harvard-M.I.T. Program in Health Sciences and Technology was developing, and its presence provided a resonance for Sloan School interests. Out of this research have now grown materials which can serve as the basis for the teaching of health professionals with respect to management. One major Sloan program in this area is conducted in collaboration with the American Association of Medical Colleges. In this program more than 120 deans of medical schools have come to M.I.T. for a short, specially designed management course. This is then followed by a slightly longer experience designed to extend beyond the dean to his school's administrative structure. A third level program in the medical school

itself leads to the development of plans and strategies which are already beginning to have an impact on curricula, costs, controls, and the organization of important medical centers.

Management is increasingly the management of change. The world needs to find new ways to manage modern industrial society and needs men and women with the energy, imagination, and will to undertake these tasks. These people increasingly need knowledge and the means to understand the world they find. The Sloan School is committed to continued innovation both in the programs it offers and in the research projects it undertakes. The School is currently considering educational options which suggest that the next 25 years will be as exciting and productive as the first have been.

School of Humanities and Social Science

In 1949 the Committee on Educational Survey chaired by Warren K. Lewis, Professor of Chemical Engineering, recommended the establishment of a School of Humanities and Social Science at M. I. T. The Committee noted that English, history, modern languages, and a scattering of general studies had always been a part of the Institute's curriculum and that economics had been taught since President Francis Amasa Walker's day. These subjects had been offered primarily to broaden the education of scientists and engineers. Formalization as a new School, the Committee agreed, would focus attention on the mastery of problems arising from the impact of science and technology upon society. The School was established in 1950 with John Burchard as its Dean.

Many of the changes that have taken place in the Institute since then reflect new conditions in the world around us. The insights of the Lewis Committee have proven to be basic touchstones for the Institute throughout this 25-year period, and their observations are as appropriate today as when they were written.

We are awake now, at last, to the knowledge that our rich and prosperous nation cannot withdraw into isolation. We have discovered that the social institutions of the United States are subject to forces similar to those that are molding the destinies of Europe and Asia. The very concepts of democracy, of equality and opportunity, and of leadership are shifting and developing in the American mind. The utter waste of two world wars confronts us with the necessity of considering the finite limits of our national resources. Even more significant, and perhaps more threatening to our present form of democracy, is a persistent tendency to growth and centralization of control in all organizations and institutions, industrial, financial, educational, and labor. There is a concerted effort to increase the efficiency of management and to eliminate fluctuations in economic and social status. One must at times wonder whether the price of some of these changes may be an ever-diminishing premium placed on the man who is different, on the function and qualities of imaginative and creative leadership.

Democracy as we have known it for more than two hundred years is the fruit of leadership that rises from the initiative and individuality of the people. If this nation is to hold to a high goal, it must continue to cultivate a superiority of spirit and intellect.

Thus wrote the Lewis Committee in 1949. The Committee went on to say:

There can be no dispute about the increasing importance of the humanities and the social sciences in the education of scientists, engineers, and architects. It is M.I.T.'s duty to prepare its students for social responsibility and for a rich and complete life. But, important though these objectives may be, technological and social problems are now so inextricably interwoven that the humanities and social sciences are also essential components of man's professional education. Without an adequate cultural background, a technical specialist is no longer qualified for leadership in his own field.

The report then lamented the fact that the contribution of the humanities and social sciences to M.I.T.'s undergraduate education had never been entirely satisfactory, due in part to a lack of status for the staff commensurate with that in other departments and to the necessity to provide "service subjects" concerned primarily with instruction at an elementary level. The Committee continued:

Now, however, there is a growing concern with human and social problems, an increased awareness of the interplay between science and technology on the one hand and the conduct of human affairs on the other, and an awakened realization of the fruitfulness of the techniques of the natural sciences in the study of human and social problems. We believe that these trends now make possible the development of the humanities and social sciences at advanced professional levels in the environment of a technical institution. The concepts and techniques of science and engineering can give important insight into certain kinds of human, social, philosophical, and historical problems and the atmosphere of an institution like M.I.T. can be made attractive to men interested in these phases of the humanities.

During the 25 years since its founding the School has had a brilliant history. Most of its departments and sections have assumed positions of leadership on the national and international scene. Some, including economics, linguistics, political science, and psychology have become dominant influences in their fields. These achievements occurred in those areas of the social sciences where faculty members were motivated primarily by professional interests; where the department's intellectual direction derived from the challenges of the discipline itself. In those areas of study, primarily in the humanities, where the perceived needs and interests of undergraduates provided the impetus, development has been less consistent and has been harder to evaluate. Changing student interests have made it difficult to develop sustained academic programs of high quality. Fortunately, once again there appears to be serious interest in humanistic studies on the part of our

undergraduates, especially with regard to the intersection of social and scientific or technical issues, and also, interestingly, in the creative and performing arts.

The "Lewis Committee" correctly anticipated the need for effective and supportive educational and research programs in the social sciences and the humanities. Those programs have provided the Institute with a reservoir of talented people who readily turned their ideas and skills to bear on the initial framing and subsequent investigation of issues which might otherwise have had a purely technical form -- energy, environment, regulation, etc. At the same time, groups within the School of Humanities and Social Science have been examining how they could make a more effective contribution to M.I.T.'s educational program. The new Institute Requirement in the Humanities, Arts, and Social Sciences, which had its first full operational year in 1975-76 after a year of transition, represents one such development.

Another contribution to the general education of M.I.T. students has been the Writing Program for undergraduates, offered since 1974. The Program appeals to many students, ranging from those who feel a need to improve their communication skills to a significant number of students who have a deep and continuing interest in writing. As the Program grew and adopted a variety of innovative methods, it became the subject of widespread debate about such matters as the allocation of resources, the qualifications of certain members of the instructional staff, and the appropriateness of academic credit for some of the work. To help understand and resolve the many issues raised, in April 1975, Dean Hanham appointed a small study group composed of M.I.T. faculty members and outside specialists who, after a year of study and discussion, have strongly endorsed both the intent and performance of the Program and proposed a number of significant steps to stabilize and improve it. This report will be considered during the coming year with the expectation that the future characteristics and scope of the Writing Program will be decided promptly.

Other developments in the School include the merger of Philosophy and Linguistics, to be discussed later in this Report, and increased attention to the interplay between technology and society through the study of selected societal problems. For the past three years a study group chaired by Professor Elting Morison has been considering how the humanistic and technological streams of the Institute might be brought together to understand vital issues of a technological society. Existing resources, i. e., existing unfilled chairs and current faculty members interested in the program, have been sufficient to start a small core of research and educational activities. Research will center on the examination of a small number of carefully selected sociotechnical problems in all their complexity, and educational activities are based around problem oriented, collaborative efforts of faculty and students. The educational program, though currently small, builds on a decade of experimenting with and reflecting upon undergraduate education, including UROP, the Concourse Program, the Unified Science Study Program, self-paced teaching methods, and the two special undergraduate degree programs combining Humanities and Engineering or Science.

For years the M.I.T. faculty -- humanists, engineers, and scientists alike -- have been searching for the role of the humanities at the Institute. Within the M.I.T. community the sense that solutions for many of society's dilemmas depend upon more satisfying fusions of our different kinds of knowledge has been expressed in many different ways and places. Some faculty members have moved beyond the boundaries of their own fields to work with others on problems, such as the future supply of energy, whose solutions appear to depend on the intersection of a variety of factors -- political, economic, technological, and scientific. Others are seeking to discover more about the impact of science and engineering on cultures developed at other times and places. Still others have started informal seminars for the study of such concepts as meritocracy, equality, and justice in a technological society. Activities of this sort suggest the extent to which the mood of the community is moving

beyond strictly professional interests. But they also suggest, in their number and variety, a dispersion of energy. As one faculty member said recently, "there is no adequate focus in the Institute for what everybody talks about all the time." We hope that from the inter-School collaborations developing around research and teaching on problems of technology and society such a focus might grow.

To close this anniversary section, we note that the Institute has a different intellectual character than it would have had without the Lincoln Laboratory, the Sloan School of Management, and the School of Humanities and Social Science. M.I.T. is distinguished for its achievements in science and engineering, and its primary focus has always been, and always should be, in these areas. The nature of our educational programs and the kinds of research possible have been significantly enhanced by the presence and the excellence of those parts of the Institute whose anniversaries we celebrate.

While our emphasis in recent years has, of necessity, been on ensuring the health and vitality of those established activities of the Institute which are its main force and which have always given it its unique character and style, that health and vitality also entails the development of new activities which capture the imagination of students and faculty, and which provide stimulation and new perspectives for ongoing programs. In these financially tight times new activities cannot be undertaken lightly -- they involve commitments of energy, space, and money which are all too scarce. On the other hand, if they contain the seeds of intellectual renewal they are an important investment for the Institute to make in its future.

We have discerned among young people interested in studying at M.I.T. a growing interest in professional careers for which the Ph.D. with its emphasis on research is not a prerequisite. In response we have been developing several programs in which the Master's Degree represents a coherent course of study in and of itself and not primarily a way-station on the path to a Ph.D. We have found considerable interest among the faculty in working with students in such programs; their development has enabled us to respond to a new range of interests without expanding the size of the faculty.

The School of Science has extended Course XXV and now offers an Interdisciplinary Science Master's Program. The objective of this program is to prepare students for positions in industry, government, education, and medicine which often require interdisciplinary breadth as well as a strong background in science. Specified programs were offered this year in Animal Cell Science, Science Education, and Environmental Chemistry; 12 students were enrolled in the first term and 16 in the second. It is anticipated that other interdisciplinary science areas will be developed in the next few years.

The School of Engineering began a Master's Degree Program in Technology and Policy. This program, a cooperative venture between departments in the School and members of the faculty in the social sciences, represents a tangible effort to create integrated educational activities in the social sciences and engineering. The program is particularly appropriate for students who wish to study economics, social science, systems analysis, and policy making at the same time they are concentrating in one of the engineering disciplines.

In the Sloan School of Management, as part of a larger set of activities in the field of health management, a new Health Management Executive Development Program was inaugurated this year. This 12-month program leading to the degree of Master of Science in Management

is aimed at mid-career health care practitioners, educators, researchers, and administrators. Six health professionals were admitted to this program in June 1975; three medical school deans; two senior directors of nursing services; and an executive from the Department of Health, Education and Welfare.

An additional new academic arrangement of considerable promise occurred in the School of Humanities and Social Science. As of July 1, 1976 the Linguistics and Philosophy programs have been combined in a renamed Department of Linguistics and Philosophy (Course XXIV). At the same time a new undergraduate degree program in Linguistics, Philosophy and Psychology, with the title Language and Mind, was agreed to as an option in Course XXIV. The changed administrative arrangements for Linguistics and Philosophy offer considerable advantages in terms of intellectual coherence and also provide a new base for moving into the more theoretical aspects of the Cognitive Sciences. Together with the Department of Psychology, work has begun to develop a new Ph.D. option in Cognitive Studies, and we look forward to the possibility of a new laboratory or center in this field that is both experimentally and theoretically oriented. Such a laboratory would form a common base for development not only in Psychology, Linguistics and Philosophy, but also for building on work in the communications area already under way in the Research Laboratory of Electronics, in the Artificial Intelligence Laboratory, and in various computer science groups.

A new physical development on the campus which has considerable educational potential is the installation of a cable television system under a grant to the Center for Advanced Engineering Study from the Alfred P. Sloan Foundation. The cable forms the spine down the center of the campus which, with a few branches, reaches to almost every center of activity on campus. The system was tried out during Independent Activities Period, when news, public service announcements, videotaped courses, and cultural events were transmitted. Materials were prepared by student groups, faculty, visitors to the Institute, and by the staff of the C. A. E. S. As anticipated last spring, there are currently more than 1,000 receiving stations in the dormitories plus about 50 stations in classrooms, departmental lounges, offices, and corridors.

In April 1976, the Sloan Foundation awarded M. I. T. a further grant to continue programming experiments on the cable system. A Cable Television Policy Board chaired by Professor Roy Kaplow, will monitor our experience with the cable and help develop guidelines regarding transmission access, suitability of program material, etc. As we experiment with the instructional and cultural uses of such a system we look forward to the time when it is fully integrated into the life of the Institute.

Activities in the arts at M. I. T. continue to be vigorous and stimulating to the community as a whole. Several major sculptures were acquired, largely through the generosity and vision of good friends and, in several cases, of the artists themselves. These sculptures include "Transparent Horizon" by Louise Nevelson, sited adjacent to the new Ralph Landau Building, and "Three-Piece Reclining Figure, Draped" a recent bronze by Henry Moore which is sited to the side of the Killian Court. In other arts-related activities, the M. I. T. Symphony Orchestra performed at the John F. Kennedy Center for the Performing Arts in Washington, D. C., under the sponsorship of the Council for the Arts and the M. I. T. Club of Washington. The concert was given in conjunction with a Club-sponsored Symposium on Technical Innovation. Both the symposium and the concert were a considerable success. As Paul Hume noted in The Washington Post:

The M. I. T. Symphony Orchestra came to town last night and its students of architecture, biology, computer science, earth and planetary science, physics, psychology, and urban planning had no difficulty in sounding like a

first-class university orchestra ... the players ... offered their Kennedy Center audience a program that would greatly honor the lists of any of our major orchestras. It was of a kind that the majors all too rarely put together ... The might of M.I.T. is clearly well divided between the sciences and the fine arts.

Paul Hume made an understandable error, for which we forgive him since he came so close to the truth. The might of M.I.T., by which we take him to mean its vigor and excellence, is not divided between the sciences and the fine arts. Rather, as in the case of the young people who performed that night, the talents of science, engineering, art, and concerns for human and social issues are combined at M.I.T. The resulting sense of hard work, creativity, and the excitement of achievement or discovery pervades the Institute and is part of what makes M.I.T. an exciting place to study or work. This phenomenon is demonstrated by increasing numbers of undergraduate and graduate applications, and the increasing academic talent of those who are admitted. It is demonstrated by the efforts of people in all parts of the Institute to improve the living and working conditions of those who study and work here, with particular attention to the stresses and strains experienced by those who are statistical minorities in this predominantly white, male community, but who are contributing much to its excellence. It is also demonstrated by the increasing attraction M.I.T. holds for the people of other nations.

We have noticed in recent years an increase in the kind and the number of Institute activities involving other nations. These include an increase in the number of foreign students, both graduate and undergraduate, who now comprise almost one-fifth of the student population. We are increasingly asked, not only to admit more foreign students from a greater number of countries, but to admit them under new and contractually-based arrangements. Foreign consulting and research opportunities always have been available to our faculty, but as other nations analyze their economic and technological needs, we see an increased incidence of such activities and proposals for new kinds of institutional arrangements. We are aware of the increasing numbers of foreign alumni, many of whom are in positions of considerable responsibility in their countries and are asking us for professional support. Each of these trends raises policy issues for the Institute, some of which come upon us unexpectedly and in ways which create considerable stress and publicity. Taken together these trends raise even larger policy issues regarding our responsibilities as an institution of international reputation and the ways in which we are organized to meet those responsibilities. We have mechanisms for deliberating the implications of some of these developments, one of which is the newly formed Committee on International Institutional Commitments composed of faculty, students, and administrators. However, the magnitude and scope of the issues arising from our international reputation deserve careful thought and discussion in all parts of the Institute.

That so many people and nations seek to share in the life of the Institute is no surprise. It is an exciting and varied place, continually inventing new possibilities for the future. The issues and activities we have described in this Report are those of a healthy, creative university with a clear vision and purpose. As we close this essay we would like to recall the concluding remarks of the late Jacob Bronowski in his television series "The Ascent of Man." We think these words are particularly appropriate for the Institute and its extended family of alumni and friends:

... every man, every civilization, has gone forward because of its engagement with what it has set itself to do. The personal commitment of a man to his skill, the intellectual commitment and the emotional commitment working together as one, has made the Ascent of Man.

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. Two members of the faculty were elected to the National Academy of Sciences; eight members were elected to the National Academy of Engineering; and three were elected to membership in the American Academy of Arts and Sciences. David Baltimore, American Cancer Society Professor in the Department of Biology, was honored as co-recipient of the Nobel Prize in Medicine and Physiology. Professor Baltimore, age 38, and two others were cited "for their discoveries concerning the interaction between tumor viruses and the genetic material of the cell." Manson Benedict, Institute Professor Emeritus, was honored by the award of the National Medal of Science.

Of special note during the year were the appointments of two members of the faculty to the distinguished rank of Institute Professor: Dr. Noam A. Chomsky, Ferrari P. Ward Professor in the Department of Foreign Literatures and Linguistics; and Dr. Nevin S. Scrimshaw, Head of the Department of Nutrition and Food Science. Dr. Frank Press, Head of the Department of Earth and Planetary Sciences, was honored as the fourth recipient of the James R. Killian Faculty Achievement Award.

The past year saw several appointments to senior posts that should receive special mention. Professor John M. Deutch was appointed Head of the Department of Chemistry; Professor Stephen Erdely, Director of Music; Professor Morris Halle, Acting Head of the new Department of Linguistics and Philosophy; Dean A. Horn, Director of the Sea Grant Program; and Professor Peter A. Wolff, Director of the Research Laboratory of Electronics. Dr. John Ross, Professor of Chemistry, and Dr. Suzanne Berger, Professor of Political Science, began their terms as Chairman of the Faculty and Associate Chairman, respectively.

The past year also marked the retirement of nine distinguished members of the faculty. Their years of service to the Institute and to their students will long be remembered and appreciated. They are: Professor William H. Brown, Department of Architecture; Professor Mason Haire, Sloan School of Management; Professor Harold R. Isaacs, Department of Political Science; Professor Charles P. Kindleberger, Department of Economics; Professor Richard C. Lord, Department of Chemistry; Professor William T. Martin, Department of Mathematics and the Division for Study and Research in Education; Professor Brandon G. Rightmire, Department of Mechanical Engineering; Professor Carroll L. Wilson, Sloan School of Management; and Professor Walter Wrigley, Department of Aeronautics and Astronautics.

Of particular sadness to us during the year were the untimely deaths of several respected colleagues and advisors.

Douglas P. Adams, Professor of Mechanical Engineering, died in October 1975. During his 35 years at M.I.T. he developed a way of handling nomograms via digital computer and became widely known for his research in kinematics, stereo-electronic recording of surfaces for criminological purposes, computer models of buildings for piping and circuitry, and computer regulation of urban traffic flow.

Alexander J. Bone, Associate Professor of Transportation Emeritus in the Department of Civil Engineering, died in March 1976. Known by generations of students as "Mr. Transportation," he was instrumental in the planning of the Massachusetts Turnpike, the Garden State Parkway, the John F. Fitzgerald Expressway, and Route 128 which surrounds Boston.

John E. Burchard, Dean Emeritus of the School of Humanities and Social Science, died after a long illness in December 1975. Close friend and trusted advisor of five M.I.T.

presidents, as the first dean of the School of Humanities and Social Science, he developed a vision of what the arts and humanities could be at M.I.T. -- a vision which was an important force in establishing within the Institute the traditions of a modern university. Equally at home in the worlds of science and of the humanities, and widely respected architectural critic and historian, he helped shape in countless ways the present style and character of the Institute.

Marshall B. Dalton, one of M.I.T.'s most active and respected alumni leaders who, with 39 years as a member of the Corporation, was its senior member, died in March 1976. His participation in Institute affairs spanned 60 years -- including major roles in every major capital funds drive conducted by the Institute, membership on five different Visiting Committees, Trustee of the M.I.T. Pension Association and advocate of strong retirement plans for staff and employees, and long-time leader in fraternity affairs. Beloved by students, faculty, staff, and employees, he is much missed.

Frederick G. Keyes, Professor Emeritus of Physical Chemistry and Head of the Department of Chemistry from 1923 to 1945, died in April 1976. His formal association with the Institute spanned the years 1910 to 1950, but he continued in active association with the Department of Chemistry for many more years. An internationally known physical chemist and leader in cryogenic research, he was also co-developer of the Keenan-Keyes steam tables used throughout the world as the basis of modern steam generating plant design.

Malcolm G. Kispert, M.I.T. Institute Secretary and former Vice President for Academic Administration, died unexpectedly in September 1975. For more than 25 years he carried a succession of important administrative responsibilities with great competence and skill. His warm friendship, great good humor, and capacity for human understanding and compassion are greatly missed.

Norman Levinson, Institute Professor and Professor of Mathematics at M.I.T. for 38 years, died in October 1975, after a long illness. A scholar widely recognized for his research on differential equations, analytic number theory, and other branches of analysis, he was a mathematician of the first magnitude. His dedication to excellence has been an indelible influence on the intellectual life of the Institute.

Alfred L. Loomis, member of the M.I.T. Corporation for 44 years and important contributor to the development of M.I.T.'s research and educational programs, died in August 1975. Mr. Loomis, who achieved success as a physicist, financier and lawyer, worked to strengthen United States science in the period between World Wars I and II. He worked closely with President Karl Taylor Compton when M.I.T. began its rise to prominence in graduate studies, science, and basic research; aided in the establishment of the Graduate School in 1952; and served as Chairman of several Visiting Committees, including biology, physics, and mathematics.

Henry L. Seaver, member of the M.I.T. faculty for 46 years, died in November 1975 at the age of 97. Joining M.I.T.'s Department of English and History in 1901, he subsequently served as Professor of English and History and as a member of the Department of Architecture. A collector of fine books and autographs, including those of King Henry VIII and Queen Elizabeth I, which he used in his teaching, he contributed much to generations of M.I.T. students.

Albert O. Seeler, Professor of Medicine and Head of the M.I.T. Medical Department, died unexpectedly in February 1976. Dr. Seeler was responsible for the improvement of health care services during a period of unprecedented growth in the use of the Medical Department, and led in the development of a wide range of innovations including exemplary programs of

student and employee health care, the environmental medical service, medical supervision of academic and research programs, and the M.I.T. Health Plan -- a comprehensive health care service for faculty, staff, and employees.

Thomas K. Sherwood, Dean Emeritus of the School of Engineering, died in January 1976. A distinguished chemical engineer who was an authority on mass transfer under turbulent flow conditions, he was a founding member of the National Academy of Engineering, and in 1966 was given special recognition as one of M.I.T.'s most eminent faculty members with his appointment as the first Lamot DuPont Professor of Chemical Engineering.

Victor P. Starr, Professor Emeritus of Meteorology, died in March 1976. A recognized authority on the circulation of planetary atmospheres, he developed the theory of negative viscosity. He was a superb guide to younger scholars and, during his 27 years on the faculty, supervised about one-quarter of all the doctoral theses in the department.

Uncas A. Whitaker, Life Member Emeritus of the M.I.T. Corporation and founder and Chairman of the Board of AMP, Incorporated, an international leader in the design and manufacture of electrical components, died in September 1975. During the 14 years he served as a member of the Corporation he was a guiding force in the development of the life sciences, biomedical engineering, and advanced training in medicine. His vision also has taken tangible form in the Uncas A. and Helen F. Whitaker Building for the Life Sciences (Building 56), support for the joint Harvard-M.I.T. Program in Health Sciences and Technology, and the establishment of the Whitaker Professorship of Biomedical Engineering. He was totally devoted to the Institute and his vision of the linkages between science and engineering on one hand, and medicine on the other was a matter of deep conviction to him which we shall seek to realize.

Minor White, a premier American photographer and Professor Emeritus of Photography, died in June 1976. He was responsible for the establishment of the Creative Photography Laboratory at M.I.T. as well as a number of major photography exhibits. His artistic influence depended not only on his work as a photographer, but on his service as teacher, critic, and publisher. His photographs have been exhibited in museums and galleries throughout the country and many are included in the permanent collections of major museums.

These men have been outstanding examples of the strength and variety of M.I.T.; they will be remembered and honored by generations of their students, friends, and associates.

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 1975-76.

Registration

In 1975-76 student enrollment was 8,482, an increase of 432 over the 8,050 enrolled in 1974-75. This total was comprised of 4,433 undergraduate and 4,049 graduate students. Graduate students who entered M.I.T. last year held degrees from 358 colleges and universities, 206 American and 152 foreign. The foreign student population was 1,481 representing 17 percent of the total enrollment. The foreign students were citizens of 92 countries.

Degrees awarded by the Institute in 1975-76 included 1,049 bachelor's degrees, 862 master's degrees, 94 engineer's degrees, 390 doctoral degrees -- a total of 2,395.

The number of women at M.I.T., both graduate and undergraduate, has increased continuously. In 1975-76, there were 1,255 women students at the Institute, compared with 1,111 in 1974-75. In September 1975, 177 first-year women entered M.I.T., representing 15 percent of the entering class. In 1975-76, a total of 257 degrees were awarded to women.

Student Financial Aid

During 1975-76 the student financial aid program was again characterized by increases 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 2,011 undergraduates who demonstrated the need for assistance (45 percent of the enrollment) received \$4,299,341 in scholarship aid and \$2,752,917 in loans. The total, \$7,052,258, represented a 22 percent increase in direct aid over last year.

Scholarship assistance was provided by the scholarship endowment in the amount of \$2,061,136, by outside gifts for scholarships in the amount of \$805,024, and by direct grants to needy students totaling \$857,515. Scholarship assistance from M.I.T.'s own operating funds was provided to the extent of \$410,859. The special program of scholarship aid to minority group students represented an additional \$164,807 from specially designated funds. An additional 377 students received direct grants from outside agencies, irrespective of need, in the amount of \$892,444. Outside scholarship support thus totaled \$2,554,983, another substantial increase over last year's total. A significant portion of the increase was again due to increased funding of the Federal government's grant-aid program. The undergraduate scholarship endowment was aided by the addition of new funds which represented an increase of \$1,452,992 and which raised the principal of the endowment to \$23,456,107.

Loans totaling \$2,752,917 were made to needy undergraduates. Of this amount \$872,249 came from the Technology Loan Fund, \$1,873,918 from the National Defense Loan Fund, and the remainder from other M.I.T. loan funds. An additional \$500,157 was obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources.

Graduate students obtained \$1,140,999 from the Technology Loan Fund. Of this total, \$462,428 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 \$3,915,771, an increase of \$647,614 over last year's total.

Career Planning and Placement

The past year was a busy one for the Career Planning and Placement Office, which means that it was generally a good year for graduating students. A total of 240 employers came recruiting -- more than in any year since 1969-70 -- and 854 students had 4,295 interviews. As usual, the majority of students looking for jobs were graduate students. While in some fields -- notably the construction industry -- one would have liked to see more employment activity, in other fields employer interest exceeded student interest. A third or so of the firms which canceled visits did so because not enough students had signed up to see them.

Two classes of students who wished they could take more advantage of the presence of so many employers on campus were those interested in summer jobs and foreign students interested in working in this country after graduation. The Office gave to the visiting recruiters some 900 resumes from students who wanted to talk with them but whose backgrounds did not fit with the employers' stated requirements. A good number of these were students seeking summer employment or were foreign students. If returning prosperity lowers the barrier which now prevents most foreign students from working in this country after graduation, and persuades more firms to hire students for the summer, we shall probably again see the sort of interview activity which was commonplace a decade ago. In 1965-66 some 1,731 students, United States and foreign, had a total of 7,374 interviews for permanent and summer employment.

Alumni activity in the Office reflected a gradual improvement in the market for experienced individuals over the year before. The number of alumni registering declined from 629 to 522, with a higher percentage of younger alumni -- 20 to 30 years old -- requesting assistance (up to 10 percent from the previous year). Job openings listed with Alumni Career Services totaled 1,519, practically on a level with the year before. The strongest demand, as usual, was for individuals with less than 10 years of experience. The Office continued to work with alumni who came in (or wrote) to discuss their career without registering themselves as job candidates.

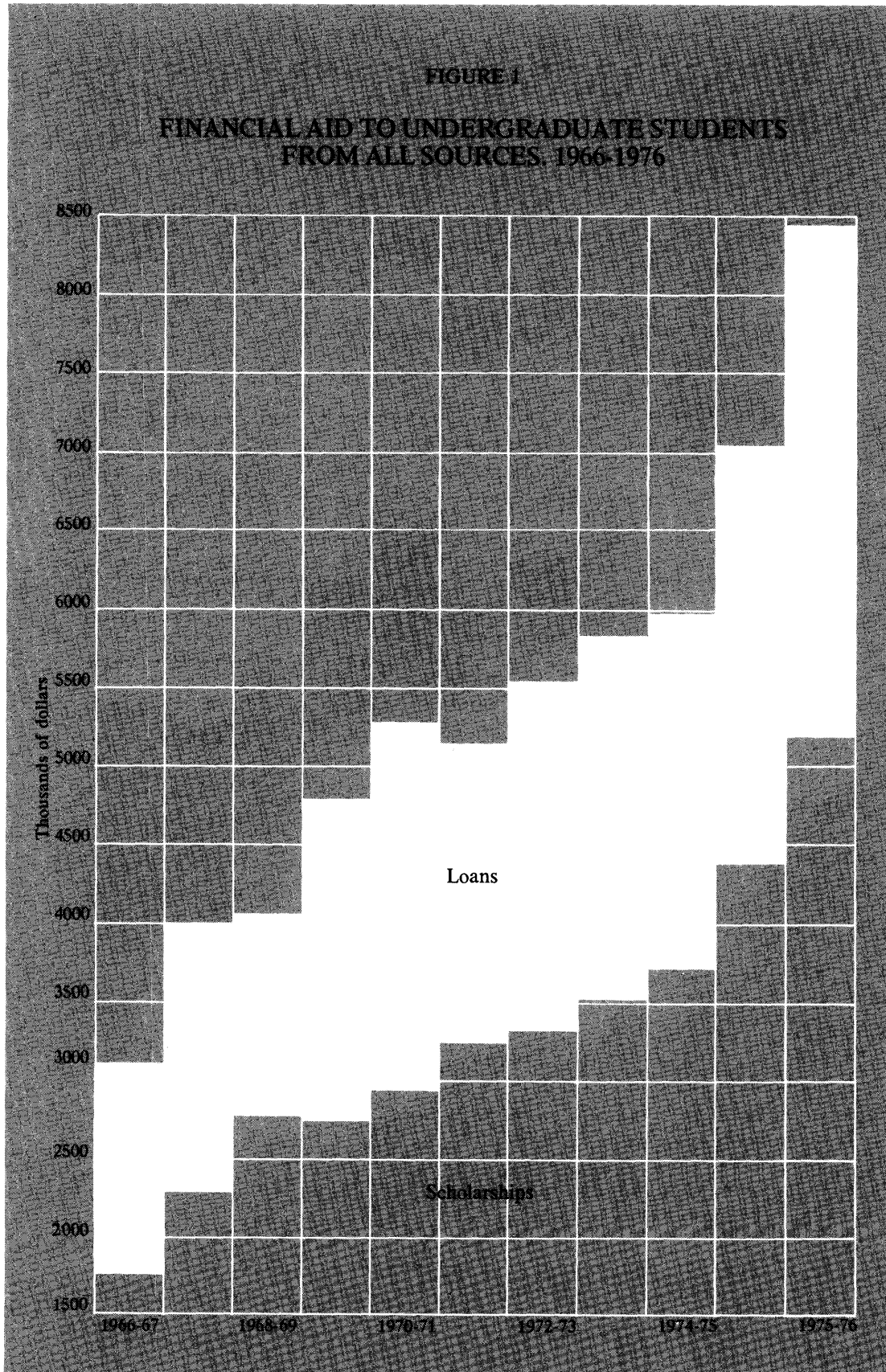
Finances

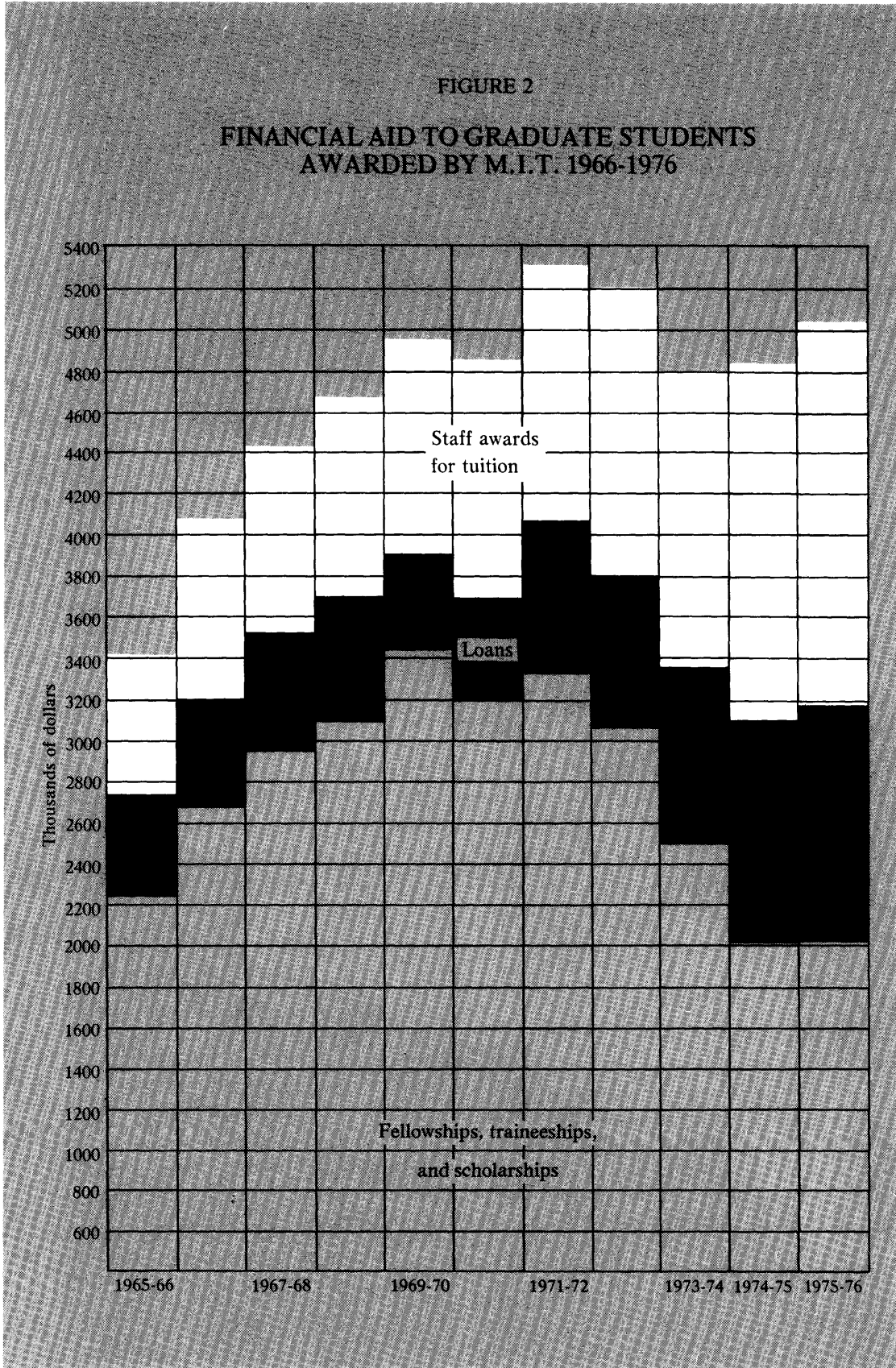
As reported by the Vice President for Financial Operations and the Treasurer, the total financial operations of the Institute, including sponsored research, increased from the level of 1974-75. Educational and general expenses -- excluding the direct expenses of departmental and interdepartmental research, and the Lincoln Laboratory -- amounted to \$110,259,000 during 1975-76, compared to \$103,152,000 in 1974-75. Reflected in the finances of the Institute was the decrease in the use in operations of unrestricted funds to \$6,493,000, compared with \$9,005,000 the preceding year, which included a drawdown of the Research Reserve in the amounts of \$240,000 in 1975-76 and \$480,000 in 1974-75.

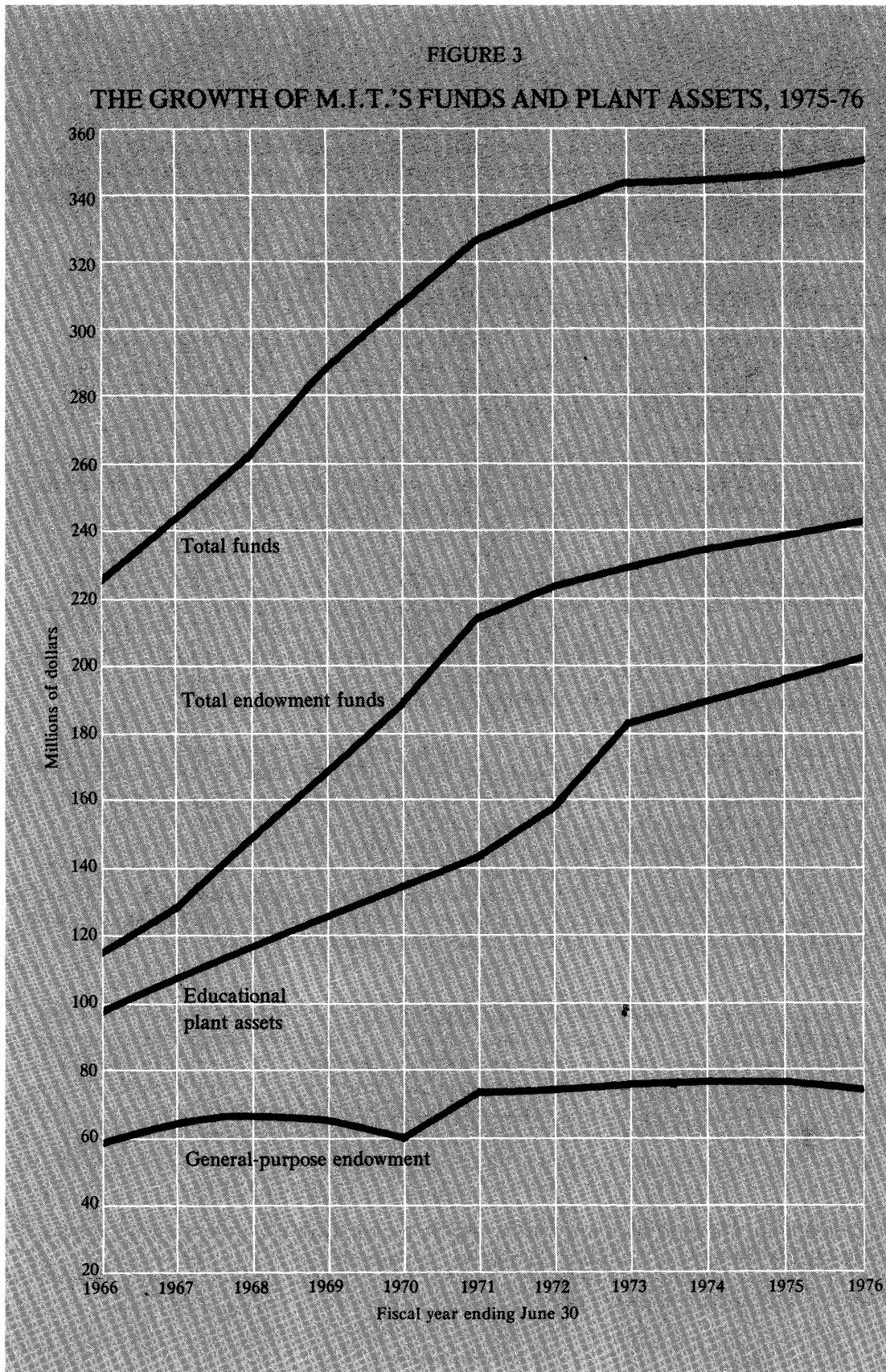
The direct expenses of campus departmental and interdepartmental sponsored research increased from \$64,992,000 to \$71,852,000, and the direct expenses of the Lincoln Laboratory's sponsored research increased from \$72,922,000 to \$81,737,000.

The construction program of the Institute continued to make progress in 1975-76, with the book value of educational plant facilities increasing from \$197,513,000 to \$201,822,000.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, students' notes receivable, and amounts due from educational plant, had a book value of \$319,878,000 and a market value of \$401,006,000. This compares to book and market totals of \$313,624,000 and \$376,061,000 last year.







Gifts

Gifts, grants, and bequests to M.I.T. from private donors increased from \$20,282,000 in fiscal year 1974-75 to \$22,393,000 in fiscal year 1975-76. The latter figure includes unrestricted direct gifts to the Alumni Fund of \$1,334,000 which constituted part of the total of \$4,025,000 reported by the Alumni Fund in 1975-76.

Physical Plant and Campus Environment

With the completion and occupancy of the new West Campus Undergraduate House in August 1975 and the Ralph Landau Building (Chemical Engineering) in January 1976, the series of major building projects which started with the Second Century Fund capital construction in the early 1960s came to an end.

The new West Campus House is the first M.I.T. dormitory to be air-conditioned and provides accommodations for 297 students in six separate living groups. The facility was designed to serve as a primary housing resource for Summer Sessions and conference guests.

Bexley Hall is undergoing a major rehabilitation effort this summer -- renovating all bathrooms and kitchens, replacing the electrical, plumbing, and gas systems, upgrading the heating system, installing a new roof, and adding storm windows. This work was started early in June and will be completed in time for occupancy for the fall term. The only remaining new construction to be initiated during the year was the addition of two building bays and a finger pier to the Sailing Pavilion.

Design work is in progress on a one-story 13,000 square feet interim animal care facility proposed for a site on Vassar Street between the Cyclotron Building and the Parsons Laboratory. An associated project scheduled to go into design later this year is the rehabilitation and modernization of existing animal facilities in the Whitaker and Ford Buildings. Phase I of the proposed new Athletic Facilities adjacent to Rockwell Cage is currently in the design/development stage. It is planned to include an ice skating rink which also may be used for graduation exercises and other large functions, and a fieldhouse with an indoor running track. Design was initiated in spring, 1976 on 4,000 square feet of additional laboratory facilities for the Center for Cancer Research in the Seeley G. Mudd Building.

Larger renovation and renewal projects completed during the year were offices for the Center for Policy Alternatives in the Webster Building on Amherst Street, student space and offices for the School of Architecture and Planning in Buildings 7 and 10, and the partial new tenancy of the Medical Department in Building 12, formerly occupied by the Department of Chemical Engineering. In addition, special efforts were made to upgrade lounge spaces in several dormitories. These projects, planned with the residents of each house, range from minimal repair and replacement to total redecorating and refurbishing.

Finally, the Housing Office has continued to add to the sprinkler systems in the corridors of all high-rise buildings, completing Eastgate, Tang Residence Hall, and the towers of Westgate and MacGregor House this year. This program, run in conjunction with the Safety Office, will continue next year.

Personnel Changes

Personnel Changes

CORPORATION

DEATHS

Marshall B. Dalton
Life Member
Honorary Chairman of the Board
Arkwright-Boston Manufacturers
Mutual Insurance Company

CHANGES OF APPOINTMENT

Donald F. Carpenter
Life Member Emeritus

Paul M. Cook
Life Member

William A. Coolidge
Life Member Emeritus

Ralph Landau
Life Member

Carl M. Mueller
Life Member

Joseph J. Snyder
Treasurer Emeritus of the
Corporation
Life Member

Julius A. Stratton
Life Member Emeritus

Edward O. Vetter
Ex Officio Member
President of the Alumni Association

ELECTIONS

Edward F. Hennessey
Representative of the Commonwealth
Chief Justice of the Supreme Judicial
Court of the Commonwealth

Ellis C. Littmann
Member

William H. Mills
Member

James A. Moody
Representative from Recent
Classes

Kenneth H. Olsen
Member

Howard L. Richardson
Member

Helen F. Whitaker
Member

David R. Wilson
Representative from Recent
Classes

TERMS EXPIRED

William S. Edgerly
Member

G. Joseph Tauro
Representative of the Commonwealth
Chief Justice of the Supreme Judicial
Court of the Commonwealth

Pamela T. Whitman
Member

RESIGNATIONS

Gregory C. Chisholm
Representative from Recent
Classes

FACULTY

DEATHS

Mac V. Edds
Professor in Nutrition and
Food Science and Executive
Director of Neurosciences
Research Program

Norman Levinson
Institute Professor

Albert O. Seeler
Professor of Medicine
Medical Director and Head
of Medical Department

RETIREMENTS

William H. Brown
Associate Professor in
Architecture

Mason Haire
Professor in Sloan School
of Management

Harold R. Isaacs
Professor in Political Science

Charles P. Kindleberger
Professor in Economics

Daniel Lerner
Professor in Political Science

Richard C. Lord
Professor in Chemistry

President and Chancellor

William T. Martin
Division for Study and
Research in Education

S. Curtis Powell
Professor in Ocean Engineering

Brandon G. Rightmire
Professor in Mechanical
Engineering

Silvio N. Vitale
Assistant Professor in Athletics

Carroll L. Wilson
Professor in Sloan School of
Management

RESIGNATIONS

Professors:

Alberto P. Calderon
Mathematics

Paul W. MacAvoy
Sloan School of Management

D. Quinn Mills
Sloan School of Management

Robert E. Stickney
Mechanical Engineering and
Nutrition and Food Science

Associate Professors:

Harry S. Colburn
Electrical Engineering and
Computer Science

Jonathan W. Green
Architecture

Gary A. Hack
Urban Studies and Planning

John E. Hart
Meteorology

Albert L. Hopkins
Aeronautics and Astronautics

William H. Matthews
Civil Engineering

Stephen F. Moore
Civil Engineering

Suhas S. Patil
Electrical Engineering and
Computer Science

Wayne M. Pecknold
Civil Engineering

Raymond T. Schnadelbach
Urban Studies and Planning

Donald Sur
Humanities

Ian D. Turner
Urban Studies and Planning

Philip Thullen
Mechanical Engineering

Dan S. White
Humanities

Assistant Professors:

Donald B. Anthony
Chemical Engineering

Donald H. Bell
Humanities

Arthur D. Bernhardt
Architecture

Zvi Bodie
Sloan School of Management

Nigel W. E. Curlet
Chemical Engineering

Charles H. Dowding
Civil Engineering

Clarence A. Ellis
Electrical Engineering and
Computer Science

Curtis Greene
Mathematics

Robert W. Hopper
Materials Science and
Engineering

Chenming Hu
Electrical Engineering and
Computer Science

Charles L. Jones
Political Science

Marcia W. Josephson
Foreign Literatures and
Linguistics

Edward C. Kern
Ocean Engineering

Charles E. Kimble
Nutrition and Food Science

Richard J. Lagow
Chemistry

F. James Levinson
Nutrition and Food Science

Sitikantha Mahapatra
Sloan School of Management

Gordon E. Nelson
Foreign Literatures and
Linguistics

Michael D. Schroeder
Electrical Engineering and
Computer Science

James Wolfson
Physics

Andrew C. Yao
Mathematics

PROMOTIONS

To Professor:

H. Kent Bowen
Materials Science and
Engineering

Personnel Changes

Clark K. Colton
Chemical Engineering

Ernest G. Cravalho
Mechanical Engineering

Richard L. de Neufville
Civil Engineering

C. Forbes Dewey
Mechanical Engineering

Robert M. Fogelson
Urban Studies and Planning

Malcolm L. Gefter
Biology

Arnoldo C. Hax
Sloan School of Management

John B. Heywood
Mechanical Engineering

Steven Kleiman
Mathematics

Lawrence M. Lidsky
Nuclear Engineering

Harvey F. Lodish
Biology

Stewart C. Myers
Sloan School of Management

Alan V. Oppenheim
Electrical Engineering and
Computer Science

Regis M. N. Pelloux
Materials Science and Engineering

James K. Roberge
Electrical Engineering and
Computer Science

Daniel Roos
Civil Engineering

Jerome H. Saltzer
Electrical Engineering and
Computer Science

Paul R. Schimmel
Biology

David H. Staelin
Electrical Engineering and
Computer Science

Gerald L. Wilson
Electrical Engineering and
Computer Science

To Associate Professor:

Michael C. Archer
Nutrition and Food Science

Klaus J. Bathe
Mechanical Engineering

B. Shawn Buckley
Mechanical Engineering

Min Chen
Physics

Kent W. Colton
Urban Studies and Planning

Wayne A. Cornelius
Political Science

John S. Dickey
Earth and Planetary Sciences

Joseph Ferreira, Jr.
Urban Studies and Planning

James M. Flink
Nutrition and Food Science

Christopher Goetze
Earth and Planetary Sciences

Ann M. Graybiel
Psychology

Gary A. Hack
Urban Studies and Planning

Jerry A. Hausman
Economics

Carl E. Hewitt
Electrical Engineering and
Computer Science

Douglas A. Hibbs, Jr.
Political Science

Ronald A. Hites
Chemical Engineering

Berthold K. P. Horn
Electrical Engineering and
Computer Science

Norberto L. M. Kerzman
Mathematics

Judith T. Kildow
Ocean Engineering

Eugene M. Kleinberg
Mathematics

Donald R. Lessard
Sloan School of Management

Peter Lorange
Sloan School of Management

Loy D. Lytle
Nutrition and Food Science

Stuart E. Madnick
Sloan School of Management

Henry S. Marcus
Ocean Engineering

James W. Mark
Mathematics

Roy E. Marsten
Sloan School of Management

Francois M. M. Morel
Civil Engineering

Michael H. O'Hare
Urban Studies and Planning

Vaughn R. Pratt
Electrical Engineering and
Computer Science

Ronald G. Prinn
Meteorology

Richard S. Sidell
Mechanical Engineering

Keith D. Stolzenbach
Civil Engineering

President and Chancellor

Marcus A. Thompson
Humanities

John Van Maanen
Sloan School of Management

Christopher T. Walsh
Chemistry

Robert A. Weinberg
Biology

Alan S. Willsky
Electrical Engineering and
Computer Science

Mark S. Wrighton
Chemistry

To Assistant Professor:

Reinaldo F. Gomez
Nutrition and Food Science

Michael P. Manning
Chemical Engineering

Michael R. E. Proctor
Mathematics

Wilma E. Wetterstrom
Humanities

CHANGES OF APPOINTMENT

Robert Alloway
Assistant Professor in Sloan School
of Management

Thomas A. Barocci
Assistant Professor in Sloan School
of Management

Richard Beckhard
Adjunct Professor in Sloan School
of Management

Adam C. Bell
Associate Professor in Mechanical
Engineering

Alan V. Berger
Research Fellow in Humanities

William F. Brace
Cecil and Ida Green Professor
of Geology in Earth and
Planetary Sciences

Noam A. Chomsky
Institute Professor

Chatham M. Cooke
Research Associate in Electrical
Engineering and Computer Science

Renwich E. Curry
Research Associate in Aeronautics
and Astronautics

Ernest G. Cravalho
Matsushita Professor of Electrical
and Mechanical Engineering in
Medicine and Associate Dean of
Engineering for Educational
Programs

John M. Deutch
Professor and Head of Department
of Chemistry

Peter A. Diamond
Professor and Associate Head of
Department of Economics

Herman Feshbach
Cecil and Ida Green Professor of
Physics and Head of Department
of Physics

Woodie C. Flowers
Class of 1922 Career Development
Associate Professor of Mechanical
Engineering

Michael B. Folsom
Research Associate in Humanities

Kenneth I. Forster
Visiting Professor and Research
Fellow in Psychology

Clark Graham
Adjunct Professor in Ocean
Engineering

Nicholas J. Grant
Abex Professor of Advanced
Materials in Department of
Materials Science and
Engineering and Director of
Center for Materials Science
and Engineering

Morris Halle
Acting Head of Department of
Linguistics and Philosophy
and Ferrari P. Ward
Professor in Modern
Languages and Linguistics

J. Herbert Hollomon
Japan Steel Industries Professor
of Engineering and Director
of Center for Policy
Alternatives

John G. Kassakian
Carl Richard Soderberg
Assistant Professor of Power
Engineering in Electrical
Engineering and Computer
Science

Roger E. Kaufman
Lecturer in Mechanical
Engineering

Marcus Karel
Associate Department Head
and Professor of Food
Engineering in Nutrition
and Food Science

Jack L. Kerrebrock
Richard Cockburn Maclaurin
Professor in Aeronautics
and Astronautics

Melvin H. King
Adjunct Professor in Urban
Studies and Planning

Stephen J. Kobrin
Ford International Assistant
Professor in Sloan School
of Management

Peter B. Laytin
Assistant Professor in
Architecture

Personnel Changes

John P. Longwell
Professor in Chemical Engineering

Stephen P. Loutrel
Lecturer in Mechanical Engineering

Roger G. Mark
Matsushita Associate Professor of
Electrical Engineering in Medicine
in Electrical Engineering and
Computer Science

Alan V. Oppenheim
Cecil H. Green Professor of
Electrical Engineering in Electrical
Engineering and Computer Science

Frank E. Perkins
Professor and Head of Department
of Civil Engineering

James Porter
Lecturer in Chemical Engineering

Mary C. Potter
Research Associate in Psychology

Alician V. Quinlan
Arthur D. Little Assistant
Professor of Environmental
Sciences and Engineering in
Mechanical Engineering

William M. Rand
Lecturer in Nutrition and Food
Science

Robert H. Rediker
Adjunct Professor of Electrical
Engineering in Electrical
Engineering and Computer Science

Melvin H. Rodman
Professor of Medicine, Medical
Director and Head of Medical
Department

Derek Rowell
Assistant Professor in Mechanical
Engineering

Michael S. Scott Morton
Associate Dean and Professor in
Sloan School of Management

Nevin S. Scrimshaw
Institute Professor and Head of
Department of Nutrition and
Food Science

Melissa Shook
Assistant Professor in
Architecture

Barbara J. Sirota
Research Fellow in Humanities

Kenneth A. Smith
Professor and Acting Head of
Department of Chemical
Engineering

Frank Solomon
Assistant Professor in Biology

H. Eugene Stanley
Lecturer in Mechanical Engineering

Keith D. Stolzenbach
Arthur D. Little Assistant Professor
of Environmental Sciences and
Engineering in Civil Engineering

Nak H. Sung
Assistant Professor in Mechanical
Engineering

Giuliana C. Tesora
Adjunct Professor in Mechanical
Engineering

Richard C. Tremaglio
Adjunct Professor in Architecture

Sherry R. Turkle
Assistant Professor in School of
Humanities and Social Science

Michael J. Underhill
Assistant Professor in Architecture

John K. Vandiver
Doherty Assistant Professor in
Ocean Utilization in Ocean
Engineering

Joseph F. Vittek
Lecturer in Aeronautics and
Astronautics

Alvin M. White
Visiting Associate Professor
in Division for Study and
Research in Education

John R. Wiley
Adjunct Professor in
Aeronautics and Astronautics

Peter A. Wolff
Professor in Physics and
Director of Research
Laboratory of Electronics

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

NEW FACULTY APPOINTMENTS

Professor:

Carl Kaysen
David W. Skinner Professor
in School of Humanities and
Social Science

Leo Marx
William R. Kenan, Jr.
Professor in School of
Humanities and Social
Science

Eli Shapiro
Alfred P. Sloan Professor
in Sloan School of Management

Associate Professor:

Franklin F. Alvarez
Ocean Engineering

Eunice J. Betts
Athletics

Oral Buyukozturk
Civil Engineering

Carl R. Peterson
Mechanical Engineering

Irene Tayler
Humanities

President and Chancellor

David Thorburn
Humanities

Preetinder S. Virk
Chemical Engineering

Assistant Professor:

Rafael L. Bras
Civil Engineering

Sallie W. Chisholm
Civil Engineering

Michael P. Cleary
Mechanical Engineering

William M. Deen
Health Sciences and Technology
and Chemical Engineering

Thomas W. Eagar
Materials Science and Engineering

Glenn R. Flierl
Meteorology

Dorian M. Goldfeld
Mathematics

Jeffrey E. Harris
Economics

Peter W. Huber
Mechanical Engineering

Mujid S. Kazimi
Nuclear Engineering

Cyril Leung
Electrical Engineering and
Computer Science

Thomas D. Lockwood
Nutrition and Food Science

F. Read McFeely
Chemistry

Richard B. Melrose
Mathematics

Starr Ockenga
Architecture

Fredrick A. Putnam
Chemical Engineering

David A. Randall
Meteorology

Jane Rosenkrans
Athletics

Louis S. Scaturro
Nuclear Engineering

William A. Shaffer
Sloan School of Management

Chong S. P. Sung
Materials Science and Engineering

Michael F. Van Breda
Sloan School of Management

Graham C. Walker
Biology

Edward L. Wright
Physics

Gregory J. Yurek
Materials Science and Engineering

Adjunct Professor:

Louis L. Banks
Sloan School of Management

Richard J. Charles
Materials Science and Engineering

VISITING FACULTY

Visiting Professor:

Claude J. Allegre
Earth and Planetary Sciences

Jens Als-Nielsen
Physics

Burrell C. Burchfiel
Earth and Planetary Sciences

Giorgio Ciucci
Architecture

Claude Cohen-Tannoudji
Physics

Bill C. Giessen
Materials Science and Engineering

Charles G. Gross
Psychology

Terje Hansen
Sloan School of Management

Otto K. Harling
Nuclear Engineering and
Director of the M. I. T. Reactor

Satio Hayakawa
Physics

Gerald Holton
School of Humanities
and Social Science

Herbert H. Hyman
Political Science

Edwin Kessler III
Meteorology

David G. Luenberger
Electrical Engineering and
Computer Science

George Lusztig
Mathematics

David G. Nathan
Biology

Gerard K. O'Neill
Aeronautics and Astronautics

Zenon W. Pylyshyn
Electrical Engineering and
Computer Science

Melvin E. Stern
Meteorology

Martin V. Sussman
Chemical Engineering

Paolo Sylos-Labini
Economics

Personnel Changes

William R. Trott
Aerospace Studies and Director
of the Air Force ROTC Program

Robert E. C. Weaver
Chemical Engineering

Peter K. E. Weyerstahl
Chemistry

Mason Willrich
Nuclear Engineering

Michael B. Woodrooffe
Mathematics

William A. Woods
Mechanical Engineering

Ogura Yoshimitsu
Meteorology

M. Michael Yovanovich
Mechanical Engineering

Dieter Zimmermann
Physics

Visiting Associate Professor:

Francesco L. Bacchialoni
Electrical Engineering and
Computer Science

Glean Chase
Architecture

Chi-Hau Chen
Electrical Engineering and
Computer Science

Michael R. Davis
Ocean Engineering

Nancy J. Gaspard
Sloan School of Management

Owen F. Hughes
Ocean Engineering

Puthenveetil K. John
Nuclear Engineering

Johan A. W. Kamp
Philosophy

Stephen D. Lewis
Electrical Engineering and
Computer Science

David B. Lipsky
Sloan School of Management

Glenys L. Luke
Mathematics

Shigetomi Matsui
Ocean Engineering

Daniel E. Murnick
Physics

Alexandra Navrotsky
Materials Science and Engineering

Louis-Francois Pau
Electrical Engineering and
Computer Science

Thomas J. Rothenberg
Economics

Hendrik G. Stassen
Mechanical Engineering

John J. Thwaites
Mechanical Engineering

Markus Zahn
Electrical Engineering and
Computer Science

Visiting Assistant Professor:

Shelton H. Davis
Humanities

Joseph H. Hall
Humanities

William A. Haseltine
Biology

Barry Lydgate
Humanities

John D. Malcolm
Mechanical Engineering

Shimon Mizrahi
Nutrition and Food Science

Charles J. Rieger III
Electrical Engineering and
Computer Science

Sidney Strauss
Division for Study and Research
in Education

ADMINISTRATION

DEATHS

Carolyn B. Cox
Director, Registry of Guests
Campus Information Services

Richard G. Driscoll
Captain
Campus Patrol

Martin M. Phillips
Regional Director
Alumni Association

RETIREMENTS

Gertrude E. Burns
Administrative Officer
Sloan School of Management

Miles P. Cowen
Assistant Director, Special
Services
Physical Plant

Ruth E. Dubois
Administrative Officer
Department of Humanities

Ruth S. Goodwin
Assistant Registrar
Registrar's Office

W. Bradford Gove
Assistant Director
Office of Sponsored Programs

Myer M. Kessler
Coordinator-Technical Data
Services
Information Processing Services

President and Chancellor

Robert F. Scofield
Construction Coordinator
Physical Plant

C. Warren Smalzel
Institute Secretary
Vice President for Resource
Development

RESIGNATIONS

Jerome H. Adler
Manager-Video Services
Center for Advanced Engineering
Study

Yale Altman
Senior Science Acquisitions Editor
M.I. T. Press

Christine Anderson
Assistant Project Planner
Planning Office

Myra L. Ballison
Applications Analyst
Information Processing Center

Stephen E. Barnes
Director of Special Events
Alumni Association

Charles E. Barringer
Assistant Dean of Engineering
for Administration
School of Engineering

Helga S. Babendreier
Applications Programmer
Office of Administrative Information
Systems

Joseph J. Bergstein
Programming Analyst
Information Processing Center

Donna D. Berman
Senior Project Planner
Planning Office

Pamela J. Blakely
Employee Instructor
Office of Personnel Development

Barbara A. Burke
Staff Writer/Editor
News Office

Rae K. Burns
Senior Systems Programmer
Programming Development Office

W. Thad Byrd
Assistant to the Director
Educational Council

Elizabeth M. Childers
Assistant Auditor
Audit Division

Sandra L. Cohen
Assistant Director
Admissions Office

J. David Colley
Graphic Designer
Campus Information Services-
Design Services

Arthur J. Collias
Manager-Self Study Subject
Distribution
Center for Advanced Engineering
Study

Robert C. Daley
Assistant Director-Information
Processing Services
Director of Programming
Development Office

Linda Desmond
Applications Analyst
Information Processing Center

Irene R. Dhosi
Senior Employee Instructor
Office of Personnel Development

Alice Drake
Technical Writer
Office of Administrative
Information Systems

Thomas G. Dreyer
Data Processing Manager
Alumni Association

Alfred E. Ennis
Administrative Assistant
Physical Plant

Barbara Farquhar
Systems Analyst
Office of Administration
Information Systems

Laurence M. Feder
Industrial Liaison Officer
Industrial Liaison Office

Daniel J. Fingerman
Associate Director of Alumni
Fund
Alumni Association

Kathleen M. Fox
Administrative Officer
School of Humanities and
Social Science

Joan Friebely
Editor for Special Projects
Campus Information Services

Mark Froimowitz
Applications Analyst
Information Processing Center

Kathleen A. Gallery
Administrative Officer
Department of Materials
Science and Engineering

Lawrence Gilbert
Patent Administrator
Office of Sponsored Programs

Ruth W. Gillies
Chief Editor
M.I. T. Press

Carol J. Greenough
Systems Programmer
Programming Development Office

Nancy L. Haggerty
Systems Analyst
Office of Administrative
Information Systems

Personnel Changes

Jonathan E. Hartshorne
Assistant Dean
Dean for Student Affairs

James L. Homan
Systems Programmer
Programming Development Office

Michael Hubner
Assistant Writer/Researcher
Resource Planning

Charles R. Johnson
Project Manager
Physical Plant

Ross E. Klinger
Systems Programmer
Programming Development Office

Jane Kosut
Assistant to the Director
Office of Sponsored Programs

Arnold M. Lieberman
Systems Programmer
Programming Development Office

Bruce MacDonald
Director of Exhibitions
Committee on the Visual Arts

Lawrence E. Maguire
Associate Director of Financial Aid
Student Financial Aid Office

Marcie F. Markley
Programmer
Programming Development Office

Dilip K. Mathur
Industrial Liaison Officer
Industrial Liaison Office

Daniel L. Needleman
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Dean for Student Affairs

This has been a year of accomplishment, and a year of unsolved and seemingly insolvable problems. The Office of Minority Education (O. M. E.) is now alive and well; women's athletics is moving forward; a new fraternity and a new independent women's living group are coming into being. At the same time, economic constraints worsened dormitory crowding, allowed no substantial relief in the pressures on athletic and student center facilities, and increased the fiscal burden on students and their parents. Current and anticipated reductions create anxiety among staff and strain their capacity to keep up with the pace of work. It is easy to become so preoccupied with the daily (and nightly) tasks as to lose sight of successful Institute recruitment of a gifted, vigorous, and dedicated student body.

Last year saw the birth of the long awaited Office of Minority Education and the appointment of Professor Wesley Harris as its Director. In his new role, he took responsibility for Project Interphase.

An ad hoc committee on women's athletics, chaired by Professor Sheila Widnall, surveyed needs of an increasing population of women students not adequately served by prior arrangements. The committee's report led to the appointment of two new full-time coaches and a search for a Director of Women's Athletics who also will serve as Assistant Director of the M. I. T. Athletic Department. A copy of the Task Force recommendations are appended to the report of the Director of Athletics.

Despite a new fraternity and a new women's living group, dormitory crowding and dormitory costs remain a problem, partially due to the decision to increase the size of entering classes for the next several years. After extensive discussion, it was decided that a fraction (1/9) of the costs for the Faculty and Graduate Residents Program would be charged to the students through rents. Because of ambiguities in the procedures governing graduate resident selection, the process was re-examined, and a revised and explicit system is being developed.

The F. A. C. program (Freshman Advisory Council) is under review by a Steering Committee chaired by Professor Hartley Rogers. Its report is expected in fall, 1976.

The Office of Preprofessional Counseling continued to place our graduates in medical schools, despite the increasing pressures of competition as the applicant pool grows more rapidly than the places available.

Although the Office of the Dean for Student Affairs always has served the needs of some graduate students, we have assumed a greater role in the graduate program at the invitation of its new Dean, Professor Kenneth R. Wadleigh. We are in the process of reassessing the deployment of resources between undergraduate and graduate activities in order to assure greater equity for graduate students.

The Dean for Student Affairs continued to serve as an advisor to freshmen and premedical students, maintain Open House during R/O week, and have scheduled informal meetings with students to discuss careers, and Institute and personal matters.

Staff promotions included Alice M. Seelinger and Bonny Kellermann to Assistant Deans for Student Affairs. David August, a senior, was appointed a student intern.

The most difficult section of this annual report is the listing of staff changes for it acknowledges the loss of a number of our most valuable members. William Speer retired as Associate Dean for Student Affairs. Nancy Wheatley accepted a position with the Alumni Office. John Hartshorne resigned to train in Jungian psychology in Switzerland. Since budget cuts allow us no funds for a replacement, his responsibilities were assumed by Associate Dean Robert Holden. Cleovonne Turner left the counseling staff to return to social work. Anne Thompson, who developed our supportive program for women students, resigned to pursue graduate training in clinical psychology. In addition, budgetary constraints have resulted in the attrition of two and a half full-time equivalent secretaries.

CAROLA EISENBERG

Freshman Advisory Council

The largest freshman class in M. I. T. 's history was advised by the largest number of freshman advisors, with the lowest advisee/advisor ratio ever. Volunteers continued to be accepted from among staff and graduate students in addition to the faculty and instructing staff. The number of volunteers by category was: faculty, 111; instructors and lecturers, 17; graduate students, 52; staff, 107. This reflects a decline in faculty participation from the previous year, and a sharp rise in the number of graduate student volunteers in response to the C. E. P. approval of an expanded experiment involving graduate students as advisors. More than 220 advisors had upperclass men and women working with them as associate advisors.

In terms of academic options, few changes occurred. The Department of Mathematics offered a new calculus option (18.01X) covering all but one of the topics in 18.01, with the hope that some students who could benefit from the slightly slower pace would enroll. Only a handful did, initially, although a total of 30 were enrolled by the end of the term. There was some growth in the list of subjects satisfying the Humanities Distribution Requirement. Faculty teaching science core subjects reported that the number of students having difficulty at the end of the fall term was comparable to previous fall terms (4 percent received C. A. P. warnings). However, at the end of the spring term, the number in difficulty rose sharply, with 6 percent receiving C. A. P. warnings and 18 students asked to withdraw for at least one semester. Part of this increase is due to a continuation of recent trends of increasing academic demands within subjects and stiffer grading practices.

The MITHELP program, developed during spring and summer, 1975 to help freshmen with deficiencies in high school math, became available during the fall semester. Twenty-seven freshmen attended one or more of the three topics offered, which was slightly more than half of the minimum number of students who were assumed to be likely to benefit from the program. Although opinions differ about the nature and extent of deficiencies with which freshmen arrive at M. I. T., the Director of the Office of Minority Education believes that a larger number of freshmen can be encouraged to take advantage of MITHELP. The program will be directed entirely out of his office in the fall, and efforts to involve freshmen will be increased. A more complete report on last fall's program is available in the F. A. C. Office.

During the summer, Chancellor Paul E. Gray appointed a Steering Committee, in lieu of a faculty chairman, to assist the F.A.C. Office with operational matters, and to conduct an extensive review of current F.A.C. policies and procedures. The Committee consisted of Dean Peter Büttner, Professors Robert Halfman and Margaret MacVicar, Kevin Miller '77, and Professor Hartley Rogers, Chairman. The Committee met frequently throughout the year, and is expected to complete its report early next fall. The F.A.C. Office conducted questionnaire surveys of both undergraduate students and of freshman advisors to obtain factual information and opinions relevant to the issues under discussion. Summaries of findings will be contained in the committee's report.

Besides serving as associate advisors, undergraduates continued to contribute to Freshman Advisory Council activities. Libby Seifel '78 coordinated the volunteers who ran Residence/Orientation Week. Alan Mink '79 organized the group of students who will be welcoming the Class of 1980. Students spent many hours during I. A. P. analyzing the questionnaires mentioned above, and helping with several aspects of the Freshman Handbook.

During fall and early spring, the F.A.C. staff continued its past practice of small group meetings with advisors. Over 60 percent of the advisors attended these sessions, which were a source of feedback for the staff and also a forum for exchanging ideas among advisors. Staff members attended meetings of the Committees on Academic Performance and on Admissions and Financial Aid, as well as committees concerning R.O.T.C. and the Community Service Fund. Several office open houses provided opportunities for discussions with freshmen. A monthly newsletter, begun in October as a service to freshmen and advisors, reduced previous costs incurred in communications with freshmen.

Bonny S. Kellermann became a full-time staff member with responsibilities for administering the Undergraduate Seminar Program, and was promoted to Assistant Dean. Naomi Landau, one of the half-time secretaries, returned to Israel with her husband, who had completed his doctorate in Civil Engineering. Marie-France Pierre went from 70 percent time to half time, filling the job-shared vacancy, in order to increase time spent working on her bachelor's degree. Patricia O'Neill filled Ms. Pierre's position, providing secretarial support for both the F.A.C. and the Undergraduate Seminar Program. Janis Bestul '76, a part-time worker for several years, received her degree in June and was replaced by John Marcou '78.

PETER BÜTTNER
BONNY S. KELLERMANN

Undergraduate Seminar Program

The seminar program continued to show increased interest from both first-year and upperclass students. In the fall term, 825 students (631 freshmen and 194 upperclassmen) registered for undergraduate seminars, an increase of 32 over the previous year. The spring term had 645 students (395 freshmen and 250 upperclassmen), an increase of 186 students (149 freshmen and 37 upperclassmen) over the previous year.

The number of seminar offerings did not grow with the enrollments. The fall term offered 67 listings representing 63 different seminars compared with 65 seminars offered the previous fall. The spring term showed a decline from 56 to 51 listings representing 50 seminar offerings.

During spring term, seminar instructors held meetings to discuss issues relevant to the seminar program. It was decided that in oversubscribed seminars, the instructor may decide the seminar composition. Freshmen previously received automatic priority.

In December, Bonny Kellermann replaced Nancy Wheatley as executive officer of the seminar program. Professor Cravalho continued to serve as faculty chairman of the program, and Patricia O'Neill replaced Marie-France Pierre in January in carrying out undergraduate seminar secretarial support.

BONNY S. KELLERMANN

Undesignated Sophomore Program

The program continued in a low-key fashion to match sophomores and advisors as needed and provide them with basic information and services. Undesignated sophomores increased in number by about 20 in the fall to 191, and 134 in the spring as compared to 98 in the spring of 1974-75. With the larger freshman class last year, there may be an increased number of undesignated sophomores in the next academic year.

The informal advisory group for the program deals with students in academic difficulty. This summer the program will physically move back to the counseling section of the Dean's Office.

ROBERT L. HALFMAN

Office of Preprofessional Advising and Education

The Preprofessional Advising and Education Office scheduled several meetings during this year for students interested in medicine and law. Early September meetings acquainted freshmen with the advisory services of the Premedical and Prelaw Councils as well as the services available at the Preprofessional Advising and Education Office. Later that month, Dr. Leon Eisenberg spoke with students about the nature and format of the medical school interview. In February, sophomores were informed of the planning necessary for their premedical education. Members of the committee met later with students who will attend medical school next year. Discussion focused on the criteria for selecting medical schools. In the spring there were meetings for students applying to medical and law school for the class entering in September 1977. For the latter we invited alumni attending law school to speak informally on their law school experiences. Representatives from eight medical schools, 14 law schools, one school of public policy, and one school of health administration visited M. I. T. during the year.

Professor Bernard S. Gould of the Department of Biology and Dean Susan Haigh Houpt attended a meeting of the Northeast Association of Advisors to the Health Professions at the University of Rochester Medical School in April. Dean Houpt attended the meeting of the Northeast Association of Prelaw Advisors at Columbia University Law School in June. The contacts made at these meetings both with other advisors and with professional schools provide an opportunity for mutual support.

The fourth Forum on the Legal Professions was sponsored jointly by the Office of Law Related Studies and the Preprofessional Advising and Education Office. Participants included a judge, a corporate attorney, and a law school professor.

William Mazzei, a third-year student, helped Dean Eisenberg and Dean Houpt organize an informal gathering for premedical students, medical students, and doctors, to give our students exposure to members of the medical profession.

During I. A. P. the Committee on Preprofessional Advising and Education sponsored or cosponsored offerings including: A Brief Introduction to the Law, cosponsored with Professor Jeffrey Meldman of the Sloan School of Management; Careers in Medicine, at which six physicians spoke informally about their careers; and The Role of Basic Science and Engineering in the Development of Modern Medicine, in which individual sessions covered neurology and psychiatry, surgery and experimental surgery, engineering and diagnosis, the study of disease, and medicine -- hematology, oncology, and pediatric medicine.

In the spring, a questionnaire was mailed to 100 alumni currently attending law school. It was returned by 53, who shared some of their thoughts and experiences about their legal education and their particular law school.

Thirty-three undergraduate students and 26 alumni who graduated between 1964 and 1975 applied to law school for admission in 1976. They submitted 316 applications to 58 law schools. The average number of applications was five. Twenty-five (75 percent) of the S. B. candidates and 17 (65 percent) of the alumni were admitted to law school. A total of 32 individuals will be attending 23 law schools. Nine (36 percent) of the S. B. candidates who were admitted to law school decided not to attend; one alumnus who was admitted to law school decided not to attend. We received 40 LSAT scores for 33 students who applied to law school this year and the mean score is 663.175. We received 25 LSAT scores for 26 alumni who applied to law school this year, and the mean score is 682.52.

There were 102 S. B. candidates who applied to medical school in 1976; 79 (77 percent) were admitted to at least one school. Of the additional 61 applicants, 28 (46 percent) were admitted. Altogether 163 applicants submitted 2,363 applications to 111 medical schools, a mean of 14 per student. One hundred and seven applicants received 262 acceptances from 80 medical schools. The mean number of acceptances was 2.4 among the students who received acceptances. The ratio of acceptances to applications was 11 percent. Forty-seven applicants (44 percent) were accepted to only one school. Twenty-five of these were accepted only by their state school (23 percent of the total number of applicants accepted). One hundred and two applicants are attending 50 medical schools; five have decided not to attend. Twenty-five alumni of M. I. T. applied to medical school through the Preprofessional Advising and Education Office. Fifteen (60 percent) were admitted. Of the 14 alumni who applied to medical school for the first time, 10 (71 percent) were admitted. There were 18 applicants who had applied to medical school in a previous year; five were admitted.

SUSAN HAIGH HOUPT

Minority Student Support

There was growth and improved quality of student participation in the support activities sponsored by the Dean for Student Affairs Office. Small group and individual discussions with students, faculty, staff, administration, and parents continued to be a viable source of information about students' living experiences at the Institute. Special academic and service interest groups continued to thrive under the advice and counsel of faculty members.

The M. I. T. Black Electrical Engineers and faculty advisor Professor Arthur C. Smith provided tutorial and other services to the M. I. T. undergraduate minority students and through the Metco Program, minority youth in the Boston area. After several years of stressing the importance of the resume, students published their first resume booklet with the assistance of Dean James Bruce in the School of Engineering.

Special concerns of undergraduate women were addressed at a summer retreat held at Talbot House with the assistance of Dean Anne Thompson and Eleanor Bruce. Several follow-up sessions planned by the students were held during the year.

The Black Students' Conference on Science and Technology was held again under the sponsorship of several corporations. "Education of Black Students in Majority Institutions" was the Conference theme. Workshop sessions geared toward career options were held in the areas of Science and Engineering, Medicine and Science, and the Social Sciences.

Student participation in off-campus educational activities continues to be encouraged and sponsored by the Dean for Student Affairs Office. Students attended the Conference of the National Society of Black Engineers held in Los Angeles, California; National Medical Students Association in Washington, D. C.; and a special course project in Architecture in Kingston, Jamaica.

Efforts to aid minority students in securing information on career possibilities continue in conjunction with the Career Planning and Placement Office.

A special awards dinner for minority students was held to motivate and encourage academic excellence. Dr. Albert G. Hill, concerned about the academic performance of minority students and specifically black students, established the Albert G. Hill Prize to be awarded to the student or students showing the greatest academic progress. This year's recipient was Patrice Yager who received an S. B. and S. M. in Course XI.

With the cooperation of resource persons from industry and business, all minority students requesting assistance in securing summer jobs for 1976 were successfully placed.

Several meetings were held this year with Richard Knight, Secretary of the Alumni Association; James Champy, Executive Vice President of the Alumni Association; and Nancy Wheatley, Director for Regional Conferences and Special Programs, to develop ways in which minority alumni can become involved with or contribute to the well-being of minority students at the Institute.

A total of 35 minority students received undergraduate degrees at graduation exercises in June 1976 (see Chart II).

MARY O. HOPE

CHART I

MINORITY STUDENTS ADMITTED AND REGISTERED
Fall 1972 (Class of 1976)

	<u>Black American</u>	<u>Mexican American</u>	<u>American Puerto Rican</u>	<u>TOTAL</u>
Graduated	19	4	3	26*
Withdrawn	8	1	0	9
Transferred	0	1	0	1
Continuing	<u>14</u>	<u>1</u>	<u>3</u>	<u>18</u>
TOTAL	41	7	6	54

* Three graduated early in June 1975

CHART II

MINORITY STUDENTS FROM OTHER CLASSES
WHO RECEIVED DEGREES JUNE 1976

Original Class	# of Students Who Graduated with the Class of 1976
1974	3
1975	8
1977	1

A total of 35 minority students received undergraduate degrees at commencement exercises in June 1976.

A total of 13 out of the 23 Project Interphase 1972 participants received undergraduate degrees in June 1976. Three of the Project Interphase 1972 participants have withdrawn, and seven others are still pursuing degrees.

Project Interphase

Project Interphase, a seven year-old summer academic program coordinated by the Office of the Dean for Student Affairs, assists freshmen who are intellectually and personally capable of succeeding at M. I. T. but whose high school backgrounds indicate academic weakness.

Concern was generated by the academic performances of some freshmen and Project Interphase participants during fall, 1974, particularly in 8.01. Therefore, an attempt was made in planning the curriculum of Project Interphase 1975 to alleviate some students' difficulties.

The staff of Project Interphase 1975 developed a questionnaire to evaluate the program. The curriculum was planned cognizant of the needs indicated by the questionnaire and the results of diagnostic tests administered to students at the beginning of the program.

The Physics, Calculus, Chemistry, and Writing Course remained required components. The Writing Program staff was increased to provide smaller group and individual tutorials and more individualized instruction as needed. The Study Skills and Institute Resources included methods of study-time management, information concerning resources, tours, and lectures by resource persons. The Humanities components retained the art and photography options, and opportunity was provided for advanced instruction in both media, according to student interest and talent.

A new course in high school studies was designed to fill academic gaps in student preparation. Subject areas covered were indicated by results of diagnostic tests and correlated with subject matter in the regular components of required physics, mathematics, and chemistry. Group and individual tutorials were assigned as needed after class sessions. Athletic and recreational activities remained the same as in 1974.

There were 25 participants this year, two short of program capacity.

The fall follow-up program conducted by the staff of Project Interphase 1975 contributed to improved academic performances of the students. Only one student received a warning from the Committee on Academic Performance. Thirteen of the 23 Project Interphase 1972 participants received undergraduate degrees in June 1976. Three students have withdrawn from the Institute and seven students are still pursuing degrees.

MARY O. HOPE

Women's Program

As in past years, Dean Anne Thompson's time was divided among counseling, other Dean's Office activities, and providing direct support for women students. About half of the students in formal counseling contacts were women, and among students seen informally, considerably more were women.

Women's Program

Dean Thompson continued to provide support for the Association for Women Students. Representative activities and projects included: a welcoming party for incoming undergraduates; a booklet distributed to incoming women students describing resources of particular interest to women at M. I. T. and in the Boston area; a resource list of M. I. T. women who are willing to extend friendship and counsel to women students; letters written to all women accepted to the first year class, offering to answer questions they might have; and volunteers "sitting in" in the Admissions Office during the peak interviewing period, to speak informally with prospective applicants.

Dean Jeanne Richard of the Graduate School Office and Dean Thompson planned a number of programs for graduate women. A series of group meetings were held for incoming graduate women called "Transition to M. I. T.;" after an initial meeting attended by about 35 students, a group of 10 met for five consecutive weeks to discuss topics of interest to the students as they adjusted to M. I. T. The group met again in May for an end-of-year reunion and follow-up. The fact that the students made a focused use of the group to obtain help and support as well as to make friends suggests that this may be a workable format for easing the adjustment of women to graduate life at M. I. T. Most attendees came from departments with few women and no support groups organized by women students. Over I. A. P., a series of luncheons for graduate women was also attended by faculty and staff, helping us tune in to the needs of women graduate students. Dean Thompson is currently participating in planning meetings for graduate women's orientation, and for a fall term series of panels and speakers for women graduate students and their friends.

Over I. A. P., Dean Thompson and Sandra Cohen of the Admissions Office organized a four-part series for freshmen on the topic of "How to Find a Summer Job." Though designed for all freshmen, it was hoped that this program would be of particular use to women students. The results of a questionnaire sent in September suggested that freshman women obtained less desirable and lower paid summer jobs, and less help from the resources available to them, including their parents. Although the coming departures of both Sandra Cohen and Dean Thompson prevented extensive evaluation of this project, it was enthusiastically received by the students.

Along with Andrea Decof, an intern in the Dean's Office, Dean Thompson has been compiling a statistical file on women students, withdrawals, readmission, course changes, C. A. P. actions, and housing changes, for the classes entering 1970 and onwards. Extensive analysis is not possible until the data is computerized, but some general statistics will be forthcoming. The conclusions should be used for counseling and support purposes since the number of women at M. I. T. is still small, and comparative data on all students are not readily available.

Dean Thompson continued to interact with the campus housing section of the Dean's Office on issues affecting women students. She was a member of the Joint Committee of the Wellesley-M. I. T. Exchange Program, and a subgroup headed by Delores Hayden analyzing the course offerings in women's studies at M. I. T. and Wellesley.

ANNE THOMPSON

Counseling

During 1975-76, the five members of the Dean for Student Affairs Office (D.S.A.) involved in the counseling section divided their efforts among five major activities: advising and counseling individual students; supporting educational and student related administrative groups directly connected with counseling; responding to individual needs of women and minority students, undesignated sophomores, students on academic warning, and recently readmitted students; participating in D.S.A., faculty, and Institute groups on educational and administrative programs not directly connected with counseling; and sharing in the evaluation and improvement of communications, policy practices, and personnel matters of the counseling group.

Individual students seeking assistance from the counseling section continued to be predominantly undergraduates whose most frequent worries were academic. In general, they are increasingly concerned about the economic picture and its impact upon their educations and careers. Many felt they were experiencing heavier academic demands and keener competition from their peers than in earlier years. Although many personal concerns were raised as in previous years, we talked with fewer students about dormitory related disputes, disagreements over student accounting, and drug related matters. To gain more objective readings on the numbers and classifications of student contacts and the concerns raised by them, and to assess the total amount of time spent in one-to-one counseling, we compiled figures on each "counseling contact." Dean Thompson devised forms for each counseling dean to keep track of weekly counseling activities. During the spring term, data on the primary and secondary reasons for students' office visits were collected. Throughout the year, Dean Thompson and Constance Fogler assured that sheets were completed consistently and regularly, and compiled data at five-week and semester intervals. Thus, for the first time, the section will have accurate and comparative figures on student counseling populations and concerns of students.

Because of start-up difficulties and the lack of an appropriate context for interpreting data, figures for 1975-76 are used only within the office. The data confirmed that about 11 percent of those counseled were graduate students, and that the most frequent reasons for visits are academic difficulties, financial questions, peer relations, Committee on Academic Performance actions, study difficulties and skills, readmissions, and withdrawals. Weekly meetings continued with Dr. Peter Jenney of the Psychiatric Service to discuss students referred between the two offices, and for the counseling section to receive professional advice on the more difficult cases.

The counseling section and Dean Eisenberg reviewed our support of individual graduate students during the past years and explored ways of making graduate students more aware of the supportive services available to them through the D.S.A. With Vice President and Dean of the Graduate School Kenneth Wadleigh and his staff, approaches, responsibilities, and cooperative ventures between the two offices were considered. Dean Wadleigh asked counseling section members to serve on the Committee on Graduate School Policy (C.G.S.P.) and to participate in its four subcommittees. Dean James J. Bishop became the D.S.A. ex-officio representative to the C.G.S.P. and Dean Cleovonne Turner and he served on C.G.S.P. subcommittees. At the orientation program for new graduate students, Graduate Student Council meetings, and other interactions with graduate students, the section informed graduate students and their advisors about our office.

The counseling section continued active support for various faculty committees and administrative groups. All staff members of the section attended the regular weekly C.A.P. meetings on a rotating basis. At the end of both terms, a large number of students discussed their academic performances and related personal matters with members of the counseling section. D.S.A. counselors and the faculty advisors talked prior to the C.A.P. grades meeting about recommendations for students' personal academic circumstances. The section also acquired, through the weekly and grade meetings of the C.A.P., calibrations regarding faculty opinions that are essential in the counseling of M.I.T. students. Dean Halfman was appointed to the F.A.C. Steering Committee. Dean Bishop served on the I.A.P. Policy Committee and represented Dean Eisenberg at the Committee on Discipline meetings on policies matters, but no longer handled cases against students.

The staff of the counseling section played key roles in support programs for minority, women, and foreign students, and for undesignated sophomores. Details of these as well as the follow-up and outreach programs lead by D.S.A. counseling staff members are described in other parts of the Office's report. As part of a review of programs for students from particular groups, the counseling section had discussions with Dean Robert Holden and Carol Beals about transfer student orientation, and with Dr. Charlotte Schwartz of the Psychiatric Service about clients' desires and needs vis-à-vis the views of the staff.

The counseling section devoted more thought to internal, policy, administrative personnel, and operational matters than ever before. Starting last summer in its weekly meetings with Dean Eisenberg, the section outlined a long list of objectives and tasks for the year. A data collection system was instituted, tested, and prepared for future use. Throughout the fall term, the counseling staff and Dean Eisenberg discussed proposed structural changes in the Dean's Office. On several occasions, the counseling section and Dean Eisenberg discussed relationships with members of the faculty, devoting particular attention to the nature of communications with faculty advisors about individual conferences with students. There was a consensus that the section could communicate more frequently and earlier with faculty advisors than in the previous two years.

After learning of the pending resignations of Deans Thompson and Turner, the counseling section reviewed in considerable detail its time allocations, its definition of counseling, its priorities, and the nature of its interactions between individual and groups of students. A thorough review of D.S.A. counseling had not been held at all within the last seven years. The sectional and staff discussions produced clear understanding of the roles of D.S.A. counselors, and pointed out the need for the Institute to re-evaluate "student counseling," and the support that ought to be given to it.

JAMES J. BISHOP

ACADEMIC FOLLOW-UP AND OUTREACH

The majority of Dean Turner's time this year was spent in counseling individual students with personal, academic, and legal concerns. Several groups were started in a continuing effort to reach out to more students who might benefit from discussions of common problems. Deans Kellermann, Thompson, and Turner again held group meetings primarily for freshmen and other undergraduate newcomers to M.I.T.

A study skills group was offered to freshmen, as was a pamphlet written by Dean Kellermann containing study tips and suggestions. Once again, we offered the freshman group for those experiencing academic difficulties. Although groups have the advantage of helping many students at one time, their continuation may not be possible due to sporadic attendance, time spent preparing for them and evaluating their effectiveness, budgetary concerns, and lessening of available staff.

Early in the second term, Myra Rodrigues and Dean Turner sponsored a minority graduate women's open house to help them get acquainted with each other and us, and to improve the quality of their lives at M.I.T. A minority women's discussion group evolved and met on a regular basis, and eventually merged with a similar group of undergraduates.

Follow-up and outreach programs were continued for newly readmitted and upperclass students who received Committee on Academic Performance warnings. Because of Dean Turner's planned departure from this office at the end of this fiscal year, the other counseling deans became more involved in programs, and will carry on next year. In January 1976, approximately 157 upperclassmen received warnings and 59 of these responded to our invitation to be followed by one of the deans. A total of 28 students in this warning group negotiated withdrawals by the end of the term, four of whom had responded to our follow-up program during the term. Eight of the entire group withdrew voluntarily, three of whom were followed in our office. Twenty-five of the entire group graduated, 13 of whom were followed.

Approximately 115 students were readmitted for the fall term, and 49 of these came in to be followed by our office. Eleven students in this group received warnings at the end of their first term back, five of whom were followed in our office. Two were given negotiated withdrawals after being back the entire year, one of whom had been followed. Four of these students withdrew voluntarily by the end of the school year. During the spring term, approximately 75 students were readmitted with 30 of these coming in to be followed.

During the year, Dean Turner met regularly with the Minority Graduate Student Association, becoming involved with their seminars, support structures, and social gatherings. Again planned for next year is the orientation for new minority graduate students, and new for next year will be a welcome pamphlet written in a HoToGAMIT fashion with brief but helpful information for the incoming students. Regular meetings of the black faculty and administrative staff proved helpful and new communication bridges were developed with students and us. During the second term, Dean Turner was appointed to serve on the C.G.S.P. subcommittee on Financial Support Structures.

Student Activities and Governance

In the student activities and governance areas, this has been a year of transition, change, and progress. There was a more rapid turnover of student leaders holding office for shorter periods of time. New patterns of operations were in effect, such as the revival of the Undergraduate General Assembly. The word progress suggests a more thoughtful, comprehensive approach to student community operations, programming, and planning. In short, community communications have improved.

The Undergraduate Association this spring elected as president and vice president the team of Phil Moore '77 and Steve Spiro '77, who stressed a revival of the General Assembly.

Representatives from the living groups were then elected and two meetings of the Assembly were held in May. Attendance at both meetings averaged 75 students.

Lee Allen '77, the outgoing U. A. president, convened a number of meetings of student leaders which dealt with the general theme of communications. In particular, he provided two occasions for the student community to meet with Chancellor Paul Gray to discuss Institute finances.

During the year, the Association of Student Activities executive committee, under the leadership of Michael Matzka '75 and Robert Resnick '76, continued to wrestle with problems of activity program space. An ad hoc committee of faculty, administration, and graduate and undergraduate students was created to clarify questions, while a smaller subset of the committee met with Provost Walter Rosenblith, Dean Eisenberg, and the Planning Office to assess needs.

Douglas Nutter '76, and Stanley Martin '77, Chairman of the Nominations Committee, together with Louis Touton '77, Chairman of the Student Committee on Educational Policy, held meetings for the first time for all students who sit on faculty, academic, and educational committees.

Bob Ice '77, Chairman of the Student Center Committee, took the initiative to convene a preliminary meeting concerned with security measures in the Student Center. Several meetings of administration, Campus Patrol, Student Center operating staff, representatives from the Association of Student Activities, and the Student Center Committee resulted in guidelines, signs, and procedures.

The Graduate Student Council, under the leadership of Max Donath, extended its outreach of service to the graduate student community. Its program of orientation for new graduate students in September and February included new methods of assistance and support. Council meetings allow members to deal directly with most segments of the Institute administration and operations.

For the many components of the community who use space for rehearsals and performances, Dean Jon Hartshorne utilized a series of procedures including a reference system for scheduling officers, scheduling meetings for program producers, and a computer report system for Kresge, the Student Center, and the Chapel.

New interest was expressed this year in the International Students Association, with 25 representatives meeting twice this spring to discuss new programs and outreach of service to international students.

The Class of 1976 broke new ground with "An Evening in May," a formal dance held at the end of the spring examination period for graduating seniors, graduate students, and guests, and by hosting a performance of the "Proposition" in Kresge for parents, graduates, and guests on Commencement eve.

A committee of student leaders met six times to discuss merits of an activities fee as a possible means of financing student activities. After examining the method, scope, and experience of other colleges and universities, the committee recommended that the present method be continued.

Changes in personnel in the activities area include Malka Kutnick who replaces David Covert as Supervisor of the Student Center Art Studios, and Professor Kenneth Russell who succeeds Professor Murray Eden as Chairman of the Activities Development Board. Terry Bussone resigned as secretary to the Undergraduate Association, and a replacement will be hired in the fall.

During the year, the M. I. T. Chapel was in use for eight christenings, 11 memorial services, 90 weddings, 430 scheduled religious services, 460 organ practices, and 35 special musical and theatrical programs. Rabbi Mel Gottlieb, Hillel Counselor, left to undertake a doctoral program and his successor, Rabbi Daniel R. Shevitz, is settling in.

JON E. HARTSHORNE
ROBERT J. HOLDEN

Fraternities and Independent Living Groups

The year started with a near record 398 pledges (including a record 32 college transfer students). The success of rush also extended to Phi Kappa Theta which was restarted by a group of dedicated chapter alumni with support and assistance from the national fraternity and the Institute. All previous residents had chosen to leave the house in the face of an alumni corporation effort to reestablish a positive social and educational tone in the house as well as a sound fiscal program. Led by alumni officers Peter Heineman '65 and Peter Ricupero '58, the alumni cleaned and refurbished the house, staged an outstanding rush, and oriented the 17 new members to the responsibilities they carried in a fraternity in general and in this "new" one in particular. This effort was made possible by a \$37,000 loan from the Independent Residence Development Fund (I. R. D. F.).

Rush Week also marked the opening of Delta Psi's newly renovated and expanded house at 428 Memorial Drive. Of the total project cost of \$654,000, an I. R. D. F. loan was requested for \$540,000. However, due to a shortage of money, only \$500,000 of this could be granted. The remainder will be carried as a construction loan until sufficient I. R. D. F. dollars are available to complete the financing. All 48 spaces in the house were filled.

In September 1976, Pi Kappa Alpha will become a coed living group. Approval was granted last year, but a nucleus group of upperclasswomen had not been formed until this year.

Expansion

The year also witnessed the germination of M. I. T. 's first new independent living groups since 1969, a chapter of Alpha Delta Phi international fraternity for men and a local Women's Independent Living Group for Undergraduate women. These new living groups are very likely the first ever at M. I. T. to have so much impetus from the Interfraternity Council (I. F. C.), the Alumni Interfraternity Council (A. I. F. C.), and the Dean's Office. Great interest and support from these groups grew from 1) a concern that a constant sized independent residence system could become sub-critical in size and impact in the face of enrollment increases (the fraternity and independent living group population has remained roughly constant at 1,200-1,300 since 1965, while the undergraduate enrollment has grown from 3,755 in 1965 to 4,433 in 1975 and is projected to be at 4,700 by 1978); and 2) a feeling that student interest was sufficient to support more independent living groups. Simultaneous to the development of this programmatic interest in creating new independent residences, there arose an opportunity to purchase from Northgate the apartment building at 351-355 Massachusetts Avenue.

Fraternities and Independent Living Groups

In late May, the decision was made for M. I. T. to purchase the building, renovate it to meet the needs of those groups while renting them some space in the building, and to sell each group its house when work was complete and the groups thoroughly established. This project is unique because of the Institute ownership and control of a facility being created for independent living groups. The project operates on the premises that 1) I. R. D. F. financing will be available in the near future, and 2) the facility could be suitable for an Institute House if the independent groups do not survive. Project cost, including purchase price but not including provisions for parking, is projected at \$1 million or \$10,000 per bed for 100 beds. The enthusiasm of the groups and the availability of a good facility make success appear likely.

In years past, women at M. I. T. had only one option of an independent living group. When some Institute Houses and some fraternities became coed, their number of choices increased. However, the opportunity to reside in an all-women's independent living group did not exist. Near exam time in spring, 1975, a group of women tried to form the nucleus of such a group but the timing was poor, and there was no available facility in the Boston/Cambridge area. The following January, upon learning of the possibility of purchasing 351-355 Massachusetts Avenue, a group of alumnae, interested students, and members of the Dean's staff formed a working group to develop the long-range program, select an architect, and prepare for the temporary living arrangements for 1976-77.

Alumni Interfraternity Conference

The A. I. F. C., working with the Dean's Office, Physical Plant Department, Safety Office, and I. F. C., was involved with several projects beneficial to the fraternity program in 1975-76.

Impetus for expanding the fraternity and independent living group program grew from discussions originated by an A. I. F. C. Subcommittee. During I. A. P., a group of students, working with the Safety Office and the Dean's Office, compiled an up-to-date manual of building codes relevant to fraternities. An update of an earlier A. I. F. C. publication, it will be distributed to fraternities and house corporations in the fall. The safety and physical plant inspection program was revised to reduce the time burden per inspection on participating M. I. T. personnel and to allow more inspections. An effort in support of bills to rescind the Massachusetts meals tax on fraternities was mounted through house corporation officers.

Institute Houses

Undergraduate Housing

The opening of the new West Campus Houses in September with beds for 300 students expanded our normal undergraduate housing capacity to 2,220. Noted for its bright colors and spacious rooms, the six houses (accommodating eight distinct living groups) represent a physical configuration and social organization new to the Institute House system. The living groups, including Russian, German, and French Houses, operate more or less autonomously, but communicate through a central association. The House was received well by freshmen as indicated by a large number of first and second preference applications. The House experienced some difficulties in getting organized because most of the residents were freshmen, so there were few established and experienced student leaders and no traditions to guide them.

In spite of the increase in capacity represented by the new House, crowding persists at the level of 55 at the start of the year, owing to the size of the freshman class and the continued high return rates for upperclass students. A full 91 percent of the freshmen were given their first choice Houses with another 5.5 percent receiving their second choices. The distribution of freshmen at the start of the year was:

Institute Houses	755
Fraternities and Student Houses	375
Off Campus (commuters, etc.)	25
	<u>1,155</u>

For the second consecutive year, records of pledging and housing assignments were easily maintained, and more accurate and accessible due to the use of a computer information system developed by students working with the private, outside firm Bolt, Beranek, and Newman. We plan to use this system in future years. Fraternities also benefited because of the readily available and current information on the location of "rushees."

A major physical facility problem in the Institute House system will be eliminated when Bexley Hall reopens after being closed during the summer for rehabilitation. In order to remedy major building system and living condition deficiencies, the Housing Office, Physical Plant Department, and Dean's Office, working with Bexley residents, planned and funded a project to provide new baths, kitchens, plumbing and electrical systems, a new roof, storm windows, and a paint job.

Coed living exists in all Institute Houses except Bexley, MacGregor, McCormick, and New House. The major problem is still the relatively small number of women in the student body and the resulting unbalanced ratio of men and women in the coed Houses. It is our policy to seek to increase the ratio of women to men in the coed Houses before expanding coed living to other Institute Houses. However, the undergraduate women's population is growing very slowly at this point. The success of coed living does not preclude the desirability of single sex living; in the case of women students, for example, McCormick Hall has been filled or nearly filled with first choices for the past three years.

Housing rents increased by an average of 11.6 percent, contract meal prices by 5 percent. As usual, these increases and the factors behind them were discussed with student residents through the Rate Review Committee.

The academic year marked a significant upturn in the activity level of the Dormitory Council. Through a series of meetings with House presidents and the Dormcon chairman, communication and understanding between the Houses and the Dean's Office were improved, although much work remains. Dormcon appears likely to re-emerge as a forum for the discussion of Institute House issues, policies, and actions.

For 1976-77, the most substantial crowding is anticipated as a result of the decision to set the entering class size at 1,100. This decision of the Academic Council was made in order to attempt to achieve the desired increase in undergraduate enrollment (over a four-year period) and to stabilize the size of the entering class.

The primary constraint on undergraduate enrollment growth is housing. Our ability to crowd the present housing system to meet our housing obligation under existing policy is not clear for future years. We continue to participate annually in studies to determine a feasible solution to the dilemma of enrollment/freshman class size and housing capacity. The current housing policy, which guarantees housing to freshmen and four years of housing to undergraduate continuous residents is still vigorously supported by the Dean's

Office; all reviews of these policies have reaffirmed them, so it seems unlikely as well as undesirable, that a change in undergraduate housing policy will be seen as a solution to the problem.

Graduate Housing

Demand for graduate housing remained high with Ashdown and Tang full for the entire year and married student housing full with a lengthy waiting list. This situation has been relatively stable for several years. Active student government groups in all four Houses play increasing roles in their communities. The 65 spaces used for undergraduates in Ashdown House for 1974-75 were returned to graduate student use in 1975-76 with the opening of New House.

Faculty and Graduate Residents Program

The Faculty and Graduate Residents Program continues as the backbone of the Institute House program. The perspective, social interaction, advice and support, academic assistance, crisis intervention, and general presence, interest, and friendship provided by the faculty and graduate residents add to the richness of student life in the Houses. Faculty residents worked closely with the D.S.A. staff on major long-range and day-to-day issues, through the monthly dinner discussions attended by all faculty resident families and a portion of the D.S.A. staff. We also maintained contact and communication with graduate residents through weekly luncheon discussions.

Graduate residents are made available to fraternities and independent living groups at the request of the House. The D.S.A. provides one-half of the support, and the House the other half; this is done to ensure House interest in program success in this rather unsupervised (due to decentralization) program. Last year, seven houses had graduate residents. The provision of two graduate residents in Phi Kappa Theta to assist with restarting the House was an important element of Institute support for that project. Also, the first graduate resident couple in an independent residence assisted Student House with a reorganization. In addition, a graduate resident is provided in the Non-Resident Student Association House.

The Institute's financial pressures have caused us to re-evaluate the funding of this program in the Institute Houses in an effort to decrease costs. Through fiscal year 1976, the full expense of the program, about \$450,000, was funded through general Institute funds. To reduce this demand for general funds, we can reduce the program level (number of persons), pass costs on to the students via their rent, or seek outside funding (e.g., endowment). After lengthy discussions with the faculty residents, the issue was raised with the Corporation Visiting Committee and a number of students were invited to offer their views as well. The Visiting Committee reaffirmed its support for the program at its present level. Since the program level was not cut and \$50,000 was to be cut, \$45,000 was passed on to Institute House residents via an addition to the rent increase after cost reductions of \$5,000 were made. We do not view this as an ideal solution for the long run, and we hope that endowment support for all or part of the program can be found.

Two faculty couples left the program after many years of support and counseling to the residents of their Houses. Professor and Mrs. Murray Eden, faculty residents of Senior House for 14 years, have moved to Bethesda, Maryland. Professor Eden is on a two-year sabbatical from M.I.T. to do research at the National Institutes of Health. Professors Rufus and Anne Hallmark, junior faculty residents in Burton-Conner, have traded brownie baking and late-night bull sessions for plastering and painting in their new home. Professor

B. Shawn Buckley and his wife Nancy Gad, will join the program as the new junior faculty residents in Burton-Conner. At this writing, we have not found a faculty family for Senior House. Professor James H. Williams, Jr. and his wife Karen Goodall joined the program in August 1975 as faculty residents in the new West Campus Houses. Professor and Mrs. Stephen Senturia returned to the Housemaster suite in McCormick after a sabbatical in Europe for the spring term.

Katharine Cutting and Joan Johnson joined our staff as secretaries in the fall, and have been instrumental in improving the quality and quantity of the Office's work.

KENNETH BROWNING
ALICE SEELINGER

Foreign Study Office

For economic reasons, the Foreign Study Office's Assistant was reduced to half time during 1975-76. The Office's responsibilities for the Foreign Scholarships Program were transferred to the Graduate School Office, which was responsible for the scholarships in prior years. The duties for the Junior Year Abroad, Domestic Year Away, and I. A. P. Student Exchange Programs were continued on a part-time basis.

Junior Year Abroad

Six M. I. T. students participated in the Junior Year Abroad Program in England, Israel, Korea, Mexico, and Norway. Three students were away for the full year, one for fall term, 1975, and two for spring term, 1976.

Although the actual number of students who leave on the Junior Year Abroad and Domestic Year Away programs continues to be low, interest in the programs is high. There were 436 visits to the Foreign Study Office by students during 1975-76. Thirty-nine students actively planned a Junior Year Abroad, and 21 applied to foreign universities and American College Sponsored Programs Abroad. Nineteen were accepted and two were placed on waiting lists. Sixteen students will go away during 1976-77.

Domestic Year Away

Six M. I. T. students participated in the Domestic Year Away Program; two for the full year, and four for a term. They studied at Brown University, University of California at Berkeley, Dartmouth University, and North Carolina State University. Also, one participated in the New York City Urban Fellowship Program.

Three students will participate in the Domestic Year Away Program for 1976-77. They will study at Harvard University, Ohio State University, and Stanford University.

The Domestic Year Away Program is still 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."

I. A. P. Student Exchange Program

Four M.I.T. students exchanged places with two students from Colgate University in Hamilton, New York, and with two students from Mount Holyoke College in South Hadley, Massachusetts.

The exchanges between M.I.T. and Colgate University included waiver of tuition and application fees, but no residence exchange because the M.I.T. women were residents of McCormick Hall, and were unable to obtain the House's approval. However, the Colgate men were able to stay with friends in Boston, and arranged for the M.I.T. women students to stay in their dorm rooms. The exchanges between M.I.T. and Mount Holyoke included waiver of tuition and application fees, residence exchanges, and one meal exchange.

ROBERT HALFMAN
PAULA KELLEY

Department of Athletics

The traditional college/university athletic program continues to be challenged on all sides to keep pace with ever changing student values in the pursuit of nonacademic interests, particularly within a university community where first priorities rightly are accorded to the mainstream of academic excellence at the level required for success. M.I.T. students and faculty value informal and recreative learning experiences outside the classroom as a desirable supplement to formal education. The Department of Athletics looks upon this as a healthy challenge to expand and enrich its many outlets in athletics and recreation. Indeed, the more demanding the academic disciplines, the greater the need for recreative outlets!

In meeting this need, our goals remain: to develop favorable qualities of personality and character; to stimulate the achievement of excellence outside the academic classroom; and to spur recreation in terms of improved general health and physical well being conducive to both career success and personal happiness.

Capital funding for major upgrading and expansion of our athletic and recreation facilities continues to be the most critical problem facing the Department in the implementation of a program to meet the needs of M.I.T. students.

Two events highlight the past year in the Athletic Department. First, the Department completed its financial operations for 1975-76 within the budget provided by the Institute. This is significant since it was the first year of operating within guidelines designed to streamline procedures following our "task oriented" budget analysis in fall, 1974. Hopefully, it indicates that we have arrived at a tenable operating base, accommodating reductions requested in the Institute's overall program of fiscal accountability without serious dilution of program -- all during a year of increased program responsibilities and growth accompanying increased numbers of undergraduate women. Second, in April construction began on the Sailing Pavilion Project. It should be completed by the opening of the fall semester. A dedication is scheduled for October 2. George Warren Smith '26, Chairman of the Sponsoring Committee, led the campaign to raise initially \$212,000 to meet the budget for building renovation, new construction, and the purchase of 30 Tech dinghies and four Larks. The Committee eventually raised more than \$300,000 to meet increased costs incurred in the final stages.

Physical Education

There were 6,354 registrations in 50 different courses offered during the year, including seven courses (Air Rifle, Advanced Squash, Box Lacrosse, Basketball Skills, Hockey Skills, Modern Dance, and Water Polo) offered only during Independent Activities Period. Registrations fell 7.6 percent from the all-time high of the previous year. This decrease, the first in 15 years, was mainly in the area of non-credit registrations (numbering 2,053), and was probably due to overcrowded conditions in the locker and dressing facilities, which makes non-credit participation in the physical education classes less attractive.

This past year, ice hockey was dropped from intercollegiate varsity to club status at the request of students active in the sport. Whether or not M.I.T. would lose the national ranking was not a consideration at the time the decision was made, for the M.I.T. intercollegiate ice hockey team was no longer competitive with the Division III colleges in New England, with whom we competed for close to 50 years. "Club" status meant that graduate students would be eligible to play with the varsity team, thus adding experienced hockey players to bolster the team. Parenthetically, it was generally conceded that the antiquated outdoor rink, inoperable during frequent periods of inclement New England weather and mechanical failures, had diminished the attractiveness of intercollegiate hockey. As a result of the move to club status, the hockey team broke a three-year losing streak early in December and went on to win five games.

More than 900 undergraduate men and women were active in 29 intercollegiate sports squads this past year. Varsity, sub-varsity, and frosh schedules included 654 events in Cambridge or at nearby New England sites. Women participated in the same proportion as the men.

Letter Awards for 1975-76

<u>Undergraduate Men</u>		<u>Undergraduate Women</u>	
Varsity Letters	254	Varsity Letters	63
J-V Letters	229	J-V Letters	<u>59</u>
Frosh Numerals	<u>49</u>		<u>122</u>
	532		

Intramural Athletics

Statistics indicate a 29 percent increase in the number of students participating in organized competitions in 23 sports sponsored within the intramural program. Three new sports, Indoor Track, Straight Pool, and Weight Lifting, were added this past year. Living group based teams showed growing popularity: basketball, 142 teams compared to 115 for the previous year; bowling 117 over 76; volleyball 107 over 82; and softball 124 over 84. Only sailing and track showed diminished participation.

The increase in participation can be expected to continue as the residence system is expanded, bringing greater numbers of undergraduate and graduate students within easy access to the athletic center and the playing fields. Intramural athletics serve the largest number of students of any of the program outlets sponsored by the Department.

Intramural Participation Statistics for 1975-76

<u>Sport</u>	<u>No. of Teams</u>	<u>Total Participants</u>
Badminton	48	192
Basketball	142	1,136
Bowling	117	351
Chess	25	150
Cross Country	15	108
Cycling	11	53
Football	70	1,050
Hockey	54	540
*Indoor Track	10	80
*Pool	12	72
Rifle	41	185
Sailing	8	32
Soccer	52	936
Softball	124	1,622
Squash	55	200
Swimming	28	134
Table Tennis	54	378
Tennis	67	335
Track	14	120
Volleyball	107	856
Water Polo	33	330
*Weight Lifting	8	20
Wrestling	17	116
	1,112	9,896

*New Intramural Sports

Club Athletics

The degree of organization of a "club" sport varies greatly with current student leadership. Clubs operate free of traditional eligibility rules and awards systems. The club program is particularly attractive to graduate students and young faculty members who are unable to make in-depth commitments to highly organized sports programs. However, this is not always true. The Rugby Club plays a fall and spring schedule within the New England Rugby Union; Table Tennis plays a regular schedule with Ivy League opponents; and the Volleyball Club competes regularly in local and regional tournaments. The Department has a policy of providing facilities, equipment, and limited subsidies to established clubs.

Clubs Active in 1975-76

Badminton	14	Karate - 2 clubs	30
Bicycling	15	Rugby - 2 clubs	37
Cricket	18	Scuba	30
Graduate Crew	12	Table Tennis	12
Graduate Soccer	20	Volleyball	22
Ice Hockey - 2 clubs	28	Water Polo (spring)	14
Judo	16	White Water	10

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

The most visible evidence of the success of the sports instruction program in Physical Education, and the extension of a philosophy encouraging sports participating experiences for all students, is the almost round-the-clock utilization of the Institute's facilities by casual participants. In 1975-76, 8,818 athletic cards were purchased entitling card holders to use of the facilities, standard equipment and towel service. This includes 6,502 students, or approximately 80 percent of the student body.

Athletic Card Sales for 1975-76

Students		6,502
Faculty	377	
Academic Staff	773	
Exempt Employees	199	
Bi-Weekly Employees	474	
Weekly	<u>137</u>	1,960
Alumni		<u>356</u>
		8,818
Sailing Cards:		
Students	797	
Faculty/Staff	322	
Alumni	105	
Specials	113	
Physical Education	<u>324</u>	1,661

Cambridge and Greater Boston Community Relations

The Department continues to make available the athletic facilities to Cambridge community interests and to Greater Boston community based programs at times not conflicting with M. I. T. student use. A special liaison has been established with the Cambridge Public Schools to extend as much use of indoor and outdoor facilities as possible during the next two years while Rindge Tech and Cambridge Latin Schools are renovated. The Department of Athletics maintains a relationship with the Office of the Special Assistant to the President for Urban Affairs to expedite community utilization of facilities.

Major Athletic Awards for 1975-76

The Class of 1948 Award to the Senior Athlete of the Year went to Gregory L. Hunter '76; the Admiral Edward L. Cochrane Award to the Senior who has best combined the qualities of leadership, humility, and scholarship in intercollegiate athletics to Campbell M. Lange '76; the Malcolm G. Kispert Award to the senior scholar-athlete of the year to Jon W. Johnson '76; the Betsy Schumacker Award for excellence in athletic competition by a woman student to Ingrid L. Klass '76; the M. I. T. A. A. Pewter Bowl for outstanding contributions to women's athletics by a woman student went to Lisa A. Jablonski '77 and Maura A. Sullivan '76.

The Straight T Award for national or regional recognition in intercollegiate athletics at M.I.T. went to Lisa M. Albright '78, Karyn A. Altman '78, Craig W. Christensen '76, Susan N. Coppersmith '78, Lisa A. Jablonski '77, Thomas A. Kush '77, Karl M. Lofgren '76, Shelia L. Luster '78, Jenny L. McFarland '78, Kathleen C. Mensler '77, Mark M. Pickrell '76, Frank C. Richardson '77, Michelle M. Roybal '79, William W. Sawyer '77, and Linda R. Yester '77.

The Burton R. Anderson, Jr. Award to the Manager of the Year went to Robert D. Kneeland '77; the Varsity Club Award to the Frosh Athlete of the Year to Barry L. Bayus '79, and Elaine D. Sears '79; and the Harold J. Pettegrove Award for outstanding contributions to intramural athletics went to Robert H. Halstead, Jr. G.

Staff Changes

Dorothy Pickard, Administrative Secretary for 15 years, resigned and Rosemary Viano, former Intramural Athletics Secretary, will replace her. John Benedick was appointed Instructor in Physical Education and Head Coach of Swimming and Water Polo. Professor Silvio Vitale, Assistant Professor in Physical Education and Head Coach of Fencing, retired after 27 years of service. Gerald Reed, Sailing Master and Instructor in Physical Education, retired after 40 years of service. Harold Brown, Jr., Instructor in Physical Education, was promoted to Sailing Master. Eric Sollee, Assistant Fencing Coach part-time, became Head Coach of Fencing and Instructor in Physical Education. James Lester, Instructor in Physical Education and Athletic Trainer, was promoted to Head Trainer.

ROSS H. SMITH

Provost

This year's annual report of the President and Chancellor deals among others with three historic events that go back approximately a quarter of a century: the establishment of two Schools and the creation of the Lincoln Laboratory.

A couple of years earlier, two changes had taken place in the administrative organization of the Institute which have -- with some adaptive changes -- withstood the test of time. The Office of the Provost was established in the spring of 1949 with Dr. J. A. Stratton as its first incumbent, and a new body, the Academic Council, was created to be responsible for the executive coordination of the Institute's educational activities and for the administrative formulation of educational policy as determined by the faculty. The Provost's primary concern was to be the administration and coordination, in concert with the Deans, of educational and research activities which do not fall within the jurisdiction of any single school. He was given cognizance over the interdepartmental laboratories, of which there were only a few at the time, and the research projects of the Division of Industrial Cooperation which corresponds most closely to today's Office of Sponsored Programs.

In the years since the mid-century, the number of activities that relate directly to the Office of the Provost, as these annual reports demonstrate, have grown considerably. One might be inclined to conclude that this growth reflects the natural proliferation of expanding and maturing institutions, and this is undoubtedly true for some of these activities. But there is more.

During the post World War II period, we have seen enormous changes in the structure of knowledge, especially scientific and technical knowledge. These changes have reflected themselves in many ways: new subjects, new courses of instruction, new departments (a few), new names for continuing departments (clearly new contents for all), new educational programs (like the joint Harvard-M.I.T. Program in the Health Sciences and Technology), new interdepartmental and interschool laboratories and centers in which research projects and programs are carried out which take advantage of the new scientific opportunities, and the willingness of outside sponsors to support these activities. When the intellectual history of this period will be written, the changing significance of the word "discipline" (and its derivatives multidisciplinary, interdisciplinary, trans-disciplinary, etc.) will need to be examined critically as well as the extent to which university departments moved away from being uni- or mono-disciplinary. In some ways this period can be characterized by a statement made by Philipp Frank, the physicist, philosopher of science, and biographer of Einstein when he said, "Problems in nature do not come carrying departmental labels," to which one might add, "...and problems in society even less so."

This is hardly the place to enlarge upon the kinds of demands which the evolution of knowledge and of knowledge-coupled societal actions bring to bear on the Institute. During the last quarter century, M.I.T. faculty (and students) have taken many initiatives which seemed hard to fit into the framework of the existing departments. The Office of the Provost's role was to assist to facilitate these undertakings and educational experiments while at the same time making sure that they were in spirit (if not always in the last detail) in conformity with the faculty's overall educational policy.

A few years ago I became persuaded of the necessity of grouping the Deans in the Educational Programs Subgroup (E.P.S.) of the Academic Council. This group maintains a continuing review of both new and existing academic programs. By serving as the E.P.S.'s chairman, the Provost is greatly assisted in his tasks of both understanding the Institute's programs and of helping to insure their necessary, and desirable, quality. The Provost has the advantage that his Office is not running operating units that might be competing with the organic units of the Institute.

During the past two years, a group of faculty members from more than half a dozen institutions in the Boston area has been working to conceptualize and bring into reality a center for the study of archaeological materials. Recent advances in scientific knowledge of materials have provided archaeologists, as Professor Cyril Smith had pointed out much earlier, with new insights into our material culture and technology. The consortium in formation has submitted an ambitious proposal to several government agencies and foundations. The M.I.T. faculty members, Professors Lechtman, Steinberg, and Kingery have had the enthusiastic intellectual and administrative support of the Provost's Office Executive Officer, Joel Orlen.

As part of M.I.T.'s contribution to the Bicentennial celebration, Dr. Norman Dahl, formerly a Professor in the Department of Mechanical Engineering, who is presently consultant to the Provost's Office, arranged a number of studies aimed at bringing better understanding of some of the changing conditions of the world of our third century. In March, the conclusions of three of these studies were presented at a two-day Convocation on Communications in celebration of the Centennial of the telephone, cosponsored by M.I.T. and the American Telephone and Telegraph Company. There were sessions on the Social Impact of the Telephone, New Approaches to a Realistic Model of Language, and the Future Impact of Computers and Information Processing. In May, a group of about 40 economists and political scientists from many countries met at M.I.T. for several days to complete a study on the Economics of the New International Order. Other studies will be completed during the biennium 1976-78, and will be published by the M.I.T. Press in a Bicentennial series.

This was the first year during which Jay Lucker was Director of Libraries, and it is a great pleasure to report that the hopes expressed in advance of his coming have been amply fulfilled.

WALTER A. ROSENBLITH

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 P. French is Consulting Editor, Dr. Steven Berger, postdoctoral student in medical physics, is Assistant Editor, and Constance Carpentiere and Carol Frakes assist in the editorial office.

During the 1975-76 academic year, an M.I.T. student, Joseph Chapman, participated in UROP through his project as American Journal of Physics Filler Editor in charge of obtaining and assembling items of historical, topical, or humorous interest for use at the ends of articles. Another student, Richard Bauer, began a study of the survival of self-paced physics courses reported in the Journal. This study will form the basis of his senior thesis in the Department of Physics.

The American Journal of Physics, published 12 times a year, is the foremost publication in physics education at the college and university level. Typical contributions deal with new ways of visualizing and teaching traditional physics subjects; discussions of specialized topics of particular interest or importance; new ways of organizing courses in physics; novel experiments and apparatus; the uses of computers, films, and other aids in teaching; and historical articles about fundamental developments and personalities in science.

EDWIN F. TAYLOR

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 available in the investigator's own laboratory. Special consideration is given to young investigators with limited resources. 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.

Since the Center began operation in November 1974, 74 applications have been received, of which 52 have been approved. Thirty-three of these projects have been completed. Examples of typical projects completed to date are:

<u>Material produced</u>	<u>Recipient</u>
1,200 Roller Bottles of HeLa cells	Center for Cancer Research Massachusetts Institute of Technology Cambridge, Massachusetts
Molony murine leukemia virus from 1,100 roller bottles of Cl-1 cells. Processed by continuous flow ultra- centrifugation.	Center for Cancer Research Massachusetts Institute of Technology Cambridge, Massachusetts
Sindbis virus from 270 Roller Bottles of secondary chick embryo cells. Processed by continuous flow ultracentrifugation.	State University at Stony Brook Stony Brook, New York
800 Liters of EL-4 cells in suspension culture.	Albert Einstein School of Medicine Bronx, New York
1,000 Roller Bottles of SV-80 cells.	Children's Cancer Research Foundation Boston, Massachusetts

Effective February 9, 1976, a Cost-Appportioning Program was implemented. Under this new policy, all users are required to pay for the cost of all consumable materials used for their projects. The Cost-Appportioning Program has been well accepted, and at the present time the Center is receiving a 100 percent return on all expendable materials purchased.

Research and Development

The Cell Culture Center conducts an active program in the development of new techniques for large-scale cell and virus production. A procedure was recently developed for synthesizing positive-charge-carrying poly-dextran microspheres which serve as an excellent surface for the attachment and growth of anchorage-dependent cells. With standard cell culture media, saturation densities in excess of 3×10^6 cells/ml are routinely obtained for secondary chick embryo fibroblasts and many cell lines.

The above described microcarrier system has obvious applications, some of which are currently being explored at the Center. Cells are being grown on microcarriers for the production of several different viruses including Sindbis and Molony murine leukemia virus. Using a relatively small volume of cells grown on microcarriers, a large number of roller bottles can be replaced, e.g., in the case of Sindbis virus, 100 roller bottles can be replaced by about two liters of microcarrier culture.

The feasibility of using microcarrier-cultured human fibroblast cells for the production of interferon is being investigated. Early results are promising in this area.

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 in the School of Science (Course XXV). 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 provides students with excellent preparation for vocations that require a broad knowledge of the techniques of cell culture and animal virology. Beginning this fall, 1976, we will have three students in the Cell Culture Center for the academic year.

PHILLIPS WESLEY ROBBINS

Artificial Intelligence Laboratory

The Artificial Intelligence Laboratory is concerned with understanding, often through insights provided by work with computers, the principles and details underlying the acquisition and exhibition of intelligence. Its research includes work on computer vision and manipulation, intelligent support systems, understanding English text, learning, common sense reasoning, expert problem solving, human development and education, productivity technology, and computer systems.

Professor Patrick H. Winston has been director of the Laboratory since 1974. Professors Marvin Minsky and Seymour Papert were responsible for general artificial intelligence and cognitive theory studies. Professor Berthold K. P. Horn directed the work in computer vision and productivity technology. His work was complemented by Dr. David Marr's development of basic theories of visual information processing. Professor Ira Goldstein supervised the work on knowledge representation and intelligent support systems. Professor Gerald Sussman worked in the area of expert problem-solving systems. Professor Carl Hewitt researched programming semantics and programming languages. Professors Jeanne Bamberger and Ira Goldstein and Dr. Harold Abelson worked with Professor Seymour Papert in developing cognitive theories associated with our research in the uses of technology to enhance education. Richard Greenblatt and Thomas Knight supervised work on computer systems development including the development of a LISP processor and a cable network. Guest faculty included Professor Zenon Pylyshyn (University of Western Ontario), Professor Charles Rieger (University of Maryland), Professor Michael Rabin (Hebrew University) and Professor Hermine Sinclair deZwart (University of Geneva).

Image Understanding and Productivity Technology

Important advances have been made in the field of image understanding. Preliminary versions of a map-shading program, a knowledge-based tracking program, and a casting inspection program were completed. The Laboratory also devised a new theory of stereo processing that promises better automatic contour cartography. Work continues on improving manipulation control and on the design of languages for automating assembly.

Knowledge Representation and Intelligent Support Systems

A major portion of our work in 1976 has gone into designing a basic system for use in intelligent analysis of large data bases and in resource scheduling. Notable progress includes an information system based on the previously unimplemented Minsky "frame" theory. In addition, several studies have been made of the natural language understanding required to deal with various kinds of newspaper articles. An interesting conclusion is that newspaper articles appear substantially easier to analyze automatically than general literature.

Expert Problem Solving

Creating programs that can do expert reasoning about limited worlds is an area in which progress has been made. In particular, the Laboratory worked with programs that understand electronics well enough to do analysis by common sense reasoning rather than by solving network equations. The resulting programs are able to explain their logic in terms human designers use and understand.

Computer Systems Development

Utilizing low cost hardware, the Laboratory designed a personal computer system to serve single users. The prototype processor was finished in early 1976. (An advanced prototype is planned for completion by June 1977.) The processor's features include LISP-oriented operations, special addressing modes, a fast internal push-down stack and a large address space.

Education

Work in human development and education has been enhanced by the construction of the new Children's Learning Laboratory (C.L.L.). This unique learning environment, made possible by financial support from the Division for Study and Research in Education (D.S.R.E.) became a reality in the fall term of 1975. The C.L.L. is a resource for new intellectual projects at M.I.T. in which individuals develop their own problem-solving procedures using the computer as a powerful tool. Some of the advantages to participants have been increased language skills, increased understanding of the thinking process, and increased mathematical competence.

Ten faculty, three visiting faculty, one research associate, four lecturers, 29 research staff, 17 support staff, 34 research assistants, and 19 M.I.T. students were employed in research activities which were funded during fiscal year 1976, by the Defense Department's Advanced Research Projects Agency, by the National Science Foundation, by the National Institute of Education, by the International Business Machines Corporation, and by the National Aeronautics and Space Administration.

PATRICK H. WINSTON

Center for Advanced Visual Studies (C.A.V.S.)

The Center for Advanced Visual Studies began and ended academic year 1975-76 with major projects. The ARTTRANSITION conference and exhibition took place in October 1975, and an environmental art exhibition was held at the Institute of Contemporary Art in Boston in March/April 1976 -- You Are Here, Boston Celebrations, Part 2.

ARTTRANSITION brought together for the first time on the M.I.T. campus a large number of artists, art theorists, and art organizers; participants of national and international status attracted 110 registrants from universities, art schools, museums, galleries, and communities throughout the United States. ARTTRANSITION, a joint project of C.A.V.S. and the University Film Study Center, hosted, among others, James Ackerman, Professor of Fine Arts, Harvard University; Fred Barzyk, producer/director, WGBH-TV, Boston; Christo, environmental artist; Douglas Davis, video artist, writer, critic; Hollis Frampton, filmmaker, photographer; Allan Kaprow, Happenings artist; Matko Mestrovic, art historian and critic from Zagreb, Yugoslavia; Charlotte Moorman, musician and video artist; John Nolan, President, Massachusetts College of Art, Boston; Nam June Paik, composer and video artist; Yvonne Rainer, dancer and filmmaker; Jasia Reichardt, London writer, critic and exhibition organizer; Manfred Schneckenburger, artistic director of the Kassel Documenta '77; Michael Snow, filmmaker; Howard Wise, New York art sponsor and promoter; and present and former Fellows, Research Affiliates, and appointed Guests of C.A.V.S. The conference was made possible by a grant from the National Endowment for the Humanities and the President's and the Provost's offices.

You Are Here -- Boston Celebrations, Part 2 presented to the public visions of how Boston's Long Wharf pier could be rebuilt. Present and former C.A.V.S. artists involved included: Lowry Burgess, Michio Ihara, Gyorgy Kepes, Carl Nesjar, Otto Piene, and Harold Tovish. Boston Redevelopment Authority invited C.A.V.S. to present this project at the Boston Institute of Contemporary Art with support from the Massachusetts Council on the Arts and Humanities, the M.I.T. Council for the Arts, the National Endowment for the Arts, and the Boston Redevelopment Authority.

The year 1975-76 was one of considerable expansion in student enrollment. During the fall semester, 117 students took C.A.V.S. subjects, and 123 students during the spring semester. The total of 240 students for 1975-76 represents almost twice the enrollment of 1974-75.

C.A.V.S. offered seven subjects per term. Besides Professor Otto Piene and Professor Friedrich St. Florian, all 20 Fellows were involved in the teaching program, i. e. teaching their own subjects or giving presentations in C.A.V.S. or departmental courses. C.A.V.S. is now deeply involved in assisting coordinating efforts regarding all art offerings of the Department of Architecture so that a coherent program will emerge. Last year's proposal for an interdisciplinary graduate (S.M.) art program led to the actual beginning of this unique teaching effort by C.A.V.S., the Department of Architecture, and other participating M.I.T. departments.

C.A.V.S.' financial situation remained complex and multifaceted. M.I.T.'s contributions to the Center's budget were matched by funds from various foundations. Project-bound monies were and will be used for the following research studies/events: "A Study of Elemental Kinetic Works in Public Spaces" -- a collaborative work of Elizabeth Goldring and Murray McNaught (The National Endowment for the Arts); "Laser Projections of Computer-Processed,

Sound-Generated Images," by Paul Earls (The National Endowment for the Arts); "Dome Experience - Feasibility Study and Research of Projection and Image Making Systems for Large-Scale Image Presentations in Dome Structures or Proscenium Spaces," by Ron Hays (The Rockefeller Foundation); New England Chamber Opera Group opera commissions for the production of two chamber operas by Paul Earls (The National Endowment for the Arts); Visual Arts Workshop Program at C. A. V. S. (The National Endowment for the Arts); "Under Aquarius," events by Joan Brigham and Stan VanDerBeek (Bradley C. Higgins); "Workshop on Theory, History, and Practice of Public Celebrations," by Professors Piene and Robert Preusser including "The Fourth of July Salute" by Professor Piene (Boston 200); ARTTRANSITION and "You Are Here, Boston Celebrations, Part 2" also were generously supported by the M. I. T. President's Office and the M. I. T. Council for the Arts, besides the aforementioned grants from the National Endowment for the Arts, the National Endowment for the Humanities, and the Massachusetts Council on the Arts and Humanities.

M. I. T.'s Committee on the Visual Arts realized a thoroughly prepared and widely noted exhibition of Professor Piene's paintings and gouaches at the M. I. T. Hayden Gallery. His drawings were exhibited concurrently in the Center's exhibition room during November/December 1975. The Center's exhibition space also was utilized to exhibit Fellows' and other artist's work, such as: "Lamps and Vases" by Dan Dailey; "Structures," silk-screened graphic works by Jose Maria Yturralde; "Vicious Cycles," reliefs and drawings by John Avery Newman; and "Imagination," a show of sculptures and drawings by David Wheeler.

Professor Piene's professional activities included "Neon Rainbow," with C. A. V. S. Fellow Alejandro Sina, at M. I. T. (ARTTRANSITION) and in New York's Central Park; a one-man show at Galerie Heseler, Munich; "ANEMONES," a workshop and work-in-progress in New York City; substantial participations in the Bologna exhibition, EUROPA-AMERICA and the Krakow Print Biennale; conclusion of environmental, sculptural work for the University of Konstanz, Germany, and the University of Hawaii in Honolulu, Hawaii; repeated showings of two 45-minute films on his work and projects on German television. Juergen Wissmann authored the book, "Otto Piene," which was recently published in Germany. The American Association of State Colleges and Universities held a forum in Boston during November 1975, and invited Professor Piene to participate as a panel member in discussions focusing on the arts, specifically "The Arts and the Campus: A National-International Perspective."

Institute Professor Emeritus, Gyorgy Kepes, founder and first director of C. A. V. S., was Visiting Professor at the University of Utah, Salt Lake City, and Rice University, Houston, Texas. He was the distinguished lecturer of the Karl Taylor Compton Lecture Series at M. I. T. on "Means and Meaning in Today's Art." A retrospective exhibition of his work was held at the State Museum, Mucsarnok, in Budapest, Hungary. Gyorgy Kepes will return to M. I. T. and C. A. V. S. for the 1976-77 academic year as a Fellow/artist in residence.

C. A. V. S. published major catalogues for ARTTRANSITION and "You Are Here -- Boston Celebrations -- Environmental Art." Robert Steele and Pamela Worden wrote reports on the 1975 Public Celebration Workshop at the Center for Advanced Visual Studies, M. I. T., which appeared in Leonardo and Cultures. Professor Preusser, Director of Education at C. A. V. S., reviewed ARTTRANSITION extensively in Leonardo. Benjamin Forgey published an article in the Smithsonian Journal, "Arttransition Is Still in Transition."

Other publications and reviews of works by Fellows of C. A. V. S. appeared in journals such as the New Yorker, a review of Paul Earl's opera "The Death of King Phillip," premier performances by the New England Chamber Opera Group at the All Saints Church in Brookline. Two articles in Artforum and October on video devoted large portions to the work of C. A. V. S. Fellow Peter Campus. "Transforming TV" from the New Age Journal included Ron Hays'

video work. Both Peter Campus and Ron Hays had recent television broadcastings on a "Video and Television Review" (Peter Campus) and the visualization of Richard Wagner's "Prelude and Liebestod" (Ron Hays).

C. A. V. S. and its Fellows won public recognition in Japan through a series of articles on "Art and Technology" which appeared in The Asahi Shimbun, one of Japan's major newspapers.

Harriet Casdin-Silver took part in a holography exhibition in Japan, in the Seibu Museum, Tokyo. Peter Campus had a one-man exhibition at Leo Castelli Gallery in New York, and participated in the São Paulo Biennale and at an exhibition at the San Francisco Museum of Art. Ron Hays' work was broadcast on WTTW in Chicago, KCET in Los Angeles, and WGBH in Boston. Friedrich St. Florian had a one-man show at C.A.V.S. and participated in an international symposium, "Positions in Architecture," at the Rhode Island School of Design and in the International Design Conference at the Anderson Ranch Arts Foundation in Aspen. Carl Nesjar concluded his work on his fountain, "Wings," in Haute Savoie (French Alps). He currently is working on commissions in Oslo and Moss in Norway, and in Rolling Meadows, Illinois.

In 1975-76 the following artists have been Fellows at the Center for Advanced Visual Studies: Maryanne Amacher, Robert d'Ancona, Karin Bacon, Joan Brigham, Lowry Burgess, Peter Campus, Harriet Casdin-Silver, Muriel Cooper, Daniel Dailey, Douglas Davis, Paul Earls, Mark Faverman, Scott Fisher, Luis Frangella, Elizabeth Goldring, Virginia Gunter, Ron Hays, Michio Ihara, Bart Johnson, Paul Levy, Mike Moser, Carl Nesjar, John Newman, Keiko Prince, Jon Rubin, Friedrich St. Florian, Alejandro Sina, Georges Singer, Stan VanDerBeek, Pam VanDiver, Jose Maria Yturralde.

The C. A. V. S. fields of interest were defined in the ARTTRANSITION catalogue in the following words: "Environmental art and design: to enhance the physical environment's psychological economy by means of beauty which is both expressive and practical; developmental media work: to find the expressive artistic language which can reach a large audience with human dignity and without commercial stimulation; art and technology: to use every chance for interaction between artists, scientists, engineers, and scholars to master the increased scale of communication. When it comes to exchange of information with large audiences the artist's efforts are futile without the powerful technological means of processing and transmitting messages; celebrations: an oft-neglected art form presumably older than painting, which is obviously communal and most inviting to people of all ages, denominations and professional commitments; education toward the new arts and general education towards a broader understanding of our "modern" world. The artist who is always corresponding with an audience is a natural educator because he leaves a materialized message widely legible beyond language barriers. The imaginary school of artists in disparate parts of the world is forming a spiritual entity by transcending academic or national boundaries. Self-expression to everybody and wholeness of mind and body in creative acts will always be basic concerns of this virtual community; but also the widest exchange of nuanced messages inspired by human emotions and mental operations in our electronic age."

OTTO PIENE

Center for Cancer Research

The Center for Cancer Research has in 1975-76 continued its growth according to schedule despite the unfortunate delays in funding due to a 10-month delay in National Institute of Health appropriations by the United States Congress.

The past year was highlighted by the award of a share of the Nobel Prize for Medicine or Physiology to Professor David Baltimore of the Center for Cancer Research. Together with the entire M. I. T. family and the Department of Biology, the Center has rejoiced in and felt honored by this award, which stimulates its personnel to emulate the standard of excellence set by Professor Baltimore and his co-workers.

The renovated Seeley G. Mudd Building, in which the Center is located, has continued to prove ideally suited for the research work of the Center. It is a rewarding tribute to the M. I. T. Planning Office and the planning architect firm of Marvin Goody Associates that in almost three years, while the Center has grown to a full time population of more than 100 workers, including 12 faculty members, no renovation or remodeling of laboratories has been required. In fact, the plans of the Center facilities have been used as models for similar centers at several other institutions.

Publications from the Center in the past year have numbered 50, with an additional 27 in press. A symposium on current research in the Center was held on October 30, 1975 to mark the dedication of the laboratories for Developmental Biology of Cancer completed through a generous gift from the Fund for Higher Education (in Israel). A Laboratory for The Biology of Chemical Carcinogenesis and an Undergraduate Teaching Laboratory for Cancer Biology have been made possible thanks to a grant from the National Cancer Institute and to gifts from other sources, and are expected to be completed in spring, 1977.

A gratifying outcome of the establishment of the Center for Cancer Research as part of the expansion of M. I. T. activities in the biomedical field has been the large number of graduate and undergraduate students who have elected to do research in the Center. Cooperative research by the Center's faculty with Harvard Medical School and the Children's Hospital has grown, and has led to the appointments of David Nathan, M. D., Ronald McCaffrey, M. D., respectively Professor and Assistant Professor of Pediatrics at Harvard Medical School, as Visiting Professors of Biology in the Center for Cancer Research. Professors David Baltimore and David Housman have been appointed Consultants in Hematology at the Children's Hospital. Dr. Frank Solomon has been appointed to an Assistant Professorship in Biology in the Center.

SALVADOR EDWARD LURIA

Center for International Studies

The Center for International Studies has continued during the past year to focus its program on international policy issues related to technology and technological change. The Center's efforts to explore the political, economic, social, and institutional dimensions of these issues have led to close research collaboration within the Center among social science, science, and engineering faculties and students at the Institute. In this way, cross-disciplinary research, to which we have long aspired, has increasingly become reality.

Work has begun on the subject of international environmental monitoring. The global environmental effects of industrial, agricultural, and other activities within national boundaries have long been recognized. In many fields, international agencies have established, or are contemplating, machinery to monitor such transnational phenomena. There are a host of policy problems associated with these efforts: which issues should receive priority; what information should be collected and by whom; who should evaluate the data and by what standards; what problems arise in translating the results into government action; and others. The answers are not obvious, and will differ with specific cases. Initial work is being focused in several areas: depletion of the ozone layer, changes in the earth's albedo, and implications of sulfur-dioxide pollution. Professor George W. Rathjens, Department of Political Science, is directing the research, together with Professor Eugene B. Skolnikoff, Director of Center for International Studies, and Howard Margolis, Research Associate at the Center. Faculty at Harvard University and Wellesley College also are involved. The research is supported by the Rockefeller Foundation and the Andrew W. Mellon Foundation, and is being conducted in close collaboration with the United Nations Environmental Program.

The future of the nuclear energy industry is the subject of research being done by Professors Joel Yellin, School of Humanities and Social Science; Henry Jacoby, Sloan School of Management; and Paul Joskow, Department of Economics. The projected scale of growth in the industry has raised a host of unprecedented regulatory problems, national and international. The study is examining the experiences of the United States, the United Kingdom, France, and Germany, with the aims of drawing comparative conclusions and of anticipating future developments. The project is funded by the Ford Foundation.

In the spring, the Center cosponsored with the Energy Laboratory a conference on the international diffusion of energy technology. Industry leaders and government personnel, together with academic specialists, discussed international policy issues as seen by American industry in particular: the government's role in inhibiting or encouraging technology and hardware transfer; the manner in which the government's international energy policies affect public and private domestic energy activities; and problems facing the government in acquiring abroad technology for use in the United States. Research is planned in the future on these and other energy related international issues. The conference was sponsored by the US Energy Research and Development Administration.

The Center has continued its long-standing research on communications, with particular focus on new communications technology and its impact on investment and regulatory decisions, both domestic and international. The research is a collaborative effort with the Center for Policy Alternatives, the Center for Advanced Engineering Study, and the Electronic Systems Laboratory. Professor Ithiel Pool (Department of Political Science) directs the Center's part of this program, which is supported by the Markle Foundation.

Professor Pool also directed a series of symposia and conferences on the sociological impact of the telephone in spring, 1976. The program was part of the centennial observance of the telephone and was funded by the American Telephone and Telegraph Company. Plans are currently being completed to continue and expand this research in the coming year. Professor Pool also will be involved in preparing a revised and updated compendium of US laws and regulations in the communications field.

Students of economic development have observed the phenomenon of the dual economy in developing countries -- the coexistence of both modern and traditional economic sectors. At one time the assumption was that the traditional sector would vanish as development proceeded; but this assumption has come into increasing question as similar dualism has been observed in advanced industrial economies. Understanding the economic, political, and social functions of this persistent dualism in Europe and North America is the objective of research by Professors Suzanne Berger, Department of Political Science; Lisa Peattie, Department of Urban Studies and Planning; Martin Rein, Department of Urban Studies and Planning; and Michael Piore, Department of Economics. The study, which is funded by the Ford Foundation, will be completed in the coming year.

Several Center studies have dealt with other economic-political problems of advanced industrial societies and the international economic system. Professor Douglas Hibbs, Department of Political Science, has been studying long-term trends in industrial conflicts with support from the National Science Foundation; NSF recently has approved funds for a new study by Professor Hibbs on public attitudes toward governmental policies on inflation and employment. Professor Lester Thurow, Department of Economics, has been examining the income distribution effects of US exports of agricultural commodities; the Ford Foundation has supported this research. Professor Thurow is planning a companion study of the income distribution effects of agricultural imports, taking the United Kingdom as an example. Over the past year Professor Nazli Choucri, Department of Political Science, continued her study of the effects of resource constraints, especially in energy resources, on US interactions with the Soviet Union, Japan, and the People's Republic of China.

The International Nutrition Planning Program, sponsored jointly by the Center and the Department of Nutrition and Food Science, completed its third year. The program has developed a course of graduate study for students from the Departments of Economics, Political Science, and Nutrition and Food Science. Also offered are a year-long Advanced Study Program and shorter-term workshops for officials from the US and other governments and international and voluntary agencies. Faculty and students affiliated with the Program have been engaged in a major advisory effort in Pakistan as it implements its national plan to raise nutritional standards, and in a number of shorter-term advisory missions elsewhere on specific nutrition policy problems. Finally, the Program has undertaken research on nutrition policy questions; during the past year, a study was continued on the impact of US food aid and trade policies on nutrition in developing countries and on Pakistan's ration shop system for increasing food availability to low income families. Plans have been formulated to continue these research efforts and to undertake a broader study of various food subsidization schemes. Professor Skolnikoff and Professor Nevin Scrimshaw, Head of the Department of Nutrition and Food Science, served as cochairmen of the Advisory Committee for the program; other members of the committee were Professors Richard S. Eckaus, Department of Economics; Lance Taylor, Departments of Economics and Nutrition and Food Science; Steven Tannenbaum, Department of Nutrition and Food Science; and Myron Weiner, Head, Department of Political Science. The Program is supported by the Agency for International Development, the Rockefeller Foundation, and the NSF.

With a program grant from the National Institute for Child Health and Human Development and research support from that source and from the Rockefeller Foundation and the Smithsonian Institution, the Center began a major series of studies on migration within and among states.

Professor Wayne Cornelius, Department of Political Science, studied internal migration in Mexico, with particular emphasis on the effects of Mexican government rural development programs designed in part to reduce presumed incentives to migrate. Professor Weiner explored the impact of municipal, state, and national measures adopted in India to regulate or restrict internal migration. Dr. John Harris, Research Associate of the Center, undertook a comparative study of the development effects of migration in Indonesia and Kenya. Dr. Rosemarie Rogers, Research Associate of the Center, examined the effects on attitudes of prolonged stays outside their home country by European migrant laborers. These studies will continue in the coming year, when work also will begin on the migration of skilled workers among Arab countries by Professor Choucri.

During the past year, work at the Center on arms control focused on problems of nuclear proliferation, especially as affected by new technological developments and the growing importance of nuclear energy generation. The Center also cooperated closely with the Department of Political Science in developing a new Master's program in arms control and defense studies. Other arms control research involved the arms trade, decision making concerning the Strategic Arms Limitations Talks, the arms control implications of precision guided munitions, US policy on trade in computers, international control of terrorist activity, the role of the Arms Control and Disarmament Agency in formulating US negotiating policy, and the use and misuse of intelligence information in US Congressional debates on arms control and defense matters. Work in this field is supported by the Ford Foundation, the Rockefeller Foundation, and the Cos Cob Foundation. The program is directed by Professor Skolnikoff with a committee made up of Professors Rathjens; Ted Greenwood, Department of Political Science; Kent Hansen, Department of Nuclear Engineering; and Jack Ruina, Department of Electrical Engineering and Computer Science. This program will continue in future years; the Center plans next year to work closely with Professor Bernard Feld, Department of Physics, and Dr. Kosta Tsipis, Research Associate at the Center, on a series of studies on military research and development, the nuclear test ban, and information problems on arms control.

The project on international business continued over the past year, under the direction of Professor Geoffrey T. Clarkson, Sloan School of Management. The project, conducted in collaboration with the Sloan School, has concentrated on four areas: the international monetary system; the climate for international business; the employment effects of international direct investment and trade adjustment regulations; and international investment decisions. The work has been supported by the Department of Labor, the Tinker Foundation, the Ford Foundation, and several corporations (John Deere, Caterpillar Tractor, Pfizer, Morgan Guarantee Trust, IBM, IBM World Trade, Merck, Unilever, Universal Oil, Nestle, St. Gobain).

Closely related has been the work conducted by Professor Daniel Holland, Sloan School of Management, with Ford Foundation support. Professor Holland convened an international group of scholars who are working on the rate of return to capital in specific countries to discuss methods that might be developed to permit systematic comparative study of this question. Professor Holland currently is developing the design of a larger program that will involve coordinated study by several national teams.

The projects and program areas described above constitute the main themes of Center research. Study at the Center also has continued on several topics that have represented major areas of work in the past. Professor Donald Blackmer, Associate Dean, School of Humanities and Social Science, has continued to study non-ruling parties in Western Europe, with support from the Ford Foundation. Communist and radical movements are the focus of work by Professor William Griffith, Department of Political Science, with support from the Earhart Foundation. Professor Harold Isaacs, Department of Political Science, supported by the Ford Foundation and the New World Foundation, has continued his work on ethnicity and ethnic identity. Professor Lincoln Bloomfield's area of research is US foreign policy making. He has been

studying ways in which there can be more effective public input into foreign policy planning; this work is supported by the Kettering Foundation. Finally, Professor Robert Rotberg, with support from the Edward W. Hazen Foundation, is examining the emergence of black politics in South Africa's homelands.

The Center also sponsors seminars on topics related to its research and on general international and social science topics for the M.I.T. community, and publishes a monograph series of research reports. In addition to individual seminars on a wide range of international issues, special seminar series have been held on communications policy, new military technologies, and, jointly with the Program for Science and International Affairs at Harvard University, on general arms control problems.

EUGENE B. SKOLNIKOFF

Committee on the Visual Arts (C.V.A.)

The Committee on the Visual Arts is a faculty committee established in 1966 to act as a coordinated body for the varied and growing non-academic interest and activities in the visual arts at M.I.T., to study the problems of the visual environment of the Institute, and to make recommendations in this area to the President.

The faculty membership of C.V.A. includes: Wayne Andersen, Chairman (Professor of Art History, Theory and Criticism), Whitney Chadwick (Assistant Professor, Art History, Theory and Criticism), Patricia Cumming (Assistant Professor, Humanities), Richard Eckaus (Professor, Economics), Aaron Fleisher (Professor, Urban Planning), Albert Gurney (Professor, Literature), David Hoult (Assistant Professor, Mechanical Engineering), John Irvine (Professor, Chemistry), Boris Magasanik (Professor, Biology), Bruce Mazlish (Professor, Humanities), Jerome Rothenberg (Professor, Economics and Urban Studies), and Myron Weiner (Professor, Political Science).

Ex-officio members are: Peter Spackman (Executive Director, Council for the Arts), Walter Rosenblith (Provost, Professor of Electrical Engineering), and Harry Portnoy (Senior Architect, Planning Office). Student representatives are: Ruth Shragowitz (Course IV, Year 2), and Guy Nordenson (Course XXIB, Year 3).

Committee Action

Over the past several years, C.V.A. has been involved in the development of a long-range public art program at M.I.T. The M.I.T. Permanent Collection of over 700 paintings, sculptures, and works on paper focuses on the documentation of contemporary American art in process. No less important are several examples of European art that, in addition to their singular quality, help to clarify the issues of the modern movement. The Collection is an invaluable teaching tool for M.I.T.'s art and architecture offerings which concentrate on 19th and 20th century modes. Intended to support the notion that art should be more integrated with daily experience, the Collection is dispersed in public spaces both indoors and out throughout the campus.

Large-scale outdoor sculpture has become a pivotal element in the M.I.T. program. A number of factors have guided the evolution of the policy: 1) recognition of the fact that the most

innovative artists of our time, liberated by the expanded choices of materials modern technology has provided and often motivated by social consciousness, are producing significant public works; 2) an ever-increasing awareness at M.I.T. of the importance of the visual quality of the environment: the relationship of all the elements that comprise the total environment and the effect of surroundings on personal and group attitudes; 3) the belief that M.I.T. has a commitment not only to its own community but to the public-at-large and the resultant importance of an accessible collection.

Today, M.I.T.'s support of contemporary art in public spaces is providing a model for the increasing number of other cities, universities, and institutions interested in revitalization of their environment. A plan was established at M.I.T. in 1968 whereby a percentage of the construction cost of a new or renovated building was earmarked as an art expenditure and funds were raised for that specific purpose. Artworks for the Electrical Engineering Building, the Cancer Research Center, and the Chemical Engineering Building have been purchased through the "percentage for art" program, while many other pieces have come as gifts to the Institute.

The innovative nature of M.I.T.'s commitment to the visual arts supported by highly qualified professional acquisitions advice has been instrumental in several well known sculptors' presentations to the Institute of their greatest works for only the cost of installation and fabrication. The Committee has had a particularly eventful year with the acquisition of major sculptures by Louise Nevelson, Henry Moore, and Tony Smith, three of the greatest artists of our time. The siting of the Nevelson piece in front of the Ralph Landau Chemical Engineering Building was marked by special ceremonies and an informal talk between the artist and Wayne Andersen, Chairman of the Committee, before a standing-room-only audience in Room 9-150. The Henry Moore, regarded by the artist himself as the culmination of his life-long investigation of the theme of the recumbent figure, will be placed in the Killian Court in the fall. Tony Smith's seminal "primary structures" work is slated for siting in the Tang residence complex in September. In addition to these acquisitions, a lecture by Claes Oldenburg was arranged in conjunction with a joint exhibition of his work with the Institute of Contemporary Art. A mesmerized audience of well over 1,000 responded to Oldenburg's exploration of his artistic pursuits. The Committee also sponsored the showing of a film on Oldenburg produced by Michael Blackwood that gave further elucidation to the themes presented in the exhibition. Following is an accounting of Committee actions.

Transparent Horizon installed in front of the Ralph Landau Chemical Engineering Building

The C.V.A. had negotiated M.I.T.'s acquisition of a major sculpture by Louise Nevelson throughout the 1974-75 academic year. The installation took place in early December and was officially celebrated on December 10 with a series of events that the artist attended. Louise Nevelson's great contribution to the art of our time was honored in a site ceremony with brief remarks by Howard W. Johnson, President Jerome Wiesner, I. M. Pei, Professor Wayne Andersen and Professor Raymond Baddour, Head of the the Department of Chemical Engineering. There followed a videotaped interview with Nevelson conducted by Wayne Andersen who first gave an introductory lecture which placed her in the context of the mainstream of recent art in America. An overflowing audience comprised of members of both the M.I.T. and greater Boston areas was dramatic testimony to a general interest in and support of the visual arts here. A buffet dinner for Nevelson jointly sponsored by the C.V.A. and the M.I.T. Council for the Arts concluded the day's schedule.

The sculpture, a large black steel construction entitled Transparent Horizon, stands at the northeast end of M.I.T.'s East Campus House quadrangle and adjacent to M.I.T.'s new Ralph Landau Chemical Engineering Building designed by I. M. Pei. Basically a shallow open construction with passage wide enough to walk through, Transparent Horizon measures 20 feet

high and 21 feet long, and weighs approximately ten tons. The artist contributed the design of her work to the Institute to foster a continuing dialogue between education and the creative process.

A major effort was made by the Committee to engage student reaction to the Nevelson sculpture. A special meeting was held by the Committee members with East Campus students to hear their grievances and explain the procedure by which art is acquired at M. I. T., as well as the general philosophy of the arts program at the Institute. The Committee also conducted an open forum on M. I. T.'s public sculpture program. There was concern expressed about the sculpture being a safety hazard, and the Committee asked the Planning Office to propose a landscape design that would act as a natural protective barrier against accidental contact with the sharper elements of the piece. The design was posted in the East Campus dormitories and commentary was solicited. The scheme appeared to be acceptable and plans are under way to make the necessary changes.

Henry Moore for Killian Court

A heroic sculpture by the internationally celebrated British sculptor Henry Moore is slated to be installed in the Killian Court sometime this fall. The 18 foot long bronze piece entitled Three Part Reclining Figure, Draped makes an unprecedented addition to the M. I. T. Permanent Collection.

Only two casts of the reclining figure are being made, one for M. I. T. and the other for inclusion in Moore's own sculpture garden in Hertfordshire, England. Moore's estate, with many of his monumental sculptures in place, will become part of the Tate Gallery after his death.

The possibility of placement of a piece in the Killian Court was a major factor in Moore's enthusiastic endorsement of one of his major works for M. I. T. The bucolic setting in an urbanscape impressed Moore when he made a special visit to the Institute in May of 1974. He assessed the Killian Court as a most suitable environment for his work. Moore maintained that, "Sculpture is an art of the open air. Daylight, sunlight is necessary to it, and for me its best setting and complement is nature." Moore feels strongly that his sculpture should be placed in a landscape... "rather than in the most beautiful building I know."

The long history of obtaining a major work by Henry Moore for M. I. T. began in 1971 with a proposal by Wayne Andersen for one of Moore's marble pieces. A detailed album entitled This is M. I. T. was produced for Moore by the C. V. A. Over the years, the Committee has discussed several alternative sculptures for the Court (see previous Annual Reports). Unforeseen legal technicalities followed the final selection of Double Oval and it became necessary to initiate another selection process.

Henry Moore's work remains intrinsically within centuries-old sculptural traditions. His materials -- stone, bronze and often wood; his reverence for shapes and forms and their solid physicality; and his recurrent interest in sculpture's major theme, the human figure, all confirm an undeniable orthodoxy. A brilliant reinvestment of the past with modern concerns has been his decisive contribution to 20th century expression. Complementing Moore's passion for primitive sculpture and the importance to him of a natural open air setting were the advances made by Brancusi in the direction of abstraction, his interest in direct carving, and his focus on form.

Tony Smith

Fabrication of the Tony Smith sculpture for West Campus Housing area is well under way, and an early fall installation is planned. The Committee arranged a meeting at the Tang residence to explore the appropriateness of the chosen temporary site at the entrance to the Westgate complex in a grassy area flanked by pine trees. Although the work was purchased for the end courtyard on the Memorial Drive side of New House dormitories, it was ultimately determined that this location would not be ideally suited for about five years when another housing unit will likely replace the parking lot to the west of the complex.

The meeting, attended by Committee members and staff, as well as interested residents of the area, was instructive in establishing a dialogue and disseminating information about the Committee's goals and procedures.

Oldenburg Exhibition

It is hoped that the Oldenburg exhibition (see Exhibitions 1975-76) will be the first of many joint ventures between Hayden Gallery and other institutions in the Boston area. Cooperation in staging shows will help to defer rising costs, solve problems of space limitations and generally help to bring to the Boston area a great many more important presentations than would otherwise be possible. The Committee sees as limitless the effect of fostering mutual cooperation: joint graduate programs with each institution concentrating on its strongest areas of interest; museum seminars and internships; an arts administration program, etc. Professor Andersen, who initiated the concept, has been exploring the far-reaching implications of such a philosophy.

George Rickey Proposal

The Committee was very interested in a proposal made by the Center for Advanced Visual Studies to bring kinetics sculptor George Rickey to M. I. T. as a visiting artist in residence who might conduct a series of seminars that would result in the realization of an outdoor sculpture for a particular site at M. I. T. This would give students an opportunity to become aware of the many issues involved when a sculpture is designed for a preconceived space.

In addition to his qualifications as an artist, George Rickey is an experienced and renowned educator. His book on Constructivism and the development of kinetic, light, and environmental art is a classic reference.

The C. V. A. suggested that a project might be developed at New House where there is some money remaining after the purchase of the Tony Smith. The Council for the Arts was asked to submit a matching grant proposal for this scheme. Rickey is very enthusiastic about the idea, and it is hoped that the grant will be forthcoming and enable the project to take place in fall, 1976 or spring, 1977.

National Endowment for the Arts Grants

Two NEA matching grants have been awarded to the Committee on the Visual Arts, one for cataloguing the M. I. T. Permanent Collection and the other for renovation (climate control, security, storage) of Hayden Gallery.

The cataloguing of the Collection will result in a written document identifying the extent and depth of the Committee's contribution to the arts at M. I. T. Not only physical objects in the Collection, but also the ephemeral artworks -- events, activities, and uses of the arts at the Institute -- will be included.

The second grant, applied for when major renovations were planned for Hayden Gallery, is a 4 to 1 matching award. Since the extensive changes planned for in better times cannot be realized at the moment, this grant may not be accepted. The Council for the Arts at M. I. T. is exploring ways to raise the matching monies for this funding.

Larry Bell for M. I. T.

Under negotiations during the year was the offer to M. I. T. of an important work by American sculptor Larry Bell from Albert and Vera List. The historic piece, entitled Iceberg and Its Shadow, has developed from the primary structures aesthetic and explores new technological processes related to bronze patinazation and the tradition of polished stone. The C. V. A. was of the opinion that M. I. T. with its strong interest in art and technology, as well as contemporary American sculpture, is a most appropriate home for the work. The sculpture will be introduced to the M. I. T. community in an exhibition entitled, Larry Bell: Iceberg, in January 1977.

Lurcat Tapestry

The Committee approved the acquisition into the Permanent Collection of a tapestry, Death and the Warrior, by the French artist Jean Lurçat. The work had been offered for the new Chemical Engineering Building by Halcon, International in honor of its President, Dr. Ralph Landau, with the generous assistance of Guy Fino, Manufactura de Tapeçarias de Portalegre, Ltd. Jean Lurçat is credited with initiating the 20th century revival in tapestry work, and Death and the Warrior is an outstanding example of his style.

The tapestry was prepared and installed under the supervision of the Committee staff in the west lobby of the new Chemical Engineering Building that bears Dr. Landau's name. The Committee staff also is supervising the design of a permanent plaque that will accompany the work, and has prepared the publicity for the announcement of the gift.

Video Security System for Hayden Gallery

A video security system was installed in Hayden Gallery, Hayden Corridor Gallery and the terrace outside the main entrance to Building 14 with a grant from the Council for the Arts at M. I. T. TV cables had already been placed in these locations by Campus Patrol, as well as in a few other "high security" areas throughout the Institute. The system relays to Campus Patrol headquarters for 24-hour monitoring. The security of the Gallery proper has been increased to relatively foolproof proportions, and the level of protection to the Corridor and terrace extended. As the worth of works on paper has increased in today's inflated art market, it has become necessary to improve security in the Corridor Gallery. The camera equipment will be activated by the Gallery staff only when the value of works on display call for such a measure.

Peter Chinni

A bronze sculpture, Natura/Extensa, by Peter Chinni was donated to M. I. T. by Ercole Sozzi and accepted into the Permanent Collection. Chinni, an American sculptor of some note, is represented in several prominent public and private collections -- among them the Whitney Museum in New York, the New York Cultural Center, the Chase Manhattan Bank, New York and that of artist Mark Tobey. Chinni's smoothly finished piece patinated in black is one of a series completed around 1965 in Rome when he was intent on suggesting organic activity through a variety of asymmetrical biomorphic forms.

Other Proposals to the Committee

The Committee reviewed many proposals during the 1975-76 academic year. An offer of a one-year loan to M.I.T. by the Sunne Savage Gallery of a monumental corten steel sculpture by John Raimondi was declined, as was a proposal submitted by Dr. Harold Edgerton to place 16" World War II artillery shells in front of the columns of Building 13. The Committee did not have the means to purchase a Takis sculpture offered by the Center for Advanced Visual Studies. A gift from Hugh McMath, Class of 1935, of a gouache by Walter Rolfe, Class of 1923, and an ink drawing publicizing an early M.I.T. Open House by McMath himself were accepted and registered in the Historical and Permanent collections.

Office of Exhibitions Activities

A diversified program, reflecting the multifaceted nature of the visual arts today and responding to various special interest groups -- both within the Institute and in the Boston area at large -- was presented at Hayden Gallery and Hayden Corridor Gallery during the 1975-76 academic year.

A grass roots aesthetic that has influenced art and architecture since the 1960s was shown in the works of Clarence Schmidt; a look at Otto Piene's more traditional work, paintings and works on paper, offered a new insight into this versatile artist who is the Director of M.I.T.'s Center for Advanced Visual Studies. World-celebrated sculptor Claes Oldenburg had his first Boston showing at M.I.T. and gave record-breaking crowds an opportunity to experience first-hand the profound talent that has made a major impact on American sculpture since the early 1960s. In Heléne Aylon's exhibition, the viewer had a chance to examine a unique application of "process issues" to the medium of painting, another "first" for the Boston area. Lowell Nesbitt's photo-realist paintings were shown at a time when the concept of realism in art today was being examined elsewhere in major Boston showings: Catherine Murphy at the ICA and Alfred Leslie at the Museum of Fine Arts. The year's closing exhibition brought together works acquired recently for the M.I.T. Permanent Collection that have been sited in buildings throughout the campus.

Hayden Gallery Exhibitions 1975-76 included the following:

Clarence Schmidt	September 26 - October 29, 1975
Otto Piene: Paintings, Gouache, Drawings	November 7 - December 7, 1975
Claes Oldenburg: Six Themes	January 17 - February 25, 1976
Heléne Aylon: Paintings That Change In Time	March 13 - April 10, 1976
Lowell Nesbitt: Selections From An Autobiography	April 17 - May 15, 1976
M.I.T. Collection: Recent Acquisitions	May 22 - July 2, 1976

Hayden Corridor Gallery Exhibitions 1975-76 included the following:

Marvin Brown: Works on Paper	September 26 - October 29, 1976
Gregory Amenoff: Works on Paper	January 17 - February 25, 1976
Parallax: Perspectives on Photography	March 5 - April 10, 1976
Josef Albers	April 16 - May 15, 1976
M.I.T. Collection: Works on Paper	May 22 - July 2, 1976

Publications

Exhibition Catalogues and Brochures included Otto Piene. Essay by Lawrence Alloway. Editor: Susan E. Cohen, bibliography and chronology, 1957 to present. Illustrated. November 1975. Helène Aylon. Essay by Marjory Supovitz. Selected bibliography and chronology. The format for this poster-mailer was devised as a low-budget measure. Lowell Nesbitt. Selected bibliography and chronology. Poster/mailer brochure.

The M. I. T. Art News is published at the opening of each term to alert students to subject offerings, exhibition plans, new programs, and events. The newspaper informs the M. I. T. community of the broad range of opportunities for experience of and participation in the visual arts throughout the Institute and is a vehicle of information on the history and development of the Institute as a visual environment. Because of the increased activity of the Committee on the Visual Arts, the fall, 1975 issue of the M. I. T. Art News was expanded to an eight-page format for the first time since it was first published in 1972.

WAYNE ANDERSEN

Division for Study and Research in Education (D.S.R.E.)

The third year of the D. S. R. E. has been one of continued program development associated with a modest growth in the number of faculty and students. In 1973-74, the Division's first year, there were 16 staff and five interdisciplinary graduate students. This year there are 29 staff and 15 graduate students, almost all with joint appointments in other departments. The 90 students enrolled in Division subjects in 1975-76 compared to fifty students in 1973-74.

The Division's primary goal has been to support both current and new approaches to research on the learning process and thus inform the practice of education both at M. I. T. and nationally. One of our initial tasks has been to determine whether the special competences present at M. I. T., supplemented by other skills and perspectives and brought together in an academic setting, could make significant contributions to the study and research of education. This effort was made possible by a grant from Cecil and Ida Green, with additional support from the Lilly Endowment, Inc. and the Ford Foundation.

At its inception, the Division was conceived as an interdisciplinary research enterprise with an associated academic program. The Division did not expect to influence M. I. T.'s educational practice or curriculum in the short run, but rather to focus on developing new concepts of educational research. The emphasis during the first two years was on finding a common language and shared set of assumptions among a disparate group of faculty.

A limited, though important consensus has emerged. Some of the research undertaken by the Division does lie within individual disciplines or fields -- cognitive psychology, computer science and artificial intelligence, sociology -- in cooperation with other departments. However, the D. S. R. E. attempts to do something more by mobilizing the resources and ideas from the various disciplines in a new approach to research in education. Intensive research within fields continues in the framework of the Division, but we expect that the Division will become either a temporary or permanent interdisciplinary intellectual home for certain faculty and staff with joint appointments.

The early expectation that the Division would focus primarily on basic research related to education and not be directly concerned with M. I. T.'s ongoing educational activities has undergone recent revision.

During the academic year, members of the Division conducted a weekly seminar of approximately 20 participants (from four M. I. T. departments, Harvard, and the Educational Development Center) who discussed case studies of institutional change and "learning" and specific ongoing research into the educational process both at M. I. T. and elsewhere. As a partial outgrowth of these seminars, several Division members have had discussions with various Institute committees on evaluating experimental programs and new approaches to professional education at M. I. T.

Another expression of the increasing interaction between the Division and M. I. T. is the Lilly Faculty Teaching Award Program. As a result of a grant from the Lilly Endowment, Inc., nine junior and three senior faculty from nine departments received small grants (from \$700 to \$4,000) to carry out projects in teaching and learning. This program has enabled the Division to identify and support both junior and senior faculty who had already been thinking about M. I. T.'s educational climate and to provide them continuing interaction and discussion about their projects and experience. These modest individual grants with the associated program appear to have provided a significant support for educational innovation and research by a growing number of faculty members.

The interaction that has developed between the D. S. R. E. and the Department of Urban Studies and Planning has been especially valuable, and has received important support from the Department's chairman. The Division has provided both time and a setting where the knowledge-in-practice seminar and associated research can clarify and develop the concepts underlying the activities of Department members in the Division. Concurrently, the Department has engaged in a serious examination of the implications of these findings for its own educational program.

Other members of the Division are exploring the implications of their research into cognition for actual teaching/learning practice. Since its inception, the D. S. R. E. has had a close interaction with the work on education of the LOGO group, part of the Artificial Intelligence Laboratory. After careful review of the Children's Learning Laboratory's potential contributions, D. S. R. E. partially supported a limited physical expansion of the Laboratory early in fall, 1975. This Laboratory is designed to be a learning environment where a modest, voluntary program of education and research can be carried out with small groups of children. At the request of the Laboratory, the Division will be involved in evaluation, assessment, and research of the Laboratory's ongoing work next year. Three subjects in our course offerings are directly related to the work of the Laboratory: SRE 111 Designing a New Elementary Curriculum, SRE 103J Experimental Studies in Musical Perception and Learning, and SRE 220 Educational Technology. The Learning Laboratory encourages the working out of alternative conceptions of education that follow sophisticated information processing models of cognition, linked to the use of the computer in the learning process. The imaginative setting and the up-close examination of the cognitive and affective impact of this setting on both teacher and student may have significant implications for education at M. I. T. and elsewhere.

There are currently five program areas within the Division, each with faculty, graduate students, course offerings, and research projects that focus on a specific set of issues.

The first area is the development of information processing models of cognition and the application of these models to education. The relation of computational models of cognition to developmental and cognitive psychology is an important aspect of this area.

The second area comprises the study of the impact of the educational environment on the affective and cognitive development of the learner, including the examination of the formal and informal supports which foster learning within an educational environment. Basic research here deals with the processes by which individuals construct their social reality and the impact of this on education.

The third area investigates the knowledge actually used by practitioners (e.g., planners, engineers, lawyers) in their professional settings and the implications of these findings for professional education.

Another focus is the development of educational technology and its application, for example, to new learning environments (like the Children's Learning Laboratory), computer aided instruction, and cable television.

Finally, the D.S.R.E. supports special projects and activities of particular relevance to education at M.I.T.

ACADEMIC PROGRAM

Twenty-six subjects were offered in this academic year. Of five graduate students admitted in the Division's first year, three have received their degrees, one is currently on leave, and one is completing the thesis. Fifteen graduate students are currently enrolled in the Division, 12 in the Ph.D. program, and three in the Master's program for Course XXV. Two students received their doctoral degrees this year, Shirley Picardi, jointly with Nutrition and Food Science, and Howard Austin, jointly with Electrical Engineering and Computer Science.

Admissions to the graduate program continue to be in association with another academic department. Four students are jointly enrolled with Electrical Engineering and Computer Science, three with Psychology, two with the Sloan School, two with Urban Studies and Planning, and one each with Physics, Linguistics, Architecture, and Nutrition and Food Science. Professor William T. Martin, as graduate student advisor, held bi-weekly research seminars for the graduate students in the Division. He also developed procedures for monitoring the students' progress and spelled out a set of guidelines for the thesis committee. In summary, the small number of graduate students have a wide range of interests and relationships with departments, and are a very important part of the life of the Division.

CONCEPTUAL DEVELOPMENT

Activities which took place this year are grouped under the heading conceptual development. Some of these were supported by the Lilly Endowment and Ford Foundation funds. A series of Wednesday noon seminars on a broad range of topics, and a more specialized seminar on educational technology, were held.

In September 1975, with support from the Lilly Endowment, Inc., the Division undertook an 18-month project to develop several new themes in educational theory and practice. These themes included: 1) access to real-life cognitive processes through verbal analytic techniques, called "Loud Thinking;" 2) investigation of the processes by which institutions as distinct from

individuals may be said to learn; and 3) the ways in which knowledge formally acquired is applied informally in practice. To stimulate development of these themes the Division has reached into M. I. T. and beyond to establish collaboration with a larger network of potential co-workers.

In the research area of "loud thinking," a working conference took place in January 1976 at which representatives of several approaches worked with one another in an intensive 10-day long work experience. Later, participants exchanged written material stimulated by the working conference.

Seminars and further collaborative research in this area involved Professors Seymour Papert, Donald Schon, and Benson R. Snyder. SRE 203 Seminar in Education - Loud Thinking, was a new course taught by Professors Papert, Snyder, and Steven T. Rosenberg this spring semester. It is a direct outgrowth of the work of the conference.

In their seminar on Metaphor in Learning and Discovery, Professors Schon and Jeanne Bamberger have used "loud thinking" methods to explore simple tasks of communication and construction, and to gain insight into the ways in which metaphorical thinking shapes problem-space and stance toward task-performance.

The Institutional Learning Seminar considered the significant effects of institutional context on the individual learner. Several detailed case studies were developed and will serve as the basis for a small conference in the coming academic year. This spring semester, several members of the seminar focused on specific research proposals and projects in the area of individual institutional interaction.

The third area of investigation, knowledge-in-practice, took Urban Studies and Planning as a case in point, both because of the interest of several D. S. R. E. faculty and because the Department of Urban Studies and Planning was engaged in experiments in curriculum reform which made it a likely prospect for the application of new insight into the nature of professional education. A small group of planning practitioners and researchers was formed early in fall, 1975 and met regularly throughout the year. They examined segments of planning practice from several different research perspectives. A three-day working conference was held in January in which the group was joined by four researchers. Through their investigations, they became aware of some of the images planners hold for structuring the contexts in which they function, and how they simplify and make manageable the complexities of day-to-day operations.

Several outgrowths of this work to date include a studio for graduate students in the Department of Urban Studies and Planning, a seminar on professional practice to be offered in the fall by Professors Schon and Martin Rein, and the generation of three doctoral theses which will explore real-world cognition in occupational practice.

The Division continues to maintain a relationship with the Oxford Educational Research Group at the University of Oxford. The common interest of the Division and the Oxford group in "Thought, Language, and Social Context" has been evident in meetings with Professor Jerome Bruner and others from the Oxford Group.

A working relationship was developed with Austin College, in which ongoing programs both at M. I. T. and at Austin have been reviewed. Five academic deans from Austin College presented a detailed case study of total institutional change and its impact on the education of undergraduates at Austin College during an extended visit in January 1976. Members of the Division have visited there several times to work with students and faculty on issues of common concern.

A grant from the Lilly Endowment was awarded for the support of M.I.T. faculty projects specifically designed to improve teaching skills. In addition to their individual projects, the grant recipients participated in monthly seminars to discuss their individual programs as well as the larger issues of teaching and learning. Selection of the 12 faculty for this academic year was made by a review of individual proposals by an interdepartmental selection committee.

In May 1976, Project Women in Technology and Science (W.I.T.S.) moved from the Center for Advanced Engineering Study to the D.S.R.E. This project is concerned with stimulating and facilitating the education of women in science and in technology.

Visiting faculty played a significant role in the Division this year. Visitors included: Dr. Hermina Sinclair-DeZwart, Department of Psychology, University of Geneva; Dr. Bruner, Department of Experimental Psychology, Oxford University; Professor Fred Reif, SESAME Group in Science and Mathematics Education, University of California at Berkeley; Dr. Bertrand Schwartz, Professor of the Science of Pedagogy, University of Paris; Dr. Martin Trow, Professor of Sociology, Graduate School of Public Policy, University of California at Berkeley; Sir Geoffrey Vickers, Goring-on-Thames, England; Dr. Anthony Ryle, Director of the University Health Service, Sussex University, England; and Dr. Tom Burns, Professor and Head of Department of Sociology, University of Edinburgh.

PERSONNEL

The D.S.R.E. began the 1975-76 academic year with the appointment of a new director. In July 1975, Dr. Snyder, Professor of Psychiatry with a joint appointment in the D.S.R.E. and the School of Architecture and Planning, succeeded Professor Martin, Professor of Education and Mathematics. After two years of dedicated service, Professor Martin remains active in the Division's research and educational programs and continues to play a key role in the development of the Interdisciplinary Doctoral Program. Professor Martin retired from the M.I.T. faculty after 38 years, but fortunately will continue in the D.S.R.E. part-time as Senior Lecturer and Professor Emeritus.

BENSON R. SNYDER

Harvard-M.I.T. Program in Health Sciences and Technology

M.I.T. and Harvard University are engaged in a major collaborative effort designed to focus science and technology on human health needs. The complementary strengths of both institutions are directed to the development of new kinds of physicians and other health scientists and to the application of modern science and technology to important health and medical problems. The solution of major health problems and the provision of excellent health care require the concern and competence not only of the biological sciences and the medical professions but also of other disciplines and professions such as the physical sciences and engineering, the social sciences, management, public administration, and law. The aims of the Harvard-M.I.T. Program are to promote productive interactions of these disciplines and professions with biology and medicine, and to integrate education for health and medicine into general university education.

EDUCATIONAL PROGRAMS

The major educational objective is the development of new kinds of health professionals -- physicians with a strong base in science or engineering, and medical engineers and medical physicists with a knowledge of human biology and medicine who can apply their knowledge and skill effectively to meet health needs.

Biomedical Sciences Curriculum

The Curriculum Committee, chaired by Dr. David W. Hamilton, made considerable progress in the establishment of areas of concentration. The principal areas are the Neural Sciences, the Musculoskeletal, Respiratory, Renal, and Cardiovascular Sciences, Endocrinology and Metabolism, and Developmental and Reproductive Biology. Brochures outlining the requirements in each area and the opportunities available for independent study and research have been prepared by the Tutor-Coordinators. Faculty members serving as Tutor-Coordinators are: Drs. Stephen Waxman, Eric Radin, Regis McFadden, Joel Haebener, Martin Carey, and I. John Davies. In developing the areas of concentration, the Curriculum Committee seeks to provide students with a better opportunity to develop a coherent curriculum which is best suited to their interests and talents and which simultaneously will afford a broad medical education.

During the past year, the Curriculum Committee completed a review of the subjects offered in the Harvard-M. I. T. Program. A full report of this review will be presented at a later date, but at this time some comments are in order. The newly developed subjects have for the most part been highly successful, indicated by the adoption of several of these educational innovations for the regular curriculum of Harvard Medical School. Since a major objective of the Harvard-M. I. T. Program is continuing educational experimentation and evaluation, it is incumbent on the Program to promote further innovation in the regular curricula. In the evaluation of the Harvard-M. I. T. subjects, the review procedure focused on problem areas. It is gratifying to note that the criticism of students is highly constructive and that faculty members are willing to engage in rigorous self-examination and to respond positively to suggestions for improvement.

During the past two years, the Harvard-M. I. T. Program has offered two subjects in the area of the social sciences and medicine, Ethics and Decision Making by Dr. Sissela Bok and Economics of Health Care by Alan Detsky. The favorable response to these offerings is encouraging. A subcommittee of the Curriculum Committee is engaged in a proposal for further development of the social science aspects of the curriculum.

A new subject, HST 160 Human Genetics, under the direction of Dr. Samuel Latt was offered this year for the first time. The success of the course warrants its inclusion as an integral part of the Harvard-M. I. T. curriculum.

During the past year, a new subject Topics in Quantitative Physiology was under development by Professors Villars, Benedek, Litster, Weiss, and Deen. It will be offered for the first time in the fall semester of 1976. This subject will deal with the principal processes in cell physiology and with regulatory mechanisms in human physiology. It is regarded as a basis for more advanced offerings in pathophysiology in which physical approaches to normal and abnormal physiology of specific organ systems are emphasized.

Admission of students into the M. D. Program is determined by a faculty committee of which Dr. Herman N. Eisen, Professor of Biology at M. I. T., is chairman. There were 389 applicants for 25 positions, compared with 349 the previous year. It was generally agreed

that most of the applicants were of unusually high quality. One hundred eighty of the most promising applicants were interviewed. Of the original group of 25 who accepted positions in the Program, three were granted deferred admission to permit their participation in fellowship programs: a Marshall Fellowship to Oxford University, a Luce Fellowship for an internship in Asia, and a Danforth Fellowship.

The following analysis of the class that will enter in September 1976 lists the number of students in various categories and, in parentheses, the number in the corresponding category of the total pool of applicants.

Females	6 (70)
Males	19 (319)
Harvard	5 (59)
M. I. T.	7 (75)
Minority	2 (23)
Juniors	2 (18)

This year marks the graduation of the second class of Harvard-M.I.T. students to receive the Doctor of Medicine degree. The excellent performance of the students is reflected in the outstanding internship appointments which they have received. These internships included five at Massachusetts General Hospital, three at New York Presbyterian Hospital, and two at Peter Bent Brigham Hospital.

Of the 109 Harvard-M.I.T. students in residence, 27 are enrolled as candidates for the Doctor of Philosophy degree at either school. Richard Cohen (Class of 1976) is the first Harvard-M.I.T. student to receive the Doctor of Medicine and Doctor of Philosophy degrees in this Program. He was awarded the Doctor of Medicine degree from Harvard University and the Doctor of Philosophy degree in Physics from M.I.T., having achieved both degrees in a total period of five years.

Medical Engineering and Medical Physics Curriculum

In 1975, a Task Force of faculty members of M.I.T. and Harvard Medical School chaired by Professor Laurence R. Young of M.I.T. studied the issues associated with the development of medical engineering and medical physics in the two universities and in the teaching hospitals. The principal recommendations of the Task Force were: the organization of medical engineering departments in the Harvard teaching hospitals with educational, research, and service responsibilities; coordination of these hospital based medical engineering departments through the Program in Health Sciences and Technology; the development of formal degree programs in medical engineering and medical physics at the graduate level including the Doctor of Philosophy degree. Curricula for these programs would include a series of clinical engineering experiences in anesthesiology, cardiology, orthopedic surgery, radiology, neurology, ophthalmology, otology, surgery, and rehabilitation medicine, and with experience in problems of hospital safety.

Two committees have been engaged in detailed planning to implement a formal degree program in medical engineering and medical physics. The objective is the education of individuals highly qualified as engineers and physicists with extensive knowledge of human

biology and medicine to engage in clinical investigation on important problems in medicine. Such individuals should be leaders in creative scholarship, and provide a base for the development of the profession of medical engineering and medical physics.

One subcommittee consisting of faculty members of the Schools of Engineering and Science of M. I. T. has focused on the overall curricular plan, and the procedures and policies governing admissions and general examinations for the Doctor of Philosophy. A second subcommittee consisting of faculty members of M. I. T. and Harvard Medical School-Massachusetts General Hospital, under the Chairmanship of Dr. Richard Kitz, has been concerned with the development of the clinical experiences which are designed to serve as an integral part of the educational program. As proposed, the program will accept students who have completed a baccalaureate degree in engineering or in physics. Prerequisites will include general biology, organic and physical chemistry, and advanced calculus for engineers. Students will be admitted simultaneously to the doctoral program in medical engineering and medical physics and to a Master's program in a department of engineering. While completing the Master's requirements in a field of engineering, the students will study the functional anatomy of man, human pathology, biochemistry, and various subjects in human pathophysiology. After the award of the Master's, normally after two years, these doctoral candidates will have a special subject offering on introduction to clinical medicine where experience in the use of advanced medical instrumentation and equipment in the diagnosis and treatment of patients will be emphasized. Subsequently, each student will participate in a number of clinical medicine and engineering experiences. The objective of these experiences is to provide students with opportunities to participate in actual operations of health care facilities, working in close association with physicians, surgeons, and clinical engineers and physicists. A general examination will normally be taken at the end of the second year with completion and oral defense of a Doctor of Philosophy thesis after approximately five years.

It is planned that this new program will be offered for the first time in the fall of academic year 1977-78. In conjunction with this program a curriculum guide, based upon recommendations of an earlier Task Force, was prepared by Professor Young. It is planned that 10 students per year will be admitted to this program.

The Harvard-M. I. T. Program has continued support for the interdepartmental Doctor of Philosophy Program in Biomedical Engineering. Five additional students were admitted during the past year, raising the total to 13.

Training Program in Medical Radiological Physics

Now in its second year, the program provides training in physics of radiation therapy, diagnostic radiology, and nuclear medicine, leading to a doctor's degree at the Harvard School of Public Health or M. I. T. Funded by the National Cancer Institute, the program is under the direction of Bengt E. Bjarngard, Ph.D., Associate Professor of Radiation Therapy at Harvard Medical School and Lecturer at the Harvard School of Public Health. Co-directors in the program are Gordon L. Brownell, Ph.D., Professor of Nuclear Engineering at M. I. T. and Director of the Physics Research Laboratory at the Massachusetts General Hospital, and Edward W. Webster, Ph.D., Associate Professor of Radiology at Harvard Medical School and Lecturer at the Harvard School of Public Health. The participating groups at Harvard and M. I. T. include the Kresge Center for Environmental Health of the Harvard School of Public Health, the M. I. T. Department of Nuclear Engineering, the M. I. T. High Voltage Research Laboratory, the Departments of Radiology at the Massachusetts General Hospital and Peter Bent Brigham Hospital, Joint Program in Nuclear Medicine at Children's

Hospital and Peter Bent Brigham Hospital, Physics Research Laboratory at the Massachusetts General Hospital, the Harvard Joint Center for Radiation Therapy, and the Shields Warren Radiation Laboratory.

RESEARCH AND DEVELOPMENT

An Interdisciplinary Program in Biomaterials Science, now in its fifth year of operation under a grant from the National Heart, Lung, and Blood Institute, has as its goal an increased understanding of natural biological materials in order to develop synthetic materials that may be used in vivo for repair or replacement of human organs. Presently consisting of 12 collaborative projects, the research program is supervised by Robert W. Mann, Sc.D., Whitaker Professor of Biomedical Engineering at M.I.T., and a steering committee of 10 faculty members, with the participation of 31 faculty members. Participating institutions are M.I.T., the Harvard teaching hospitals, Northeastern University, Boston University, and the Walter Reed Army Research Institute. Research is evaluated annually by an Advisory Board chaired by Robert A. Alberty, Dean of the M.I.T. School of Science. An extensive proposal for the continuation and expansion of this program for five years has been submitted.

The Rehabilitation Engineering Center at Children's Hospital Medical Center and M.I.T., now in its fifth year, is funded by the Social Rehabilitation Administration of the US Department of Health, Education and Welfare. The purpose of the Center is the rehabilitation of physically handicapped children, and the major focus is the design, fabrication, and evaluation of specific bioengineering aids for children for whom routine therapy and apparatus are unsuitable. The Program Director is William Berenberg, M.D., of Children's Hospital Medical Center and Professor of Pediatrics at Harvard Medical School, and the Co-directors are John E. Hall, M.D., of Children's Hospital Medical Center and Professor of Orthopedic Surgery at Harvard Medical School, Melvin J. Glimcher, M.D., of Children's Hospital Medical Center and Harriet M. Peabody, Professor of Orthopedic Surgery at Harvard Medical School, and M.I.T.'s Professor Mann, who is also Lecturer in Engineering at Harvard Medical School.

The Nuclear Medicine Program involves six collaborative research projects directed toward the application of nuclear techniques to medical problems: metabolic disorders, bone diseases, and congenital heart disease. The collaborating groups include the M.I.T. Department of Chemistry, Nuclear Engineering, Electrical Engineering and Computer Science, the Laboratory for Nuclear Science, and groups at Massachusetts General, Peter Bent Brigham and Robert B. Brigham Hospitals, New England Regional Primate Research Center, and Children's Hospital Medical Center. The program is under the direction of Professor Brownell and S. James Adelstein, M.D., Ph.D., Director of Nuclear Medicine at the Peter Bent Brigham Hospital and Children's Hospital Center and Professor of Radiology at Harvard Medical School. Now in its third year, the Program is funded by grants from the National Heart, Lung, and Blood Institute, and the National Institute of General Medical Sciences. Supplementary proposals have been submitted to the National Institute of Arthritis, Metabolism and Digestive Diseases, and a proposal for competing renewal will be submitted in February 1977.

The Optimization of Dose Distribution in Cancer Radiation Therapy Research Program, supported by a grant from the National Cancer Institute, is now in its second year of research directed toward the ultimate goal of technically improved delivery of ionizing radiation for cancer therapy. The five individual projects involve collaborative participation by groups from the M.I.T. Department of Mechanical Engineering, High Voltage Research Laboratory,

Artificial Intelligence Laboratory, the Charles Stark Draper Research Laboratory, Inc., and the Harvard Joint Center for Radiation Therapy. The program is directed by an executive committee consisting of Martin B. Levene, M.D., Deputy Director of the Harvard Joint Center for Radiation Therapy and Associate Professor of Radiation Therapy at Harvard Medical School, Henry M. Paynter, Sc.D., Professor of Mechanical Engineering at M.I.T., and Irving A. Bernstein, Assistant Director for Research Program Development of the Harvard-M.I.T. Program in Health Sciences and Technology. A proposal for continuation and expansion of this program to include clinical evaluation of new instrumentation and equipment will be submitted to the National Cancer Institute in September.

The Biomedical Engineering Center for Clinical Instrumentation, established in June 1975 with the support of the National Institute of General Medical Sciences, has as its purpose the application of microprocessor technology to development of new instruments for a variety of clinical fields including cardiology, neurology, anesthesiology, pulmonary diseases, surgery, and nuclear medicine. The Principal Investigator is Roger G. Mark, M.D., Ph.D., Associate Professor of Electrical Engineering at M.I.T. and Assistant Professor of Medicine at Harvard Medical School, and the Technical Director is Stephen K. Burns, Ph.D., Senior Research Scientist, Harvard-M.I.T. Program in Health Sciences and Technology. The M.I.T. departments participating in this program are Electrical Engineering and Computer Science, Aeronautics and Astronautics, and Mechanical Engineering, and the Harvard teaching hospitals providing the clinical application sites are Peter Bent Brigham Hospital and Beth Israel Hospital. The research projects and Principal Investigators are an ambulatory arrhythmia analysis system (Professor Mark), a vestibular/postural test battery (Professor Young), a thermal diffusion probe (Dr. H. Frederick Bowman) and a pulmonary function system (Dr. Regis McFadden).

A proposal for a study of health effects of combustion generated soot and polycyclic aromatic hydrocarbons has been submitted to the Energy Research and Development Administration. This interdisciplinary research program couples energy engineering, analytical chemistry, and biomedical sciences to study the toxicological effects of soot and polycyclic aromatic hydrocarbon carcinogens produced under combustion conditions pertinent to practical-scale combustors. The Co-investigators in this program are William G. Thilly, Sc.D., Assistant Professor of Toxicology in the M.I.T. Department of Nutrition and Food Science, Jack B. Howard, Ph.D., Ronald A. Hites, Ph.D., and William A. Peters, Ph.D., all of the M.I.T. Department of Chemical Engineering. The program involves participation of individuals from the M.I.T. Departments of Nutrition and Food Science, Chemical Engineering, Aeronautics and Astronautics, Mechanical Engineering, Chemistry, and the M.I.T. Energy Laboratory.

The following programs are under development: a proposal for a research program in health effects of fossil fuel energy production and utilization (environmental carcinogenesis and mutagenesis) will be submitted to the National Cancer Institute. A proposal for a Harvard-M.I.T. radiopharmaceutical development program for the improvement in understanding of the chemistry underlying radiopharmaceutical production and the development of radiopharmaceuticals with improved specificity, reduced dose, and improved imaging quality will be submitted in August 1976 to ERDA. A proposal for a hyperthermia in cancer therapy research program to develop techniques and instrumentation for achieving hyperthermic states which are to be coupled with radiation therapy and chemotherapy in the treatment of cancer will be submitted to the National Cancer Institute in February 1977.

A proposal for a program in myocardial perfusion scintigraphy using a new technique, the mesh chamber, and aiming at the development of a high efficiency, high resolution scintillation detecting system to be used as a primary screening test in evaluation of patients with coronary artery disease will be submitted to ERDA in August 1976 and to the National Institutes of Health in October 1976.

Provost

Dr. Irving A. Berstein, Program Officer for Research and Development, continues to play a major role in the organization and management of these collaborative research programs.

ADMINISTRATIVE STRUCTURE

The Joint Faculty Committee serves as the senior faculty body of the Harvard-M.I.T. Program. Its members include Drs. Walter H. Abelmann, Harold Amos, William Berenberg, David G. Freiman, David W. Hamilton, Alexander Leaf, and William V. McDermott, all of the Harvard Medical School; Professors George B. Benedek, Herman N. Eisen, Boris Magasanik, Robert W. Mann, John Ross, and Laurence R. Young, all of M.I.T.; Professors Farish A. Jenkins, Jr. and Richard E. Kronauer of Harvard University; Drs. Irving M. London and Roger G. Mark of Harvard Medical School and M.I.T.; and Dr. James L. Whittenberger of the Harvard School of Public Health. This committee receives and discusses the reports of the Curriculum Committees, the Admissions Committee, and the various research and development groups engaged in Program activities.

The Program's Planning Committee, chaired by Provost Walter A. Rosenblith of M.I.T. and Dean Robert H. Ebert of the Faculty of Medicine of Harvard, completed a review of the appointment and promotion procedures of the two universities, and reconciled divergencies in order to have a common set of regulations to govern these areas in the faculty of the Harvard-M.I.T. Program. A proposal describing the governance and procedures for the proposed School of Health Sciences and Technology has been submitted to the Presidents of Harvard and M.I.T.

FINANCIAL RESOURCES

As of June 30, 1976, endowment funds received or pledged totaled \$6.7 million of which \$1.39 million was raised during the past year. Operating funds received during the past year totaled \$139,000. The total funds raised this year are \$1.529 million; 23 proposals requesting \$6.6 million are outstanding.

Since 1970, approximately \$16.5 million has been raised, \$6.7 million for endowment, \$1.9 million for operations and facilities, and \$7.9 million for research and development. More than 90 percent of these funds have been utilized in support of existing faculty and staff members; less than 10 percent has been spent in support of newly appointed personnel. Dr. Walter L. Koltun, Assistant Director for Resources, is in charge of these activities in the Program.

IRVING M. LONDON

Independent Activities Period (I.A.P.)

The Independent Activities Period of January 1976 was the sixth I. A. P., the third since the program was voted by the faculty in 1972 as a permanent part of the M. I. T. academic calendar. In its sixth year, I. A. P. still remains very popular with both students and faculty, and the number, variety, and scope of activities offered continue to increase.

There must be few, if any, undergraduate students on campus now who can compare I. A. P. with the previous academic calendar. Instituted as an experiment in academic calendar reform, I. A. P.'s main purpose was to reduce the unrelenting academic pressure that characterized the previous calendar. It did so by increasing the interval between the first and second semesters from one weekend to a period of three and a half weeks, thus providing some fallow time to be used by students and staff for research, teaching, and study at a more leisurely and independent pace, and easing the between-semester rush to resolve academic and administrative problems. This change also eliminated the lame-duck period from the end of Christmas vacation to the end of the first-term final examinations in late January. Now, when students go home for Christmas vacation, they are for the most part finished with their first term class work and can relax.

Each year, student and faculty attitudes toward I. A. P. are measured through the use of a mail questionnaire. Responses to our questionnaire this year still show that about 90 percent of both the students and faculty continue to favor I. A. P. both personally and for the Institute as a whole, and that the majority of both students and faculty are actively engaged on campus during January. As in previous years, much of the effort of teachers and graduate students was devoted to their usual area of concentration, but for a substantial portion of their time, they joined undergraduate students in the nearly 500 special activities generated explicitly for I. A. P.

1975 I. A. P. Activities

	Teachers	Graduate Students	Undergraduate Students
Regular academic work	67%	47%	12%
I. A. P. generated activities	6	18	31
Other M. I. T. or professional activities or paid student work	23	10	19
Recreation	-	25	38
	96%	100%	100%

The December issue of the I. A. P. Guide included listing for 530 publicly advertised I. A. P. activities. This is an increase of about 10 percent over last year. The cancellation rate of publicized activities remains just below 10 percent, and about 495 of these activities actually took place.

This year's list continues to illustrate the vivid imagination and wide range of interests of M.I.T. students, faculty, and staff. One activity, listed as the Giant Mind, offered participants an intensive course in microprocessors, and well over 200 students signed up to purchase at cost a parts kit to build their own minicomputer system. A second activity, which attracted large audiences from the entire Boston area, was listed as "James Michael Curley's Boston." It was an examination of the city's history from 1915 to 1940, and the role played in that history by one of its most colorful figures, through a series of lectures by some of the prominent figures in today's local and state politics.

Each year during I. A. P. there emerges a more or less pervasive theme that threads through a number of activities. This year a practical approach to cooking and sound nutrition was evident. One of the most unusual of these was a "how-to-cook" activity aimed at students who cook for themselves. It focused on quick and easy-to-prepare dishes that are both nutritious and inexpensive. Classes were held at supertime in the kitchen of one of the housekeeping dormitories, and the students themselves, working under the supervision of the instructors, prepared their own meals for that evening. The teachers were two women graduates of M.I.T. who joined together to start a computer based business to analyze family menus for nutritional content. Campus-wide use of cable television for instructional and informational purposes was introduced to the M.I.T. community on a trial basis during I. A. P. '76. The foregoing are examples of the nonacademic type of I. A. P. activities. As in past years, the majority of I. A. P. activities are of a character that bears a much closer resemblance to aspects of regular academic work, though are approached in a more flexible and unorthodox style than are the regular subjects to which they are related.

Again this year, relatively few students sought academic credit for I. A. P. A total of 771 requests for credit were submitted for January 1976, which compares with 35,000 registrations for the previous fall semester and with about 900 credit requests for January 1975. About half (364) of these 771 requests were for thesis, UROP, and other activities that do not represent I. A. P. generated initiatives. Of the remaining 407 requests, 161 were for a calculus sequence that overlaps with either the first or the second semester, and 136 were for graduate subjects. This suggests that the remainder of just over 110 requests for credit were submitted for activities generated expressly for I. A. P. Only 35 letter grades were granted, 24 to graduate students and 11 to undergraduates.

Again this year, we tried to measure the extent and depth of faculty participation in I. A. P. generated activities of the type that are advertised in the I. A. P. Guide. Of the 530 activities listed in the Guide, 251 (50 percent) were led by faculty members, 125 of whom had not been activity leaders last year. Of the 495 offerings that took place, 378 activities (76 percent) were of the more serious types classified as academic or semi-academic; 172 activities (35 percent) were led by faculty members; 240 activities (48 percent) were activities that met frequently (once a week or more); and 105 activities (21 percent) were activities that combined all three of these features, namely, were led by faculty, were semi-academic, and met weekly or more frequently.

The I. A. P. Policy Committee feels that I. A. P. is sustaining its place in the Institute calendar as an opportunity for experiences and activities for both teachers and students that would be difficult, if not impossible, to achieve during the regular term. This view may be tested this coming year when the I. A. P. Policy Committee reports to the faculty.

JOEL ORLEN

Joint Center for Urban Studies

The year just ended has been an extremely productive and interesting one for the Joint Center staff and researchers. As Ian Menzies, Associate Editor of the Boston Globe, stated in an editorial (December 17, 1975), "Old 'Joint' gets new excitement." Menzies reported that the Joint Center for the first time since the days of Martin Myerson, James Q. Wilson, and Daniel P. Moynihan is being drawn "closer to the mainstream of immediate public issues, governance, economics, and public debate."

In spring, 1975 the presidents of Harvard and M.I.T. requested a review, as they do periodically, of the Joint Center's research agenda and governing structure. The results of this review are twofold. First, the Joint Center is strengthening its already deep commitment to housing research, but it is broadening its scope of research to include new areas of investigation which are related to the core research in housing. Some of these areas concern housing finance, changing preferences of consumers, and the costs to society of instability in the construction industry. Two other related fields of inquiry for the Joint Center deal with balancing land use, urban growth, and environmental considerations and the problems of state and local economies (e.g., fiscal difficulties, job creation). Both topics were subjects of seminars this year, as described below.

Second, the Joint Center's financial and intellectual base has been broadened by including faculty and students from Harvard's Law School, Business School, and Graduate School of Design. The newly formed Faculty Executive Committee, whose purpose is to chart the Center's research agenda and build its financial base, reflects the new additions. The committee's members from M.I.T. are: Langley Keyes, Vice Chairman, Head of the Department of Urban Studies and Planning; Alan Altshuler, Professor of Political Science and Urban Studies and Planning; Bernard J. Frieden, Professor of City Planning; William Porter, Dean of the School of Architecture and Planning; and Robert Solow, Institute Professor of Economics. The committee's members from Harvard University are: John J. Meyer, Chairman, Professor of Economics and Director of the National Bureau of Economic Research; Hale Champion, Vice President for Finance; John Kain, Chairman of the Department of City and Regional Planning; Maurice Kilbridge, Dean of the Graduate School of Design; Oliver Oldman, Professor of Law; and Lee Rainwater, Professor of Sociology.

The strengthened and enlarged research program has flourished with new contracts for studying such problems as savings flows in and out of thrift institutions, impacts of differential energy, property tax, land costs on business locations, and changes in social status and income both on this continent and also in Europe.

The Joint Center has received its share of national recognition this year. Still drawing interest is America's Housing Needs, to mention an old publication in its second printing; newer is Arthur P. Solomon's "The Effect of Land Use and Environmental Controls on Housing: A Review" (no. 34), originally a speech delivered at the annual conference of the Home Loan Bank Board of San Francisco. Among other working papers which were well-received in both the public and private sectors are Dennis Carlton's "A New Method for Estimating the Distribution of Permanent Income from Current Income" (no. 36); and Clinton Bourdon's "Demand Instability and the Labor Force in Construction" (no. 37).

The route to Washington was well-traveled by faculty members at the Joint Center. Among their other responsibilities, several were asked to testify on legislation dealing with housing and housing finance that was before the Congress.

Newspapers and news magazines have served to put the Joint Center's research even more in view. The St. Louis Dispatch and the Boston Globe reported on Richard Coleman's work on how people classify themselves and each other socially. Time Magazine devoted a full page to Dr. Coleman's work. And, more recently, the Wall Street Journal reported on a newer study analyzing trends in household formation in this country. In addition, Professor Solomon, of the M.I.T. Department of Urban Studies and Planning, occasionally writes a column on national housing and urban policy for the New York Times.

Professor Solomon guided the Joint Center through a vigorous first year of directorship. Associate Director since 1972, he was appointed for a term beginning July 1, 1975. Professor Frieden, the preceding director, spent this year at the University of California at Berkeley, on sabbatical with a Guggenheim fellowship. He will return to the Joint Center and the Department of Urban Studies and Planning at M.I.T. in September 1976. John E. Jackson, Associate Professor of Government at the Kennedy School of Government, Harvard, was chosen to succeed Professor Solomon as Associate Director of the Joint Center.

HOUSING RESEARCH

Several projects related to housing research form the core of the research at the Joint Center. Stemming from the earlier work which produced America's Housing Needs are two newer studies backed by grants from the US Department of Housing and Urban Development. Beginning in fall, 1974, the two projects are designed to analyze the evolution and decline of neighborhoods and the intermetropolitan migration of populations in the United States.

Neighborhood Evolution and Decline

The research previous to 1974 strongly suggested that decaying neighborhoods and patterns of migration play important roles in determining how many housing units will be needed in the future, and in what locations. A better understanding of both phenomena is basic to the development of more accurate forecasts of national housing needs. The neighborhood study, due to run for three years, attempts to explain and anticipate the processes by which neighborhoods evolve and eventually decay -- and sometimes are rehabilitated. Fieldwork, based largely on interviews, is being conducted in six metropolitan areas carefully selected to be representative of urban areas as a whole. They include New Haven, Dayton, Houston, Worcester, Rochester, and Charlotte. Within these six areas, a detailed classification is being made of selected neighborhoods according to the age of the housing stock, the price trends, the racial composition of the population, the prevalence of crime, and the quality of public services. Other factors included in the analysis are the shift in manufacturing employment from city to suburb, court decisions on racial integration in the schools, and the condition of the mortgage market.

During the past year, attention has focused on creating extensive data bases for neighborhoods in the six regions under study. A software package was developed and installed to permit local users access to these data. In parallel, a behavioral model of neighborhood change has been developed and coded, and is now being tested in all six cities.

Simulation Model of Interarea Migration

For over a year the Joint Center has been studying how people move from one urban or rural area to another and their reasons for choosing to locate where they do. This study is closely related to the neighborhood study. Both are under the direction of Senior Research Scientist David L. Birch. A major determination of neighborhood change is the pressure from migrants entering single neighborhoods or large metropolitan areas. Therefore, a simulation model is being developed as a planning tool to be used on state and local levels for analyzing neighborhood change. The researchers this past year have concentrated on developing and testing the underlying behavioral model and the production of forecasts of migration trends. To record the progress of the investigation, Dr. Birch has developed a series of technical papers, the first eight of which are now available upon request at the Joint Center.

Working with Dr. Birch are Professor Lee Rainwater (Department of Sociology, Harvard), Dr. Richard Coleman (Senior Research Associate, Joint Center), Dr. Eric Brown, Dolores Mendelson, Linda Sharpe, William Parsons, and Sheryll Weber (all Research Associates at the Joint Center). Dr. Peter Allaman, a former Joint Center fellow, is assisting on the migration study.

Household Formation Study

As part of the Joint Center's continuing study of future housing needs, Research Associate John Pitkin has been looking at changes in the pattern of household formation since 1940. Major trends in this pattern have been 1) an increase in marriage rates and family sizes during the late 1940s and 1950s, 2) a rise in the rate of occurrence of households headed by single, widowed, and divorced adults after 1950, and 3) a decrease in marriage rates and family sizes since the mid-1960s. In order to project future household formations on the basis of these conflicting and changing trends, Dr. Pitkin has developed a behavioral theory of the important relationships involved. According to this theory, the demand for forming separate households is determined by the number of married couples and single, widowed, and divorced adults, or potential households; their preferences and incomes; and the relative prices of small, medium, and large housing units. The price and availability of the diverse types of housing units are jointly determined by the demand and the supply of such units. Projections made from estimates using this model indicate that the number of households formed between now and 1990 may fall 5.6 million below the 18.5 million projected by the Bureau of Census on the basis of simple extrapolations of recent trends. A working paper describing the model and projections is in progress.

Microeconomic Models of Metropolitan Housing Markets

Work funded by the National Science Foundation on the development of a microeconomic model of metropolitan housing markets ended in October 1975. Under the guidance of Principal Investigator Jerome Rothenberg (Professor of Economics, M.I.T.) and Project Manager John Pitkin, researchers have explored the functional relationships existing among housing submarkets and their implication for different policies such as housing code enforcement, housing allowances, interest rate subsidies for new construction, rent control, and government construction of public housing.

The investigation is premised upon the belief that the net effects of regulatory policies on the entire housing market or metropolitan area need to be evaluated. (Previous efforts have evaluated only the immediate influence of such policies on the specific submarkets to

which they are directed.) The repercussions that are then transmitted among submarkets from policy impacts on the general market constitute a second step among submarkets.

Professor Rothenberg and his group have developed a unique definition of submarkets. They are seen as parts of a "functional hierarchy" of the overall quality of the housing units rather than as groups formed according to single aspects of quality such as neighborhood location, age, size, or condition. The researchers feel that this definition of housing submarkets will be of use in future modeling efforts because it corresponds more directly to the perceptions of both housing suppliers and households.

Disintermediation Function

A new one-year contract with the Federal Home Loan Bank Board was signed in fall, 1975 to finance a study, under the direction of Professor Solomon and Kenneth T. Rosen, a faculty associate of the Joint Center, of the disintermediation process by which thrift institutions are periodically drained of some of their deposits. The task this year included 1) developing an explicit model of the flow of savings to savings and loans associations, 2) examining the functional form of disintermediation, and 3) examining regional differences in the sensitivity of savings flows to interest rate fluctuations.

Since the process of disintermediation is accompanied by a decline in mortgage lending and a sharp drop in new housing starts, a monthly forecast of savings flows developed from the results of this study will be of prime importance to the mortgage and housing market.

Short-Run Model of Housing Cycles

A second project for Professor Rosen has been the development of a causal and predictive econometric model of housing starts, which contains a number of technical innovations over previous efforts along the same lines. These innovations include a disaggregation by type of unit and by region, a causal approach to seasonal adjustment, and the incorporation of recent structural changes in financial intermediaries and government intervention techniques.

Financial Impact of Energy Costs on Business Location

The Lincoln Institute for Land Policy has funded a study of the impact of differential energy, property tax, and land costs on the location decisions of businesses. Under the direction of Research Associate Dennis W. Carlton, the project draws on data from Dun and Bradstreet records of individual firms in order to develop an explicit econometric model of locational decision. Important insights into the impact of public policy, on both regional and national levels, should result.

SOCIAL STRATIFICATION AND SOCIAL POLICY

Work continued on a research program begun in 1970 which examines the social structure and living standards in America. It is being directed by Professors Rainwater and Christopher Jencks of the Department of Sociology at Harvard and Professor Martin Rein of the Department of Urban Studies and Planning at M.I.T. The work analyzes people's perceptions of poverty and social standing, consumer patterns of behavior and demand, and the views people hold of the housing in which they live or would like to live.

During the year 1974-75, new grant support from the US Department of Health, Education and Welfare and the Ford Foundation enabled the Joint Center staff to extend research in new directions. The purpose of the study was to develop a path model of family income which fully accounted for all sources of income, year-to-year fluctuations, and long-term projections of earnings. Their intent was to examine how family income as a part of the socioeconomic resources available to individuals affects social standing and consumer decisions. A preliminary report, "The Sources of Family Income and the Determinants of Welfare," was issued in May 1976.

Other aspects of this major research agenda deal with 1) the role of women in establishing the family's social status and standard of living, and the effect of the class standing on a wife's educational background, the number of children she has, and her contribution to family income through participation in the labor force; and 2) the different patterns of living that exist between white and black families. Comparative data for this study are being collected in Europe with the aid of a grant from the German Marshall Fund (November 1975-June 1977). Joseph Schwartz, a doctoral candidate in the Department of Sociology at Harvard, is analyzing the data from the English General Household Survey. He is being directed by Professor Keith Hope of Nuffield College, Oxford. In Sweden, Professor Sten Johansson of the Institute of Social Research at the University of Stockholm is analyzing the data from the Swedish Level of Living Survey. Both these surveys are very rich sources which will enable the researchers to make a detailed comparative analysis with the American experience as recorded in the Panel Study of Income Dynamics.

In another area, Professor Jencks is completing a report in which he reestimates the model published earlier in his book, Inequality. The report on his findings is based on data sources different from those he used previously. It will be released during the course of the next year.

In another report to be released in summer, 1976, Professors Rein and Bennett Harrison review the year's work on the co-mingling of work and welfare in the context of family income.

DELIVERY OF PUBLIC SERVICES

Politics of Street-Level Bureaucrats

Street-level bureaucrats are the front line in providing services to the public. They are the teachers, welfare workers, legal service attorneys, emergency room personnel, and the police -- people who have considerable discretion in what they do and whose actions have a significant impact on the lives of their clients. A three-year project, scheduled for completion in fall, 1976, studies the interaction between these public service workers and their clients. The empirical research is divided into three parts.

The first part is an exploration of the "slotting" phenomenon, the technique used to divide clients into categories in order to simplify bureaucrats' work loads. The second part of the research agenda looks at the quality of interaction between legal service lawyers and their clients. The third section reviews the reaction of public school personnel to the requirements of a newly enacted Massachusetts law (Chapter 766) which makes mandatory the provision of educational services to children with special needs.

For each of these three studies, arrangements have been made to share findings with the agencies concerned in an effort to contribute to the development of their policies and practices.

The entire project aims at providing a more general conceptualization and analysis of street-level bureaucracies. The Principal Investigator is Professor Michael Lipsky of the Department of Political Science at M.I.T.

Public Employee Unions and Urban Services

The description, analysis, and evaluation of municipal employee unions on the delivery of services to the urban public is the purpose of research being continued under the direction of Professor Robert Fogelson (Department of Urban Studies and Planning, M.I.T.) and Ralph Jones (Contract Research, Inc.). Case studies of police, social workers, teachers, and hospital personnel in Boston, Detroit, Los Angeles, and Philadelphia are being prepared for publication in a new Joint Center series. These 15 monograph-length papers report the results of investigations of such issues as pensions in Detroit and Los Angeles, lobbying and electioneering in Boston, work determination in Los Angeles, class size in Philadelphia, residency rules in Detroit, and case loads of social workers in Massachusetts. Another type of research paper to be included in this new series will address the more general questions raised by the project such as the role of new actors like management negotiators, professional union staff, and neutral third parties in public sector collective bargaining. The project is supported by the Center for Studies of Metropolitan Problems of the National Institute of Mental Health.

SEMINARS

Luncheon Seminars

The Joint Center's biweekly luncheon seminars continued as a successful part of the academic year. The wide range of speakers reflected the Joint Center's tripartite community, from university settings, government positions, and private industries. Speakers included Alan Altshuler (Professor of Political Science and Urban Studies and Planning, M.I.T.); Richard F. Babcock (attorney and land use specialist); Edward C. Banfield (George Markham Professor of Government, Harvard); Charles Halpern (Executive Director of the Council for Public Interest Law); Marshall Kaplan (city planner); Raymond D. Nasher (city planner and expert in new town development); Dick Netzer (Dean of New York University Graduate School of Public Administration); Jerome Rothenberg (Professor of Economics, M.I.T.); Kathleen Sullivan (member of Boston School Committee); and Lester Thurow (Professor of Management and Economics at M.I.T.).

Land Use and Urban Growth Policy

Throughout the academic year, Senior Lecturer and former Massachusetts governor Francis W. Sargent conducted a seminar on land use and growth policy issues. Lewis Crampton, former Commissioner of the Massachusetts Department of Community Affairs, assisted Mr. Sargent in an exploration of how Massachusetts has handled problems of balancing economic growth with environmental control. The first semester was devoted to case studies, which included local, state, and Federal roles in preserving Martha's Vineyard; the control of air traffic at Logan Airport; and the proposed Park Plaza Plan in Boston. The key actors in the actual events took part in the debates. The second semester focused more on the policy issues that lay behind the conflicts raised during the previous semester's sessions.

State and Regional Economies

Another seminar series, directed by H. James Brown (Associate Professor, Harvard Graduate School of Design), Ann Friedlaender (Professor of Economics and Civil Engineering, M.I.T.), and Gregory Ingram (Associate Professor, Department of Economics, Harvard), is aimed at developing a literature review of the economy of Massachusetts. This is the first step toward outlining a new research agenda to answer the basic question: What can a state or region do to affect its own economy? The issues being investigated are the availability of capital for economic activity; the influence of differential transportation, energy, and tax costs on industrial location; and the adjustments made by local labor markets.

Regional and Urban Policy

Throughout the academic year, Professor Walter Isard of the Regional Science Department at the University of Pennsylvania continued last year's seminar on regional and urban policy. Speakers during the 1975-76 academic year included David Birch; Jerome Rothenberg; Steven Putnam (Professor of Regional and City Planning, University of Pennsylvania); and Nathan Glazer (Professor of Education and Social Structure, Harvard).

Nuclear Power Plants and their Impacts

On June 28, 1976, the Joint Center and the World University of the World Academy of Arts and Science cosponsored a conference on the Socioeconomic Impacts of Nuclear Power Plants. The objective was to identify and discuss the economic and social impacts associated with the construction and operation of nuclear plants which are significant at local and regional levels. The participants focused on research materials and issues of practical importance to planners and policy makers. Those invited included representatives of several regional, state, and Federal agencies and commissions; members of the academic community; and representatives of consulting firms experienced in socioeconomic impact assessment.

FELLOWSHIP PROGRAM

Nine M.I.T. and Harvard graduate students completing their doctoral dissertations or third-year law papers received Joint Center Fellowships for 1975-76. Their thesis topics ranged from a social portrait of a girl's reform institution from 1856-1905 to corrections reform in Massachusetts during the 1970s, and a theoretical analysis of optimal pollution control in a world of imperfect information and costly regulation. The Fellow's Seminar, under the direction of Dr. Jackson, met six times during the academic year.

Structure of Youth Labor Markets

Paul Osterman, Faculty Associate and Professor at Boston University, received a fellowship this academic year from the Department of Labor to examine the operation of urban labor markets for young workers aged 16 to 25. The study explored the evolution of labor force commitment and the institutional structure of the different kinds of jobs available for different age groups. Professor Osterman made extensive use of interviews with firms, young people, and manpower officials. In addition, he incorporated into his material data sources such as the National Longitudinal Survey of Young Men (the Parnes data).

ECONOMIC ADVISOR TO THE PRESIDENTS OF HARVARD AND M.I.T.

The Office of Economic Advisor to the Presidents of Harvard and M.I.T. was established in September 1975. Its purpose is to provide the two universities with information concerning the general economic health of the city of Cambridge and a long-term outlook for economic development in that city. Penelope Schafer, formerly of the Department of City Planning at Harvard, was appointed the Economic Advisor for a term ending in December 1976. Among Dr. Schafer's projects this year has been an analysis of the current employment and labor-force characteristics of Cambridge in terms of past trends. In conjunction with this study, she has determined the amount of unemployment and the characteristics of the unemployed living in Cambridge. A second area of investigation for the Economic Advisor has been to ascertain the amount and type of construction which has taken place here over the last 16 years. In all cases she has compared the trends in Cambridge to those in the city of Boston as well as in the entire Boston metropolitan area. Her most current project is an evaluation of the fiscal impact that the two universities have on the city of Cambridge.

SURVEY RESEARCH PROGRAM

In the last two years the Survey Research Program has undertaken its biggest research agenda to date. The first of three of the largest projects at Survey Research was sponsored jointly by the United Community Planning Corporation and the Combined Jewish Philanthropies, and was directed by Dr. Floyd J. Fowler, Director of Survey Research. The purpose of this study, which ran through the fiscal year, was to identify the social, educational, recreational, and health needs of residents in the Boston metropolitan area. The data, collected from 3,000 Boston Standard Metropolitan Statistical Area (SMSA) households interviewed, are the only comprehensive updating of the 1970 Census data for that area.

The impact of anti-gambling laws on the criminal justice system is another Survey Research project, conducted under a grant from the National Institute for Law Enforcement and Criminal Justice. The objective is to describe in detail the experience of police and prosecutors with existing anti-gambling laws, including recent introductions of lotteries and off-track betting. In a supplemental study on gambling enforcement, the Program is analyzing a part of a data set collected by the University of Michigan from a national sample and dealing with the respondents' participation in gambling (both legal and illegal) and attitudes toward gambling.

The health and long-term care needs of the elderly in Massachusetts are the subject of an investigation under the direction of Laurence G. Branch. Using a panel of 1,600 elderly residents and funded by the Administration on Aging, Dr. Branch collected the second wave of data during winter, 1976. (The first wave of data collection was sponsored by the Massachusetts Department of Public Health early in 1975.) The major focus of the current analytic effort is the determination of how the sample's health care needs have changed during the 15-month period and the development of measures for predicting these changes.

Publications

During the past year, staff members of the Joint Center published one book and five working papers. Eight publications appeared under the migration study.

ARTHUR P. SOLOMON

Laboratory for Computer Science

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 (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 have expanded, leading to a broad front of research activities that now span three principal areas. One of these is making programs more intelligent by capturing, representing, and using specific knowledge: examples are the use of "expert medical knowledge" for diagnosis and 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; and the use of knowledge in a specific domain in order to comprehend typed natural language (English) in that domain.

A second main focus of Laboratory research is making sizable improvements in the ease of utilization and cost effectiveness of computing systems: the Automatic Programming Research Group strives to reduce programming costs through the generation of inventory control programs by other programs, on the basis of high-level descriptions of desired activities, while another group strives for the same broad goal through structured programming, i. e., by imposing constraints on the programmer. Other examples include the automatic programming of micro-computer systems from higher-level, domain-specific languages for the control of physical processes; and the study and synthesis of very large data bases. Finally, the architecture of individual "personal" machines and the organization of geographically distributed, more complex systems of computers, is studied from the point of view of exploiting the decreasing costs of processors and memories, improving overall performance and reliability, protecting information, and insuring privacy.

The Laboratory's third principal area of research involves exploration and development of theoretical foundations in Computer Science. The Theory of Computation Research Group strives to understand ultimate limits in space and time associated with classes of algorithms, while the Computation Structures Research Group searches for a combination of appropriate programming languages and machine architectures that insure trouble-free asynchronous computation by several processors.

During the past year, the Laboratory was composed of approximately 210 members -- 30 faculty, 60 support and professional staff, 90 graduate and 30 undergraduate students -- organized into 13 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, Humanities (Music), and the Sloan School of Management.

Laboratory research was funded by eight governmental and industrial organizations.

The 1975-76 year has been a very active one. The Laboratory was renamed (from Project MAC) in order to better reflect its evolving role as a computer science laboratory engaged in a broad spectrum of research activities. During the year we instituted a Distinguished Lecturer Series which has proven to be of great interest to the M. I. T. community. We also launched a nationwide study on the long-range future of computers and information processing, with contributions from 20 distinguished scientists and engineers. The study, which should be completed in 1977, strives to identify likely and desirable trends in computer hardware, software, and applications, as well as in the potential societal implications of the projected technical developments.

A new activity launched in 1975-76 includes research in large data bases. As a data base becomes large, numerous problems emerge such as maintainability, reliability, currency, and cost to access and update information. Research in this area seeks to understand these and to improve effectiveness through novel data base structures.

Another new research activity in 1975-76 entails the study of geographically distributed computing systems, consisting of data bases, processors, and terminals. Through this research we hope to understand how to design and cope with the computers that form the foundation for the anticipated information networks of the future.

To aid in our experimental understanding of distributed systems and to consolidate our current computational resources, we also have begun design and construction of a Laboratory local network. This network, which should be completed in 1976-77, will interconnect our computational resources and make them more readily available to our researchers. Current computational resources consist of three PDP/10 computers, including a powerful PDP-10/80 system, and several smaller machines comprising a total of seven million bytes of primary memory and almost one billion bytes of secondary memory. The machines are accessed by terminals located within the Laboratory and by terminals within M. I. T. or in other parts of the world through direct telephone lines and through the ARPA network. In addition, Laboratory members have access to the Multics time-sharing system based on a Honeywell 6180 computer with one billion bytes of secondary memory. This system is a nationwide resource, managed by M. I. T.'s Information Processing Center.

Continuing research during 1975-76 in previously established research areas has yielded several new results and insights in a) automatic programming, which involves the generation of high-level (e.g., PL/1), programs by other programs given very high-level descriptions of the desired program's function; b) automated mathematical assistance, where we strive to aid scientists and engineers through programs such as MACSYMA for the symbolic manipulation of mathematical expressions; c) natural language understanding, by computer programs, where we have made significant improvements in our OWL programming system; d) clinical decision making, where in cooperation with physicians at the New England Medical Center we study and experiment with the acquisition, representation, and use of specialized medical knowledge for the purpose of aiding diagnosis and facilitating drug administration; e) theory of computation, where the methods of discrete mathematics are brought to bear on a variety of computational problems for the principal purpose of characterizing the optimal amounts of time or space required to carry out computations, to analyze the power of different computing machine organizations, and to analyze the mathematical properties of programming languages; f) programming language semantics and computer architecture, where we are developing novel structures and associated theories in order to exploit parallelism and asynchronous computation, and where we try to provide sound semantic foundations for programming languages and computer architecture; g) computer systems research, where we seek to understand and develop reliable, secure, and efficient computer systems; h) micro-computer applications, where we are concerned with the automatic

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programming of real-time (micro) computers for control and instrumentation from higher level languages; and i) knowledge based pattern recognition, where we seek to extract signals from noise using knowledge about the signal content, e.g., a vocabulary of the English language.

Our results in these areas were published through Laboratory technical reports (TR153 - TR163) and technical memoranda (TM67 - TM71), as well as through articles in the technical literature.

Visitors to the Laboratory for Computer Science for the year have included the following: Professor Uwe Pape, Technische Universitat Berlin, Berlin, Germany; Dr. William B. Schwartz, Endicott Professor, Chairman, Department of Medicine, Tufts University New England Medical Center Hospital, Boston; Nathaniel Rochester, International Business Machines, Inc., Cambridge; Tadatoshi Minamikawa, Toshiba Electric Company, Tokyo, Japan; Dr. Samuel Estes, International Business Machines, Inc., Yorktown Heights, New York; Dr. Stephen Pauker, New England Medical Center Hospital, Boston; and Dr. Michael Rabin, Rector, Department of Mathematics, Hebrew University, Jerusalem, Israel.

MICHAEL L. DERTOUZOS
JOEL MOSES

Libraries

In many ways, 1975-76 has been an extraordinary year for the M.I.T. Libraries. The arrival of the new Director in September in the framework of a reduced budget, increased costs, an accelerating development drive, and the necessity for addressing a number of situations requiring almost immediate decisions, placed an unusual burden upon all members of the staff. In retrospect it may be said that their response was a happy combination of enthusiasm, cooperation, and understanding.

The record of accomplishment of the Libraries during the past year is reflected in the detailed reports of the various departments to the Director, with major achievements and goals summarized below. The real accomplishments of the M.I.T. Libraries are in the day-to-day work of providing materials and services to faculty, students, research staff, and other members of the Institute community. Understanding how to do this job more efficiently -- in essence, how to do more with less -- and how to anticipate and respond to new and more sophisticated demands is really what this report is about. The improvement of internal operations, the extension of the Libraries' resources beyond the confines of the Institute, adapting to new technologies, and planning for the future are only important insofar as these activities affect the level and quality of library service.

During the year, a major reorganization was effected in the central administrative offices. Margaret A. Otto, whose title had been Associate Director for Library Services, was designated Associate Director and given the responsibility for the day-to-day operation of the entire library system as well as for the technical services area and professional personnel activities. The remaining personnel responsibilities of Suanne W. Muehlner were transferred to the office of William J. Duggan, Assistant Director for Administrative and Personnel Services. He took on these duties as well as overseeing matters involving

budget, fiscal management, supplies and equipment, and building maintenance and security. Ms. Muehlner was appointed Assistant Director for Public Services whereby she became responsible for supervising and coordinating the operation of the divisional and branch libraries, all programs aimed at non-M. I. T. library users, and liaison between the public service departments and other parts of the library system. Sheelah Britt, formerly Administrative Assistant, was promoted to Administrative Officer and has operational responsibility for the Libraries' ongoing activities in personnel, budget, and accounting including supervision of the Invoice Section and the Messenger Unit, which were formerly in Collections Development.

Equally noteworthy was the establishment of the new office of Collections Development Librarian, a position which combines administrative supervision of the entire acquisitions operation with that of responsibility for the intellectual and physical growth of the collections. As the first incumbent, Jutta R. Reed, formerly Associate Humanities Librarian, has primary responsibility for establishing an overall acquisitions policy for the M. I. T. Libraries and for the implementation of this policy. Despite the relative recency of this change, its impact already has been evident in reduction of duplication, establishment of routines for the replacement of lost and missing materials, and in the emergence of acquisitions policies in a number of critical areas. The cooperative efforts of the public service librarians in all of these activities has been significant in the progress that has been made.

Despite the pressures of their regular duties, the staff participated in a wide range of other activities at M. I. T. and in a variety of professional organizations and associations. In addition, many individuals availed themselves of the M. I. T. Tuition Assistance Program to pursue degree programs in library science, business administration, and undergraduate studies. The Libraries' part in the Independent Activities Period in January involved the participation of many employees and was characterized by several successful programs. Community oriented I. A. P. projects included film showings, the preparation of specialized reading lists and bibliographies, machine literature searching demonstrations, lectures on micrographics and on specialized reference tools, and a book collecting contest. The contest, a first for the M. I. T. Libraries, elicited 23 entries, providing the judges with an interesting and enjoyable occasion but a rather difficult decision process.

One of the most welcome events of the year was the selection of William Presson, Associate Dewey Librarian, as co-recipient of the James N. Murphy Award for 1976. Recognition of Mr. Presson's "distinguished service to the Institute family, especially students" at the Awards Convocation was applauded by his many friends and colleagues both within and outside the Libraries to whom he represents the ultimate in library service.

Public Services

Any Director of Libraries, certainly one relatively new to the scene, would find it difficult, if not impossible, to summarize the activities of the public service units of the M. I. T. Libraries in a concise yet meaningful manner. Statistics alone do not convey the variety and diversity of services nor do they reflect the complexities inherent in a decentralized system where the available resources of people, money, and space must be allocated to what always seems to be an insatiable demand. Given the difficulty of the task, therefore, the highlights below should be read primarily as a sampling of the achievements in the public service areas.

The Public Services Group is comprised of the following groups under the Assistant Director for Public Services: the librarians of the five divisional libraries -- Barker Engineering, Dewey, Humanities, Rotch, and Science; the Student Center Librarian; the heads of the Aeronautics and Astronautics, Lindgren, and Music collections; the Circulation Librarian; and the Head of Northeast Academic Science Information Center (NASIC). Their activities and

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concerns during the past year ranged over the entire spectrum of library services and included the following: development of a model acquisitions policy in transportation; revision of the Public Services Group Manual; developing policies and guidelines for use of the M.I.T. Libraries by outsiders; coping with a reduced acquisitions budget in terms of real dollars, necessitating the cancellation of serial and journal subscriptions and a lower level of monographic ordering; establishing new and improved programs of bibliographic instruction; drafting statements of needs for development in the Leadership Campaign.

The following examples, while confined principally to one of the major library units, are typical for the year just past: participation in the Sloan television grant by the taping of lectures (Barker and Rotch) and the taping of the construction of a major new Boston building (Rotch); establishment of new services in the Dewey Library for the International Environmental Monitoring Project in the Center for International Studies, funded by the Center; publication of a new series of guides to abstracting and indexing services in the Barker Library; formal opening of the new Visual Documents Collection facilities of the Rotch Library; coping with an increased level of interlibrary loan and interlibrary borrowing in the Humanities Library in the context of regional and national change and formal membership in the Boston Library Consortium; development and implementation of a workshop on human resources and organization in the Science Library.

Cooperative Efforts

Considerable attention was paid during the year to cooperative activities with other libraries. After a number of years as a provisional member, M.I.T. formally joined the Boston Library Consortium (BLC), whose other members are the libraries of Boston College, Boston University, Brandeis University, Northeastern University, Tufts University, University of Massachusetts at Amherst, Wellesley College, and the Boston Public and Massachusetts State Libraries. While still a fledgling network, the BLC offers the potentiality of extending M.I.T.'s resources through direct borrowing, interlibrary loan, cooperative acquisitions, and, hopefully in the near future, cooperative storage. Evidence of the importance of M.I.T.'s membership in the BLC may be seen in a substantial increase in photocopies received by M.I.T. from BLC member libraries subsequent to the publication of the Consortium's Union List of Serials with a concomitant reduction of dependence upon Harvard libraries. The availability of a truck for delivery of materials has reduced substantially the turn-around time for interlibrary transactions. Perhaps of even greater significance was the purchase with Consortium funds of an important joint acquisition, the back file on microfilm of the Daily Labor Report, which, because of M.I.T.'s great strength in the area of industrial and labor relations, is located in the Industrial Relations Collection of the Dewey Library.

Continued close relationships were maintained with Harvard, including both formal and informal exchanges, and the end of the academic year saw the designation of M.I.T. as exempt from Harvard's new interlibrary loan fee system. The effect of the proposed new copyright law on interlibrary loan and the increase in the number of institutions charging for loans are respectively so uncertain and so new at this time that one can say no more than that these events will have a major impact upon all academic research libraries including the M.I.T. Libraries. The proposed use of the NELINET (New England Library Information Network) facilities for interlibrary loan should be developed sufficiently within the next year to enable members to evaluate its potentiality as a sharing mechanism.

OTHER ACTIVITIES

The past year was the first full year of centralized operation of the Libraries' machine literature searching services (NASIC). In almost all respects the new configuration has been quite successful. The number of individuals availing themselves of the services, the number of searches performed, the number of data bases available, and the number and extent of demonstrations and seminars all have increased significantly. While certainly no basis for complacency, statistics gathered during the past year indicate that 1,241 searches were performed as compared to 310 during the period March 1974, to February 1975. In 1975-76, almost 30 data bases were accessed contrasted to only 13 during the 1974-75 period. Significantly, 21 SDI (Selective Dissemination of Information) searches are being run on a current monthly basis, a majority of them through the MEDLINE data base.

Under the guidelines of a new Institute archival policy, the Libraries will be endeavoring in the future to preserve the record of M.I.T.'s history through the collection, cataloguing, and servicing of the Institute's official papers. While there were no major additions of papers to the Institute Archives, considerable progress was made during the year in identifying and evaluating collections of official papers and in developing acquisition policies in consultation with members of the faculty and administration. Close relations have been established with the Oral History Project and the transfer of the first of a number of collections generated by this group is anticipated early in the new academic year.

Considerable time was devoted to another principal area of responsibility of the Institute Archives -- M.I.T. theses. The time consumed was not without its rewards. At the end of the academic year and after full discussions in the Library Council and in the Committee on Graduate School Policy, a number of basic changes were in the offing or had already been instituted. These included a revision of the fee structure for doctoral and masters theses, the discontinuance of producing 35mm microfilm copies of newly acquired theses, revision of the section on thesis preparation in the Graduate School Manual, and, finally, a decision to have available in September 1976, a set of specifications for the preparation of theses to be developed by the Libraries and issued jointly by the Libraries and the Dean of the Graduate School. In addition, policies regarding copyright of theses, authorization to publish theses, and publication of abstracts of doctoral dissertations in Dissertation Abstracts International were all developed and will appear in the revised Manual.

Although a significant number of major problems confront the Libraries, it is still proper to report that it was a very good year in the technical services area. The wide and complicated range of activities that are directed toward "getting the book on the shelf" occupied the attention not only of those directly involved in materials acquisition and processing, but also that of the entire Libraries' staff. Characteristic of the Collections Development and Catalogue Departments in 1975-76 was coping with the constant flow of books, serials, microforms, and other materials, albeit somewhat reduced in the face of inflation, while at the same time facing change in organization, personnel, space assignment, and procedures.

As reported above, a new position of Collections Development Librarian was established during the year. With the ultimate goal of developing a systematic, logical, and, insofar as possible, non-duplicative program for the growth of the collections, the new appointee initiated a number of important policies and procedures in consultation with the Public Services Group and the Library Council. One of the most significant of these was the formulation of a pre-order searching system. The searching and screening of orders for new materials previously checked only in the catalogues of individual libraries but now centralized through the Institute Library Catalogue, will serve as the foundation for monitoring the acquisitions process. Under this system, the Collection Development Librarian will be able

Libraries

not only to monitor and control the purchase of multiple copies of books and serials but also, and perhaps more important, to see that the Libraries' collections are being developed in accordance with the overall acquisitions policy.

Libraries abhor backlogs! Whether they are called arrearages, work to be done, books in process, or just plain backlogs, the accumulations of books, serials, or pieces of paper have a doubly negative effect. Psychologically, the sight of packed shelves or boxes full of cards seldom fails to depress even the most optimistic staff member. In addition, the process of locating an individual piece or record seems to increase in difficulty in geometric proportion to the work on hand. With this introduction, it is extremely gratifying to report that the Catalogue Department has achieved the elimination of the backlog of materials for which Library of Congress cataloguing copy is available and a substantial reduction of the remaining backlog, principally material requiring original cataloguing. The attainment of this status was the combination of a number of factors: establishment of an optimal holding period based on experience with the OCLC (Ohio College Library Center) cataloguing system, streamlining of the pre-catalogue procedures whereby new materials awaiting cataloguing are held in divisional and branch libraries, and more flexible use of the resources available in the Catalogue Department, both personnel and equipment.

The pre-catalogue process guarantees that all new books are either catalogued upon receipt assuming the immediate availability of Library of Congress copy, or alternatively, delivered to the appropriate subject library where they are available for use. Given M.I.T.'s emphasis in its library collections on current publications, the ability to assure readers that new books are moving through the processing system in an expeditious and efficient manner is something for which the Libraries have long striven. That this has been accomplished in the face of a reduced staff and a still-improving computerized cataloguing data base is no mean achievement. The staff of the Catalogue Department are to be commended for their conscientious and persevering efforts to reach the current "no-backlog" status.

During the past year a number of administrative and equipment decisions were made with the aim of improving both the services and the financial structure of the Libraries' Microreproduction Laboratory. It is anticipated that the results will be in keeping with the tradition of variety and excellence of service which has been characteristic of this operation. In the area of policy a new scale of thesis processing fees was developed, charges for several specialized copying services were increased to reflect the effects of inflation in labor and materials costs, and a decision was made to eliminate the preparation of reel film copies of M.I.T. theses except as needed for the production of full-size enlargements. A major new equipment acquisition was the installation of a microfilm reader-printer which will provide enlargements on demand, and in September the Laboratory will make available a quick copy machine offering the facility for self-service, rapid copies which M.I.T. personnel can charge to Institute accounts. Study continued during the year on the feasibility of the Laboratory's acquiring a COM (Computer Output Microfilm) machine to serve the increasing requirement for such capacity at M.I.T.

Although the Libraries acquired fewer printed volumes last year than in the year preceding -- a distressing trend traceable to a rate of inflation in materials prices greater than the rate of growth of the acquisitions budget -- and although the Libraries acquired more microforms than in any prior year, the need for space continues to be a constant headache. While no additional space was obtained during the year, significant discussion and planning did occur. One important activity was the preparation of a program for a library storage facility that would serve as a repository for less frequently used materials now housed in divisional and branch libraries, and for the housing of large collections of archival and manuscript material. Efforts were undertaken in conjunction with the Planning Office to identify a suitable location for this facility, which will be a major element in the Libraries' development program. Additional space needs identified as having high priority include expansion and renovation of

the Rotch Library of Architecture and Planning, additional space for the Music Library, expansion of facilities for archives, rare books, manuscripts, and related collections, and renovation of the Hayden basement. Subject to the availability of funds, it is expected that the Libraries will undertake a major program of furniture repair and restoration during fiscal year 1977 with emphasis on the Student Center, Rotch, Humanities, and Science libraries.

In various sections of this report, reference has been made to the effects of inflation on the Libraries' operations. Although final figures for the fiscal year just completed are not yet available, it is evident that the continuing upward spiral in the cost of library materials, principally periodicals, has not abated. A few selected examples illustrate the magnitude of this problem:

	1975 Subscription Price	1976 Subscription Price	Percent Increase
<u>Applied Mechanics Reviews</u>	\$135	\$165	22.2
<u>Chemical Physics Letters</u>	420	534	27.2
<u>Coordination Chemistry Reviews</u>	135	203	50.4
<u>Operations Research</u>	20	30	50.0

While prices of monographs and other serials apparently have not risen as dramatically, there have been significant increases in these areas as well.

One of the first problems faced by the new Director was to reconcile the funds available for fiscal year 1976, representing a considerable reduction from the previous year, with the requirements of the library system. A net reduction of 11.5 positions had its impact throughout the Libraries in the elimination of a number of services, major reductions of service in other areas, and considerable pressure on the entire staff. The maintenance of quality library service in the face of these cutbacks must be credited to the ingenuity, dedication, and diligence of all concerned.

In the area of library materials, while there was a net increase in current dollars, the overall effect in 1975-76 was a further inhibition in the growth of the collections. The M. I. T. Libraries added 2,600 fewer printed volumes in 1975-76 than in the previous year. The books not acquired were primarily monographs, some representing decisions to provide only a single copy for the entire Institute, but, in other cases, extremely difficult and time-consuming choices were required. The entire net increase in the acquisitions budget was absorbed by the increased prices of serials, principally scientific, technical, and social science periodicals. The distressing result was an inability to subscribe to new journals without first canceling existing subscriptions. Both duplicate and single titles were canceled to the point where any further reduction will surely result in problems of reader access. Given a situation where more new journals are being published each year in disciplines directly relevant to M. I. T. teaching and research than are being discontinued, the prospect is not a happy one. Budgetary prospects for fiscal year 1977 do not appear to offer more than another year of belt-tightening and marking time. There is some hope, however, that a combination of the M. I. T. Leadership Campaign, a slowing down of materials price inflation, and the potentiality for regional and national cooperative sharing of resources will improve the situation.

At one of the sessions of the March meeting of the Corporation Visiting Committee for the Libraries, the Director presented his program for activities in the Leadership Campaign. Major areas of development were seen as 1) funds for strengthening the Libraries' collections including funds for new areas of instruction and research as well as for filling in gaps in

existing collections; 2) support of new activities in automation and cataloguing including linkage with existing computerized networks, establishment of on-line access to the M. I. T. catalogue, and conversion of the pre-1963 Dewey Decimal catalogue to either a book form or computerized catalogue; 3) specialized programs in the areas of microforms, non-print media, and expanded facilities for the history of contemporary science and technology combining the Institute Archives, manuscript collections, rare books, oral history, and related materials; and 4) funds for the various physical additions and renovations mentioned previously including the Rotch Library, storage building, Music Library, and the Hayden basement.

As in the past years, the Libraries are indebted to the many individuals and organizations who have donated materials to the collections. Of special interest were the gift of one of a thousand numbered copies of a facsimile of the Sanders Reader, written by Alexander Graham Bell and presented by Lillian Grosvenor Jones on behalf of the Alexander Graham Bell Association for the Deaf on the occasion of activities at M. I. T. commemorating the centennial of the telephone; and two valuable works on microscopy for the rare book collection given by I. Austin Kelly III, Curator of Rare Books in the M. I. T. Libraries. Two funds for the purchase of books were established during the year. A gift from Edward Payson Jones will support the acquisition of books in mathematical physics in memory of his brother, Roderick Bissell Jones, Class of 1923. Funds from the estate of Alfred S. Niles, Class of 1917, will be used for the purchase of books in the history of engineering and technology prior to 1900.

While the past year has been an unusual one for the Libraries with the many changes described above, and while there have been problems and difficulties to be resolved, it has been, withal, a successful year. The Libraries, and especially the Director, are most appreciative of the support and encouragement they have received from the Faculty Committee on the Library System under the chairmanship of Professor Evsey D. Domar, the Visiting Committee chaired by Thomas F. Creamer, the faculty, administration, and students of the Institute, and, particularly, from Provost Walter A. Rosenblith.

JAY K. LUCKER

Lowell Institute School (L.I.S.)

The Lowell Institute School was established at M. I. T. 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's degree or equivalent experience.

The programs of study range from single subjects designed to broaden an individual's skill level in his present employment to comprehensive study of new technological areas which will prepare a technician for employment in the 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.

During 1975-76, L. I. S. continued its expansion of low-cost evening courses for industrial technicians. In particular, every effort is made to offer instruction in the topics in which

M.I.T. has special expertise and the necessary educational facilities and which are not covered by other Boston evening schools. Added to the curriculum of Op-Amp Applications, Digital Electronics, Television Systems Technology, Mechanical Drafting, Dimensioning and Tolerancing, Machine Tool Fundamentals, Principles of Metal Joining, Scientific Glassblowing, and Creative Photography were new courses in Technical Writing, Introduction to Electronics, High Speed Photography and Videography, and Advanced Digital Electronics.

The high interest in digital electronics prompted the offering of three one-week daytime courses in this subject, one of which was given during the winter and two during the summer. In addition, a new course in the rapidly expanding field of microprocessors will be introduced in the 1976 fall term.

Enrollment at L.I.S. also continued to climb, with 542 students admitted to classes. This represents a 38 percent increase over the 1974-75 figure of 394. Of those enrolled, 73 percent successfully completed the certificate requirements. Among those who completed courses were 33 M.I.T. employees and nine regular M.I.T. students. The high completion rate is testimony to the dedicated instructor staff, which consists of M.I.T. faculty and graduate student teaching assistants as well as skilled instructors from Boston area industry. The continued increase in enrollment and the high completion rate indicate that both the subjects offered and level of instruction are well-matched to the needs of technician-level personnel.

BRUCE D. WEDLOCK

Neurosciences Research Program (N.R.P.)

The Neurosciences Research Program is an international and inter-university organization of scientists operating as a Research Center of M.I.T. Its main purpose is to facilitate and promote the development of theoretical interpretations bridging the gaps separating the data and concepts of traditional scientific disciplines engaged in research on the nervous system at its various levels of organization: molecular, cellular, neurophysiological, and behavioral. Theoretical breakthroughs are essential if the flood of new information is to be transformed into a scientific understanding of how the nervous system mediates the behavior of animals, including the mental life of man.

There are four main elements in the program of the N.R.P.: the operation of information exchange activities within the world-wide neuroscience community, the organization of scientific collaboration and meetings, a program of publications, and a program in graduate and postdoctoral education.

To carry out these activities, a group of approximately 36 N.R.P. Associates, who are leaders in major neuroscientific disciplines, provide advice and guidance to a small professional staff at the N.R.P. Center in the House of the American Academy of Arts and Sciences in Brookline. In developing scientific activities, the Center Staff and N.R.P. Associates enlist the participation of consulting scientists from the neuroscientific community at large. Over 1,500 scientists have participated in N.R.P. activities.

The following work sessions and/or conferences were held during academic year 1975-76: Neuroanatomical Functional Mapping as Determined by the Radioactive-2-Deoxyglucose Method,

Plasticity in Retinotectal Connections, Depolarization-Release Coupling Systems in Neurons, Pain, Averaged Evoked Potentials, Generation of Movement, The Hippocampal Formation: Structure and Function.

The October 5-8 Stated Meeting of N. R. P. Associates for 1975 was held at Marine Biological Laboratory (MBL) at Woods Hole, Massachusetts. Six Associates, including three newly-elected ones (Drs. Iversen, Koshland, and Kandel), characterized the major growing points in their research fields. These presentations were vigorously discussed by Associates and the N. R. P. Center Science Staff, and will be helpful for planning future N. R. P. projects.

Special reports were given by Donald M. MacKay ("Cross-disciplinary Fertility in Neuroscience: Retrospect and Prospect") and Detlev Ploog (on the first European Neurosciences Meeting).

Other scientific discussions by Associates covered the following topics: local circuits and brain function, efferent sensory systems, and a proposed work session on hippocampus.

A feature of the fall Stated Meeting was the third F.O. Schmitt Lecture in Neuroscience, given on October 7, 1975 in Kresge Auditorium. The 1975 medalist, Dr. Vernon B. Mountcastle, Chairman of the Physiology Department of the Johns Hopkins University School of Medicine, gave an address entitled "The World Around Us: Neural Command Functions for Selective Attention." This lecture has been published as a Supplement to the NRP Bulletin.

The first two days of the Thirty-first Stated Meeting of Associates (March 22-23) were devoted to a discussion of changing concepts of neuronal interaction with particular focus on local circuit neurons, electrotonic junctions, and their implications for understanding higher neurobehavioral and psychological processes. As a result of presentations and ensuing discussions, the Associates, at their Executive Meeting, recommended that N. R. P. Center Staff proceed with the planning of an Intensive Study Program to bring world leaders together to collaborate on conceptual advances covering the role of electrotonic processing and local circuit systems in brain function.

On March 24, the Associates (Drs. Bodian, Hydén, Livingston, McConnell, and MacKay) who had reached the end of their terms of active memberships, gave talks on their years of experience in N. R. P., evaluating its influence on neuroscience and on their own professional activities.

During 1975-76, the following Bulletins were published: Local Circuit Neurons, Frontiers of Psychiatric Genetics, The Neurobiology of Lithium, Neuron-Target Cell Interactions.

Other publications of N. R. P. for this year are: The Neurosciences: Paths of Discovery, Opiate Receptor Mechanisms, Conceptual Models of Neural Organization, F.O. Schmitt Lecture in Neuroscience, 1974, F.O. Schmitt Lecture in Neuroscience, 1975.

Dr. Mac V. Edds, Jr. served as Executive Director from January 1, 1975 until his untimely death on November 29, 1975. Dr. Edds' scientific duties have been assumed by Barry H. Smith, Ph.D., M.D., appointed Program Director in January 1976; his administrative and executive duties have been assumed by the Director, F.G. Worden.

Dr. Izchak Z. Steinberg, a student of Professor Aharon Katchalsky, presently Head of the Biophysics Department of the Weizmann Institute, was appointed the third Katchalsky Scholar. He arrived in September 1975, and will remain in residence for one year.

The M. I. T. Graduate Seminar 20.515 Seminar in Neuroscience Research Topics continues to attract graduate students from M. I. T., Harvard, and other Boston-area institutions.

Students attend all N. R. P. work sessions, Stated Meetings, and conferences. They are required to take notes during work sessions and to participate in a review of the session with N. R. P. staff and work session chairmen. Each student prepares a written proposal for a possible session which would define a growing point in neuroscience, outlining the scope of a topic, the issues around which it would be organized, and a list of scientists who have contributed importantly to the subject area. During academic year 1975-76, the following students completed the course: Stephen Jones, David Margulies, Kwok-Fai So (fall term); Kate Bernstein, Bjorn Merker, Andres Polit (spring term).

F. G. WORDEN

Northeast Radio Observatory Corporation (NEROC) Haystack Observatory

M.I.T. is a leading member of NEROC, a consortium of 13 educational and research institutions formed to promote radio and radar astronomy research. Through a NEROC-M.I.T. agreement, the administrative services of M.I.T. are used by NEROC in the conduct of its business. Member institutions are Boston University, Brandeis University, Brown University, Dartmouth College, Harvard University, M.I.T., Polytechnic Institute of Brooklyn, 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.

The primary current responsibility of NEROC is the operation of the Haystack Observatory, located at the Millstone Hill Field Station of M.I.T., in Westford, Massachusetts. The main instrument at the Observatory is a 120-foot diameter, paraboloidal antenna enclosed in a radome, used almost continuously by the astronomy community as a radio telescope covering the wavelength region from 21 cm down to about 0.7 cm. At the latter wavelength the telescope has a beamwidth smaller than the 1 arc minute resolution of the human eye. In addition, a modest fraction of the observing time is scheduled for radar observations of satellites by M.I.T. Lincoln Laboratory.

Five doctorates were awarded this year to candidates who had done an important fraction of their research at Haystack. Some 20 students are currently committed to research at Haystack under the direction of faculty members from NEROC institutions and elsewhere. More than 60 scientists from some 25 institutions have been involved in the past year.

Very Long Baseline Interferometry (VLBI), an area in which Haystack is in the forefront of research and instrumentation, has continued as a prime activity. This technique, which involves simultaneous observations of the same object with widely separated telescopes, has unique potential for astrometry of unprecedented accuracy, study of the detailed structure of small but complex sources, "gravitational bending" tests of general relativity, and precise geodetic measurements of several types. Of particular interest is the study of complex objects whose parts appear to move apart at speeds greater than light. The intense interest in this work resulted this past year in the organization of eight existing radio observatories in the United States into a network for the coordinated scheduling of VLBI experiments. The Haystack Observatory is a charter member.

Many types of spectral line investigation have relied heavily upon the new 1,024-channel correlation spectrometer which went on line during the past year, and upon Haystack's advanced receivers in the 3.6, 1.3, and 0.7 cm regions.

Continuum observations at several frequencies have provided maps and measures of the variability of a number of radio sources.

Studies of these sorts help reveal the chemical composition and physical states as well as the motions of objects within and beyond our galaxy, contributing to theories of evolution of many types of objects in the universe and of how they develop their enormous energies.

In November 1975, the operation of the Observatory was reviewed by a new Visiting Committee authorized by the NEROC Board of Trustees. The Committee, whose report was generally favorable, advised increased familiarization of the astronomy community at large with the unusual capabilities of the Observatory, and recommended several important receiver and telescope additions and improvements. Members of the Committee were: Professor W.L. Kraushaar, University of Wisconsin (Chairman); Professor Peter Goldreich, California Institute of Technology; Dr. David S. Heeschen, Director, National Radio Astronomy Observatory; Dr. B.E. Turner, National Radio Astronomy Observatory; and Professor Gart Westerhout, University of Maryland.

PAUL SEBRING

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

During 1975-76, Wesley L. Harris served as the director of the Office of Minority Education, and combined his O. M. E. administrative and faculty related academic responsibilities equally. O. M. E. has a full-time secretary, Gloria Payne. During the past year, three M. I. T. graduate students assisted in the research conducted by O. M. E.

Advisory Structure

In order to better understand the teaching-learning process of minority undergraduates, O. M. E. has sought the counsel of students, faculty, and staff throughout the Institute. Much of this essential counsel has been provided by the Minority Student Advisory Committee and the Faculty-Staff Advisory Group. Members of the Minority Student Advisory Committee for 1975-76 included: John Arnett, Ralph Deadwyler, Jose Fernandez, William Gilchrist, Austin Harton, Lissa Martinez, Gary Oliver, Bernard Robinson, Stanley Washington, Delonia Watson, and Gwen Wise. Members of the Faculty-Staff Advisory Group for 1975-76 included: Professors Eugene E. Covert, Ernest G. Cravalho, Alan Davison, Charles E. Holt, Willard Johnson, Margaret MacVicar, Arthur P. Mattuck, Arthur Smith, and James E. Young; Deans Peter Büttner and Carola Eisenberg; Drs. Alan J. Lazarus, Mary Rowe, and Clarence G. Williams; and Nelson Armstrong and Julia C. McLellan.

PROJECTS

Assessment of Academic Performance of Minority Undergraduates

Using data provided by the Office of Admissions and the Office of the Registrar, O.M.E. has focused upon the academic work done by black undergraduates at M.I.T. in the period from 1969 to the present. In this, its initial study, O.M.E. asked three questions. Academically, what happens to blacks while they are undergraduates at M.I.T.? Can a predictive algorithm, based on M.I.T. indices, be developed which predicts the academic achievement of black undergraduate students? What is the relative quality of the academic performance and success of PROJECT INTERPHASE students throughout the freshman year? A report summarizing and documenting our findings is in preparation.

Undergraduate Senior Minority Student Survey

With essential input from the Minority Student Advisory Committee and the Analytical Studies and Planning Group, a 17-page survey-questionnaire was prepared and distributed to 48 undergraduate senior minority students. This survey-questionnaire focused upon the particular students' academic and family background, and admissions, academics, financial aid, and the social climate at M.I.T. O.M.E. has received a 45 percent return of this survey-questionnaire. Data contained in the returned survey-questionnaires currently are being analyzed. A report describing our findings will be made available.

Black Student Union Tutorial Program (B.S.U. -T.P.)

The B.S.U. -T.P. became a managerial responsibility of O.M.E. at the beginning of the second semester of the 1975-76 academic year. Mr. Gilchrist is the current B.S.U. -T.P. coordinator-chairman, and Professor Young (Physics) is B.S.U. -T.P. faculty advisor. This program has provided tutorial assistance for minority undergraduates in more than 60 subjects during the year. The B.S.U. -T.P. utilized 31 tutors who spent approximately 4,300 hours tutoring. The program is performing a needed service and is functioning quite well. Plans coordinated through O.M.E. to continue and improve the effectiveness of the B.S.U. -T.P. have been initiated.

Minority Students Leadership Conference

O.M.E. sponsored a weekend retreat at Talbot House to focus on freshman advising, future directions of the B.S.U. -T.P., coordination of black undergraduate academic groups (Black Mechanical Engineers, Black Students in Electrical Engineering, Black Chemical Engineers, Black Pre-Medical Organization), the relationship between minority faculty and staff and minority students, and to discuss career possibilities for minority students with M.I.T. degrees. Students from all classes attended the retreat. O.M.E. received valuable counsel from the students and stressed with them the goals and responsibilities that O.M.E. has taken on. O.M.E. intends to sponsor this retreat annually.

Faculty -Student Exchange Program

The Virginia State College/M.I.T. Cooperative Program originated in the Department of Physics five years ago under the leadership of Professor Young. This program is currently supported by HEW with funding through the 1977-78 academic year. This program will be

managed by O.M.E. beginning July 1, 1976. Two other proposals for programs with other predominantly black colleges were not funded by HEW.

Project Interphase 1976

Forty students are enrolled in PROJECT INTERPHASE 1976, which is supervised by O.M.E. Subject offerings include physics, chemistry, mathematics, writing, computer programming, and research. The latter two subjects are being offered for the first time in this program. A complete report on PROJECT INTERPHASE 1976 will be available at the conclusion of the program, and will be summarized in the Report of the President and the Chancellor for 1976-77.

MIT-HELP

This academic support service provides instructions in algebra, trigonometry, analytical geometry, exponentials, and logarithms for all first-year students. This service was developed in Freshman Advisory Council and will be managed by O.M.E. beginning September 1976.

FACULTY-STAFF ADVISORY GROUP ACTIVITIES

Subgroup on Tutoring

An assessment of the various tutorial programs at M.I.T. which have undergraduate students as their main clients will be valuable to O.M.E. for defining the kind of support services needed for minority undergraduates. O.M.E. has requested an assessment of PROJECT INTERPHASE, B.S.U.-T.P., MIT-HELP, E.S.G., Concourse, departmental operated tutorials, and the dormitory house tutoring programs. This essential task is being handled by a subgroup of the Faculty-Staff Advisory Group. Membership of this subgroup consists of Professors Lazarus (Chairman), Cravalho, Holt, Mattuck, Young, and Ms. McLellan. A report from this subgroup on their findings is anticipated before February 1977.

Faculty-Staff Survey Subgroup

In order to obtain a more complete perspective of the general academic health of minority undergraduate students at M.I.T., O.M.E. seeks the views of faculty and staff concerning minority undergraduates. Specifically, O.M.E. seeks an understanding of the areas that need attention to enhance and maintain the general academic health of minority undergraduate students and a clearer formulation of the responsibility of faculty and staff to assist minority undergraduate students in various facets of their student life. Membership of this subgroup consists of Drs. Rowe and Williams (Cochairpersons), Mr. Armstrong, Dean Büttner, and Professors Covert, Davison, and Smith. A report from this subgroup is anticipated before February 1977.

Minority Undergraduate Research Participation

O.M.E. currently is exploring alternatives to increase minority undergraduate participation in research at the Institute. Professor MacVicar is leading this effort, and has already, with the assistance of Gregory Smith, contributed substantially through the development of a research component to PROJECT INTERPHASE 1976.

NATIONAL WORKSHOP ON MINORITY UNDERGRADUATE EDUCATION IN SCIENCE/ENGINEERING

O.M.E. is working with Dr. Williams to obtain funding from sources outside M.I.T. to address the areas of recruitment, admissions, financial aid, academic support services, retention, placement, and careers of minority undergraduates in science and engineering. The format of the proposed series of related workshops would limit participation to colleges, universities, and institutions similar in nature and range to M.I.T. The workshops would be located at M.I.T. and would take place in fall, 1977 provided funding is obtained.

WESLEY L. HARRIS

Operations Research Center

The Operations Research Center conducts interdepartmental academic and research programs in operations research. The academic staff of the Center is drawn from many departments, including the Sloan School of Management, the Departments of Urban Studies and Planning, Electrical Engineering and Computer Science, Aeronautics and Astronautics, Mathematics, and Physics. At present, approximately 15 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 programs by attending seminars or courses.

During the past year, the academic staff of the Center has engaged in a wide range of research activities sponsored directly by the Center. There was basic research into the methodologies underlying operations research including mathematical programming, decision analysis, and probabilistic models. There also was a variety of model building and applications oriented research using these methodologies.

Basic research into the mathematics of operations research received continued strong attention. This year's developments included further work on the use of mathematical programming duality theory to study integer programming. New results were obtained on sensitivity analysis and multi-criterion optimization of these problems. Research was performed on the solution of nondifferentiable optimization problems, a class which includes the above mentioned integer programming dual problems. Additional significant research was performed in robust statistics, network optimization, and fractional programming.

An important research project which began last year was conducted jointly with the Center for Transportation Studies on decomposition techniques. Three application areas were considered and analyzed: freight flow management, multi-fleet routing, and urban goods distribution. The research involved model building, mathematical programming analysis, and computer implementation and validation. Decomposition methods are required because of the large size of these decision problems.

Another applications project was concerned with public attitudes and decision processes regarding blood donation. The field work for this project, including survey research in seven metropolitan areas, was completed this year. Several aspects of the study, such as investigations of samples of ex-donors, cast doubt on the popular belief that the reluctance of the public to donate is the primary constraint on blood supply.

Substantial progress was made last year in a long-standing project devoted to the study of multilevel logistics systems. Research was completed on methods to partition, link, aggregate and disaggregate large scale production, distribution, and inventory systems. In addition, computer programs were implemented and tested for the solution of mathematical programming that can be used to support production planning decisions.

Operations Research Center staff and students were involved in a variety of research activities with other departments and centers both within and outside M.I.T. For example, several students and staff were involved in joint work with the Energy Laboratory. A network flow model was designed and implemented to predict local shortages of heating oil in emergencies and to determine fuel inventory management. Research continued on a probabilistic model of the oil and gas process that constitutes the physical component of an economic supply function for petroleum reserves from new discoveries. Computational methods were developed for estimating parameters of the model and forecasting sizes of new discoveries, and these methods were applied to the North Sea petroleum exploration sites. Finally, there was research into an important class of economic equilibrium/mathematical programming used in energy planning. Specifically, methods were devised for decomposing these models into their econometric forecasting and linear programming components.

Staff and students participated in a water resources planning project being carried out by the Department of Civil Engineering. This project is concerned with development of the Vardar River Basin in Yugoslavia. A mixed integer programming investment model was constructed to analyze the decision alternatives; computer testing and solution of the model will be done during the first part of next year.

Several members of the Operations Research Center staff were active in research programs at the National Bureau of Economic Research Computer Research Center for Economics and Management Science located in Cambridge. Their activities included development of interactive computer systems for linear and integer programming and methods of robust estimation. The computer tools developed at the Computer Research Center are publicly available and have been used on many applications of the research projects mentioned previously.

Support for the Center's research during the past year has come from the Army Research Office - Durham, The US Department of Transportation, the Public Health Service, the Office of Naval Research, the National Science Foundation, and International Business Machines, Inc.

JEREMY F. SHAPIRO

R.O.T.C. Programs

This year, as in the past several years, the attention of the R.O.T.C. Advisory Committee focused on the problem of R.O.T.C. enrollments at M.I.T. Because of increased cost pressures on the military, the services have had to establish and enforce minimum enrollment standards for R.O.T.C. units. At M.I.T., the Air Force and the Army units have been in particular jeopardy, though the expectation is that their enrollments will improve dramatically in the next few years because of increased scholarship resources. The Committee's concern has been to preserve the three-service option at M.I.T. so as to maximize the scholarship and career opportunities available to students.

The Committee explored the possibility of cross-enrollment agreements with neighboring universities. One such agreement covering the Air Force was concluded with Northeastern University. Another involving Tufts University and our Army R.O.T.C. is still being discussed. Wellesley students already are eligible to enroll in M.I.T. R.O.T.C. courses under the terms of the M.I.T./Wellesley Exchange Program. In May, the Harvard University faculty voted to permit Harvard students to enroll in R.O.T.C. as part of the Harvard/M.I.T. cross-enrollment agreement. Due to these actions, it appears that the short-term R.O.T.C. enrollment problem has been resolved successfully. The Committee reported on these developments and the general R.O.T.C. situation to the M.I.T. faculty at a spring meeting.

Especially gratifying to the Committee has been the success of M.I.T. students in the national competition for R.O.T.C. scholarships. While nationally 25 percent of R.O.T.C. students hold service scholarships, 75 percent of the M.I.T. R.O.T.C. students are scholarship recipients. Approximately 150 M.I.T. undergraduates help pay for their education with this scholarship support. The number of M.I.T. students receiving this support is expected to grow rapidly in the next few years.

With the enrollment problem eliminated, the Committee now expects to be able to devote its attention to other aspects of the R.O.T.C. program. A new procedure for the review of R.O.T.C. instructor nominations already has been established, and during the next year the Committee expects to complete the first thorough review of the R.O.T.C. curricula conducted at M.I.T. since 1969-70.

The reports from the individual R.O.T.C. commanders follow.

HARVEY M. SAPOLSKY

U.S. ARMY R.O.T.C.

Sixty-five students were enrolled in the Military Science Program at the completion of academic year 1975-76. Twenty-four were freshmen, 16 sophomores, 9 juniors, and 16 seniors. Of this total, 49 had R.O.T.C. scholarships. For academic year 1976-77, scholarship prospects appear even brighter. Current indications are that at least 22

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incoming freshmen will enter the Institute with four-year R.O.T.C. scholarships. Overall, the interest in R.O.T.C. continues to increase significantly. We anticipate a total of at least 78 cadets in September 1976 in the Army R.O.T.C. Program.

During 1975-76, 12 cadets were commissioned. All received their first choice of military branch: five Corps of Engineers, three Signal Corps, two Ordnance Corps, one Military Intelligence, and one Adjutant General Corps. An additional three will be commissioned upon completion of training this summer. Of those commissioned, seven received commissions in the Regular Army and the remainder were commissioned in the Army Reserve. Four of the commissionees have elected to enter active duty, two have been assigned to active duty for training, and the remainder will be pursuing advanced degrees, three at M.I.T. and one at medical school. (Among those going to graduate school, two have received Army Graduate Fellowships, and one will enter medical school with the first class of the Uniformed Services University of the Health Sciences at Bethesda, Maryland.)

Efforts of the R.O.T.C. staff have been dedicated to improving the quality of instruction, increasing enrollment, and ensuring maximum accommodation of our students. We are pleased with the tremendous gains in these vital areas.

To further cadet interest and improve upon their military proficiency, two 24-hour training exercises were conducted during the academic year at Fort Devens. Cadet reaction to the exercises was extremely favorable. As part of a more diversified orientation to the Army, a series of guest lecturers from various professional fields within the Army were invited to M.I.T. to speak to our cadets. In addition, several orientation trips to military installations in the area were conducted. This year during Independent Activities Period, the R.O.T.C. program offered a historical tour of Bicentennial Boston which was extremely well-received by cadets and non-cadets alike. Our cadets won First Place Trophy in the New England Orienteering Meet sponsored by First R.O.T.C. Region.

The M.I.T. chapter of the National Society of Pershing Rifles continued to show significant growth in its fourth year. Members of the chapter's Tactical Platoon participated in 12 field exercises this year. The Pershing Rifles Drill Team participated in more than 20 parades and ceremonies in Eastern Massachusetts. In addition to the annual Columbus, Veterans', and Patriots' Day activities, this year was a particularly busy one with the team participating in several area Bicentennial observances. The Rifle Team participated in several shoulder-to-shoulder and postal matches with other universities throughout the nation.

Three staff members (one officer and two non-commissioned officers) and 12 cadets participated in Advanced Camp activities this summer at Fort Bragg, North Carolina. There have been two changes in the military staff in the past year. Captain Kevin M. Upton left M.I.T. in October after four years at the Institute. On June 30, Sergeant Major David H. Doughty will retire after 20 years of service.

JOHN S. KARK

U. S. NAVY R. O. T. C.

At the conclusion of academic year 1975-76, 84 students were enrolled in the Naval Science Program. The breakdown by class is as follows: 8 seniors, 14 juniors, 17 sophomores, and 45 freshmen. N.R.O.T.C. continues to enjoy substantial growth as a direct result of

the scholarship program instituted four years ago. Eighty of the 84 N.R.O.T.C. students receive aid from the Navy, in the form of four- and two-year N.R.O.T.C. Scholarships, and the Professor of Naval Science Scholarship. The latter is awarded by the Professor of Naval Science to N.R.O.T.C. non-scholarship students who demonstrate superior academic and military achievement. Initial indications are that 48 scholarship students will enter the freshman N.R.O.T.C. next fall. This number will be augmented by a smaller number of non-scholarship students. In addition to the projected freshman input, five M.I.T. sophomores will attend the Naval Science Institute at Newport, Rhode Island this summer. Upon their successful completion of the program, they will join the N.R.O.T.C. junior class. This input will offset any attrition that may occur among the present sophomore class. N.R.O.T.C., with the enthusiastic aid of the Institute and the active interest of the students, has successfully achieved the goal of a viable, strong, and self-sustaining unit. Additionally, the planned future growth of the unit will add immeasurably to the present strength of N.R.O.T.C. on campus.

Curriculum content has been considerably strengthened, particularly in the areas of navigation, weapons, and engineering. Seminars in conjunction with the Department of Ocean Engineering were continued this year and have been quite successful. A new program of Flight Indoctrination for qualified midshipmen who hope to pursue Naval Aviation careers, was initiated in October. Two midshipmen participated while seven are scheduled to participate next fall. Field trips in conjunction with Naval Science subjects have proven beneficial in demonstrating the applicability of curriculum content to the various fields in the operational Navy.

Additions to the staff during the academic year included Lieutenants Paul R. Brown and John D. Urmston, and Lieutenant (junior grade) William V. Moody. These instructors replaced Lieutenants Mark J. Ryan and Robert J. Leonard. Chief Yeoman Martin L. Bullock replaced Chief William Welch, and Chief Quartermaster Joseph Drasko joined the staff as an assistant navigation instructor. Prior to next fall, Commander Kenneth Bergstrom, Executive Officer, will be relieved by Commander Kenneth B. Russell.

KEVIN J. O'TOOLE

U. S. AIR FORCE R. O. T. C.

The Air Force R.O.T.C. program had 54 cadets enrolled at the end of academic year 1975-76, with distribution as follows: General Military Course -- 32 freshmen, 10 sophomores; Professional Officer Course -- 10 juniors, two seniors.

Of this total, 33 have A.F.R.O.T.C. scholarships. In addition, nine have applied for two- or three-year scholarships. During 1975-76, four cadets were commissioned into the United States Air Force, with two of these commissioned at the end of the first semester.

Throughout the academic year, efforts have continued toward solving the low enrollment problem experienced by this detachment. The limited consortium agreement with Northeastern University which was concluded on June 3, 1975, provided for 14 Northeastern cadets enrolled in the 1975-76 program. Harvard voted in the spring to permit their students to cross-register at M.I.T. for participation in R.O.T.C. This action came too late to affect the 1975-76 enrollment, but should provide an excellent opportunity to expand the enrollment of the detachment. Therefore, while the detachment continued on a probationary status during 1975-76, the prospects for the future are encouraging.

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The forecast of four-year scholarship students for next fall in the scientific/technological area is 22. Coupled with our projected sophomore enrollment of at least 23, this indicates that the detachment should have viability by academic year 1977-78.

An agreement between the Air Force and M. I. T. was adopted in May 1976 with the provision that along with the Air Force curriculum, cadets take one desideratum subject during the first two years and two desideratum subjects prior to graduation. The desideratum subjects are to be established by mutual agreement between the M. I. T. Provost and the Professor of Aerospace Studies. Efforts continued toward an arrangement acceptable by both the Institute and the Air Force to provide academic credit for the final two years of the Air Force curriculum.

During this academic year, there have been no changes of personnel, although Colonel Larry Schwartzman will retire on June 30, 1976, and Captain George J. Vrtiak and Sergeant William Maciura will be reassigned this summer. Colonel William R. Trott has been selected to replace Colonel Schwartzman and will assume command on July 1, 1976.

WILLIAM R. TROTT

Sea Grant Program

During academic year 1975-76, the M. I. T. Sea Grant Program continued its successful tradition of significant research, education, and advisory services in the marine field, while strengthening and redefining its role as a focus for bringing the Institute's engineering and technological disciplines to bear on the balanced use of ocean and coastal resources.

In its fourth year as a Sea Grant institution, M. I. T.'s Program again received increased Federal funding through a grant of \$984,100 from the Office of Sea Grant, a division of the National Oceanic and Atmospheric Administration in the US Department of Commerce. Matching funds of \$632,101 comprised well over the required one-third of the total Program funding of \$1,616,201. This matching support came from the Institute, the Henry L. and Grace Doherty Charitable Foundation, Inc., the University of Massachusetts, the New England River Basins Commission, the Commonwealth's Division of Marine Fisheries and its Energy Policy Office, the National Fisheries Institute, Boston Edison Company, and the Welding Research Council.

The Sea Grant Program's leadership changed during the academic year 1975-76. In order to devote more time to departmental duties and his teaching and research responsibilities, Professor Ira Dyer, Head of the Department of Ocean Engineering, resigned as Director of the Sea Grant Program in November 1975. Dean A. Horn, who had been Executive Officer of the Program since its inception in 1970, was designated Acting Director. The Search Committee charged with finding a new director for the Program was led by Professor Alfred A. H. Keil, Dean of the School of Engineering and Chairman of both the Sea Grant Policy Committee and the Sea Grant Faculty Council. In May 1976, Mr. Horn was named Director of the M. I. T. Sea Grant Program, and also was appointed Senior Lecturer in the Department of Ocean Engineering. Ernst R. Pariser, Advisory Services Officer for the Program and Senior Research Scientist in the Department of Nutrition and Food Science, and James E. Grayson, Administrative Officer, continue to guide the Program's daily operations.

In seeking to refine and strengthen the Program's goals and activities, the Sea Grant staff have engaged in numerous planning meetings during the past year. In conjunction with the Sea Grant State-Industry Advisory Council, they have outlined significant themes for Sea Grant research at M. I. T., and have designed coordinated advisory activities to serve the Program's constituencies in Massachusetts, New England, and the nation.

M. I. T.'s seagoing research capabilities were augmented in August 1975 by the long-term charter to the Institute of a US Army T-Boat, loaned on arrangement through the Oceanographer of the Navy as a larger and more seaworthy replacement for the R. R. Shrock. Under the direction of Arthur B. Clifton, Sea Grant's Marine Liaison Officer, the vessel was activated in Charleston, South Carolina, and brought under its own power to winter berthing at the Massachusetts Maritime Academy on Buzzards Bay. The T-Boat's equipment and accommodations will be converted to meet Institute needs for a full-fledged research ship. The T-Boat's equipment and accommodations will be converted to meet Institute needs for a full-fledged research ship. The first conversion phase was completed at a local shipyard in June 1976, and the vessel has been moved to a permanent mooring at the New England Aquarium on Boston's Central Wharf. The Research Vessel Management Committee, chaired jointly by Mr. Horn and Professor Bryan P. Pearce of the Department of Civil Engineering, was disbanded after completing its work of setting the management policy for M. I. T. research vessels and overseeing the acquisition of the T-Boat.

ADVISORY SERVICES

The M. I. T. Sea Grant Program's Advisory Services continued during 1975-76 to improve the substance and efficiency of the assistance that it is charged to deliver to its two major constituencies: the industries that can apply new technologies to business opportunities in the oceans; and the individual citizens, local and regional governments, and organizations that are concerned with the wise use of the oceans and coasts.

The M. I. T. Marine Industry Collegium of the M. I. T. Sea Grant Program's Marine Industry Advisory Service (MIDAS) was established in April 1975. More than 80 companies of national and international stature were enrolled as Collegium members during the first year of operation. MIDAS is designed to bring about a close and productive collaboration between marine oriented industries and the M. I. T. Sea Grant Program. Working toward this goal, the Collegium has helped to keep participating firms abreast of economically significant opportunities for new enterprise in the seas. Five Opportunity Briefs, produced for and distributed to Collegium members during 1975-76, describe the technical and market potential of chitin and chitin derivatives, mining of offshore sand and gravel, telemanipulators for undersea operations, underwater welding, and remote controlled submersible instrumentation systems. Seminars on each brief brought together subject experts and representatives of member industries.

The Marine Industries Business Strategy Program (Maribus), also a part of MIDAS, sponsors each year an intensive study of a selected marine resource, product, or service that is of particular interest to and of high economic potential for industry. During 1975-76, a Maribus research team in M. I. T.'s Center for Policy Alternatives has been working with MIDAS staff to analyze, define, and report on the economic and technical aspects of the commercial and industrial use of chitin and chitin derivatives.

The M. I. T. Sea Grant Program has entered into an agreement with the University of Massachusetts Cooperative Extension Service to establish a joint marine extension service for Massachusetts that will be initiated in July 1976. This extension educational program will be one vehicle for disseminating the results of Sea Grant and other marine research to coastal and consumer clientele.

The M. I. T. Sea Grant Program is also an active participant in the New England Marine Advisory Service (NEMAS), a consortium of the region's Sea Grant schools and marine oriented institutions. NEMAS responds to regional needs for information pertinent to ocean and coastal zone activities. Mr. Pariser is vice chairman of the NEMAS Board of Directors for 1976-77.

The M. I. T. Sea Grant Program maintained its advisory links with state government over the past year. Professor Judith T. Kildow of the Department of Ocean Engineering was the Program's representative on the Governor's Task Force on Coastal Resources, a citizens' group appointed to assist the Commonwealth's Office of Coastal Zone Management in policy matters. Bronwyn Hurd, Sea Grant Editor, served on the Task Force's Public Participation Committee. Mr. Clifton is working with the Lieutenant Governor's Massachusetts 200-Mile Work Group that advises the Commonwealth on extended jurisdiction, and has participated in national planning meetings on the 200-mile fisheries management zone.

The Massachusetts Division of Marine Fisheries joined the M. I. T. Sea Grant Program, NEMAS, and the New England Fisheries Steering Committee in a joint effort to ensure efficient manufacture and distribution of the new Sea Grant Towing block to the region's side trawlers. The Division of Marine Fisheries was instrumental in obtaining a New England Regional Commission Grant for the construction of ten prototype blocks that will be tested under actual fishing conditions. Other cooperative advisory service projects undertaken by the M. I. T. Sea Grant Program included a pilot study with the Massachusetts Beach Buggy Association on the effectiveness of a new, vigorous strain of American beach grass for stabilizing a washed-over section of Nauset Beach on Cape Cod; and with the University of Massachusetts Aquacultural Engineering Laboratory, provision of expert assistance to shellfishermen, aquacultural concerns, and local seacoast towns.

A sophisticated Sea Grant advisory project has been providing user documentation for a number of computer programs developed in the Department of Ocean Engineering to analyze a range of issues in ocean engineering, marine economics, and the marine environment. To meet the demand from government agencies, public utilities and industries, and consulting firms for these computer models, Professor Ronald W. Yeung of the Department of Ocean Engineering has prepared standardized programming and user's manuals for the models.

A highlight of Sea Grant Advisory Services symposia during 1975-76 was October's Fourth Annual Sea Grant Lecture, "The Science, Engineering, Economics, and Politics of Ocean Hard Mineral Development." John E. Flipse, President of Deepsea Ventures, Inc., delivered the lecture. Panel respondents were Professor Roger G. Burns of the Department of Earth and Planetary Sciences; Marne A. Dubs, Director of the Ocean Resources Department, Kennecott Copper Corporation; Leigh S. Ratiner, Administrator of the Ocean Mining Administration, US Department of the Interior; and Sergio M. Thompson-Flores, Counsellor of Embassy, Brazilian Mission to the United Nations. Professor Dyer was moderator.

In fall, 1975, Sea Grant cosponsored with the New England Aquarium a series of eight lectures supported by the Lowell Institute School on "Energy and the Environment." In order to present to industries and government agencies the capabilities of M. I. T.'s new precision flume developed by Sea Grant researchers in the Department of Ocean Engineering,

the Program held a workshop in April 1976 to explain the flume's potential role in oil spill research. During April, the M. I. T. Sea Grant Program was one of the cosponsors of "Coastal Recreation Resources in an Urbanizing Environment," a conference held on Cape Cod by the University of Massachusetts Cooperative Extension Service.

ACADEMIC PROGRAM

The M. I. T. Sea Grant Program sponsors marine education and provides opportunities for the practical application of students' classroom knowledge to marine and coastal zone problems.

The Department of Ocean Engineering offered four new subjects, Hydrostatics, New Linear Wave Propagation, The Sea and Society, and Offshore Petroleum Exploration and Development during academic year 1975-76. Supported by Sea Grant, professors in the Department are also preparing a much needed textbook for advanced undergraduates on random processes in ocean engineering. During summer, 1975, the Sea Grant Program cooperated with the Summer Session office in presenting to practicing professionals from industry and government three week-long subjects: Analysis and Design of Transportation Systems, Engineering and Environmental Aspects of Heat Disposal from Power Generation, and Ocean Resources Management: Legal and Policy Aspects.

In the summer laboratory led by Professor A. Douglas Carmichael of the Department of Ocean Engineering, undergraduate and graduate students continued to concentrate their primary efforts on the free-swimming robot submersible that can be programmed to do oceanographic research. This submersible's successful development and testing at sea prompted a MIDAS Opportunity Brief and seminar on untethered submersible instrumentation systems. During spring, 1976, students who were enrolled in the interdisciplinary systems design subject studied the technical, economic, and legal background to possible development of the harbor area in Lynn, Massachusetts. The students' findings were passed on to Lynn city officials at an informal presentation in May 1976. Professor William W. Seifert of the Department of Civil Engineering taught the subject.

Also during the spring term, the M. I. T. Sea Grant Program established on a trial basis a student internship in the office of Massachusetts' Secretary of Environmental Affairs. The internship, designed to provide practical working experience as part of a student's education in ocean engineering and coastal zone management, entailed an evaluation of the Commonwealth's program for the construction of municipal wastewater facilities. If this first internship proves successful, other M. I. T. students may be assigned to state executive agencies, legislative offices, and other committees and commissions, and to marine industries.

RESEARCH

New technology for offshore structures will provide the means of advancing human activities in the seas. Several research projects sponsored by the Sea Grant Program during the past year aimed at improving methods and materials for ocean engineering. Professor Koichi Masubuchi of the Department of Ocean Engineering continued his research on designs for new, improved underwater welding and cutting techniques. The unique stud-welding gun developed through his project is being patented, and an underwater flux-shielded arc welding process was invented. During June 1976, Professor Masubuchi and his colleagues tested their

new methods in the Baltic Sea as participants in the joint US-German program of the National Oceanic and Atmospheric Administration's Office of Manned Undersea Science and Technology.

In his research on multipurpose offshore platforms, Professor Chryssostomos Chryssostomidis of the Department of Ocean Engineering completed conceptual plans and cost/benefit analyses for one type platform that would combine an oil storage terminal with a processing plant to convert natural gas into ammonia or urea for fertilizers. Professor Chiang C. Mei of the Department of Civil Engineering worked to develop a computational method for calculating and predicting the effect of ocean waves on offshore structures. This numerical technique should prove useful in the design of deepwater ports, oil terminals, man-made islands, floating platforms, and submerged storage tanks.

In February 1976, Professor J. Kim Vandiver of the Department of Ocean Engineering was named the second Henry L. Doherty Assistant Professor in Ocean Utilization, a chair established through the generosity of the Henry L. and Grace Doherty Charitable Foundation, Inc., and administered through the M.I.T. Sea Grant Program. During the coming year, Professor Vandiver will seek to develop an analytic technique for predicting the dynamic response of offshore structures to random ocean waves.

In related Sea Grant research on structures in ocean environments, Professor Jerome H. Milgram of the Department of Ocean Engineering is preparing a paper that reviews current methods of determining wave forces on offshore structures, and will present this at an international conference on the Behavior of Offshore Structures in Trondheim, Norway, August 1976. Professor J. Daniel Nyhart of the Sloan School of Management and the Department of Ocean Engineering undertook a study on regulatory regimes governing offshore technological developments under extended jurisdiction.

A major goal of the M.I.T. Sea Grant Program's research is to ensure that, while society's use of marine resources expands, ocean and coastal environments remain productive for future generations. In the Department of Civil Engineering's Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Professor Jerome J. Connor, Jr. and Professor Pearce, Principal Investigators for Sea Grant's long-term project on the sea environment of Massachusetts Bay, refined and expanded the computer models that describe and predict hydrodynamic processes in the Bay. The circulation and dispersion models have been verified according to observed data and are being applied to the Bay and to other offshore bodies of water. The researchers are developing designs for cost-effective water quality monitoring systems, and are documenting the models for dissemination to agency and industry users.

The M.I.T. Sea Grant Program had provided support for the first three years of research of Professor Emeritus John G. Trump, of the Department of Electrical Engineering, on the use of high energy electrons as an effective and economical method for treatment of waste water and sludge. On May 19, 1976, a full-scale experimental facility to demonstrate municipal sewage treatment with irradiating electrons was dedicated at the Metropolitan District Commission Deer Island Sewage Treatment Plant in Boston Harbor. Construction and operation of this pilot facility, as well as completion of laboratory work, were made possible by major grants for academic years 1974 through 1976 from the National Science Foundation's Research Applied to National Needs program.

In addition to his research on the development of a biochemical model for coastal waters, Professor Francois M. M. Morel of the Department of Civil Engineering, Sea Grant's first Henry L. Doherty Assistant Professor of Ocean Utilization, studied possible causes of the toxic red tides of dinoflagellate algae that have occurred regularly in New England waters during the past four years. Recent findings by Professor Morel and graduate student Donald Anderson indicate that trace amounts of copper in seawater may inhibit the growth of *Gonyaulax tamarensis*, the alga causing

the red tides. An influx of organic substances into coastal waters may chelate the dissolved copper, thus preventing its toxic effect on *G. tamarensis* and allowing the organisms to bloom. Professor Shaoul Ezekiel of the Department of Aeronautics and Astronautics and Dr. G. Gregory White of the Environmental Management Institute studied the feasibility of developing an airborne, remote sensing, spectrofluorometric system for the detection of *G. tamarensis* in coastal waters before the alga population reaches bloom levels.

The Sea Grant Program's continuing interest in and involvement with the Commonwealth's efforts for coastal management under the Federal Coastal Zone Management Act of 1972 was reflected in research on public sector and private industry needs in the New England coastal zone. Professor Kildow created a matrix that demonstrates conflicting and complementary desires for public and private uses of the coast. This technique should help state planners to make rational decisions in the allocation of coastal resources and to discern possible areas for regional cooperation in coastal zone management.

The Sea Grant Program sponsors research designed to increase society's beneficial use of living marine resources. Professor Benjamin L. Averbach of the Department of Materials Science and Engineering conducted investigations into the chemical and physical structure of chitosan, a material with many potential commercial uses that is derived from the organic polymer chitin, which is a major structural component of crustacean shells. Professor Averbach found that chitosans obtained from several shellfish species have similar crystalline structures. However, processing methods cause variations in chitosan's polymeric properties, which affect the usefulness of the clear flexible films that can be cast from the material. Seeking data needed by doctors, dieticians, and fish processors, Professor Samuel A. Goldblith of the Department of Nutrition and Food Science and Mr. Pariser have studied the content, composition, and conversion of physiologically important lipids in raw and processed finfish and shellfish. Numerous samples of commonly eaten seafoods were analyzed for cholesterol content by gas chromatography, and a comparative study on cholesterol in canned tunas was completed.

Following development of the Sea Grant Program's towing block for New England's side trawling fishing boats, Professor Stephen P. Loutrel of the Department of Mechanical Engineering and graduate student Cliff Goudey designed a safer and more efficient system for hooking up the trawl doors that must be attached to the towed nets at the beginning of a trawling run, and released when the nets are hauled in. The Sea Grant researchers are working with local fishermen to test the new trawl door hook-up system. Professor Seifert and Professor John W. Zahradnik of the University of Massachusetts completed their project on the use of heated water effluents from power plants for growing marketable oysters in aquacultural systems. They analyzed the technical efficiency, capital, and operating costs of various types of heat exchangers needed to transfer effluent heat to the seawater in which the oysters are actually raised. The investigators also have determined the timing and amount of supplemental feeding required for proper growth of the molluscs.

During 1975-76, several Sea Grant projects concerned marine oil pollution. Professor Milgram, with a research team supported by Sea Grant and by the National Science Foundation's Division of Engineering, invented a precision flume for measuring accurately in laboratory analysis the behavior of oil spills in seawater. The 30-foot long flume, the first of its kind known to exist, will be used by Professor Milgram and his associates as an experimental aid in designing effective methods for cleaning up offshore oil slicks.

To augment prediction of the environmental impacts of major oil spillages, Professor Edward C. Kern of the Department of Ocean Engineering, graduate student Brad Campbell, and Mr. Horn analyzed available data on World War II tanker sinkings along the United States Atlantic coast. For the most severely affected shorelands, the investigators tried to document the natural environmental recovery and residual damage from fouling by the cargo oil spilled from the

Special Freshman Programs

sunken ships. They did computer simulations of the tracks of the oil spills, and correlated these with historical data on sightings. Professors Connor, Pearce, and Keith D. Stolzenbach, of the Department of Civil Engineering, initiated a research project to evaluate all of the various computer models created for practical application in predicting the trajectories of oil slicks from the original spill sites at sea.

Periodically, the National Oceanic and Atmospheric Administration's Office of Sea Grant funds research with a national public interest focus that stands apart from a Sea Grant institution's programmed schedule of projects. During the past year, Dr. J. Herbert Hollomon, Director of the Center for Policy Alternatives, and Dr. James M. Utterback, Research Associate, led a special study analyzing the potential economic impact of a sample of research projects done at Sea Grant programs around the country, with special reference to the United States balance of payments.

DEAN A. HORN

Special Freshman Programs

In addition to the "regular" freshman program of required and elective subjects, two special programs exist in the freshman year -- the Concourse Program and the Experimental Study Group (E. S. G.). Concourse and E. S. G. normally accept between 30 and 50 freshman students. The programs offer a pattern of subjects, seminars, and tutorial classes, which are distinct from the subject offerings in the regular program. Each originated as an experiment sponsored by the Committee on Educational Policy (C. E. P.). E. S. G. enrolled its first students in 1969, Concourse in 1971. In 1975-76, E. S. G. enrolled 33 freshmen in the first term and 39 in the second; Concourse enrolled 51 freshmen in the first term and 36 in the second. The programs continued under the sponsorship and educational overview of the C. E. P., with a special C. E. P. subcommittee as liaison. The chairman of this subcommittee for 1975-76 was Professor Suzanne Berger.

During the past year, principal faculty responsibility in E. S. G. was carried by Professor Robert Halfman. There were eight part-time teaching staff each term, and administrative support was provided by Margaret Norris. Principal faculty responsibility in Concourse was carried by Professor Jerome Lettvin. There were seven part-time teaching staff each term, and administrative support was provided by Dr. Martin Horowitz and Cheryl Butters.

In 1973, the C. E. P. extended the approved term of each program until 1976, with the provision that the programs would be subject to yearly review by the C. E. P. and with the implication that a final review would result in recommendations as to their possible continuation under more permanent administrative arrangements.

In its informal interim report for 1974-75, the C. E. P. subcommittee noted: "there appears to be a great deal of enthusiasm for the programs on the part of the faculty and staff, and the programs seem in good health." The subcommittee went on to comment that "both programs provide an academically based community for a group of faculty and students, but Concourse has a more structured program than E. S. G., which is geared toward individualized learning. . . Both programs seem to have evolved over the years toward a greater emphasis on fulfillment of the General Institute Requirements, and both programs seem more regularized now than at their inception. . . . A feature of both programs which received very favorable comment from

the students was the opportunity to engage with faculty in the exploration of ideas, in contrast to the lecture style of education in which information is prepackaged and presented as a piece. It was noted also that the programs provide opportunities for faculty from different departments to work together, and that this contributes positively to the atmosphere of the academic community. "

During the academic year 1975-76, both programs were studied by the special C. E. P. subcommittee, and discussions about them were held within the C. E. P. and between the programs and the C. E. P. As a result of this study and discussion, the C. E. P. recommended that Concourse be made a regular part of the academic program provided that an appropriate administrative home could be found and that certain other conditions concerning format and content could be satisfied. A regular home was not found by the end of the year, but discussions were under way regarding a possible arrangement with the Department of Electrical Engineering and Computer Science. The C. E. P. therefore voted to extend its own sponsorship of Concourse for a further year. If a departmental home is found, the C. E. P. expects to consider, during the coming year, the educational policy implications of such a location for an interdepartmental program. The C. E. P. also voted to extend its sponsorship of E. S. G. for the coming year and asked E. S. G. to address certain questions concerning format and selection of students. The Dean of the School of Science and the Science Council will continue to take an overview of E. S. G., as they did during 1975-76, with the possibility in mind that E. S. G. might develop an administrative association with the School of Science if and when it becomes a regular part of the academic program.

HARTLEY ROGERS, JR.

Summer Session

SPECIAL PROGRAMS

The economic recession had an adverse effect on the Special Summer Program activity. The one- and two-week Special Programs are presented for professional men and women who wish to keep pace with developments in their fields. Of the 72 programs planned for the 1975 session, 16 had to be canceled because of projected low enrollments. There was a total registration of 1,635 in the 56 programs compared with a 1974 registration of 1,946 in 54 programs. A similar decline in attendance was experienced from 1969 to 1970, which must be attributed to the unfavorable economic climate.

The two significant changes in the composition of the registrant body are increasing percentages of women and people from foreign countries. From 1972 to 1975, the percentage of women attendees has increased from 5 to 9. For the same period, foreign registrants have increased from 14 to 23 percent. Despite the understandable economic decline, the Special Program activity continues to have widespread appeal.

REGULAR SUBJECTS

Graduate students comprise 85 percent of the student body in the summer. The 1975 registration of 2,238 students represents a small increase from the 2,153 in 1974.

CONFERENCES

A total of 1,350 persons attended the Sixth Triennial World Congress of the International Federation of Automatic Control (IFAC), Boston/Cambridge, August 24-30, 1975. Its theme was "Control Technology in the Service of Man." Thirty-five countries were represented with the USA contributing slightly more than one-half of the attendees. The American Automatic Control Council (AACC), as the US National Member Organization of the International Federation of Automatic Control, was the official host for the United States. The overall planning of the Congress was the responsibility of the US Organizing Committee, chaired by Nathan Cohn, '27. The M.I.T. arrangements were handled by an on-site committee under the chairmanship of Professor George C. Newton, Jr. of the Department of Electrical Engineering and Computer Science. The program of the Congress included 63 technical sessions, where 347 papers were presented, and seven plenary sessions with invited speakers. The keynote speaker for the opening session was the Honorable John T. Dunlop, US Secretary of Labor. In addition, there were special activities conducted by the Electronic Systems Laboratory, the Center for Advanced Engineering Study, the Department of Ocean Engineering, and the Sloan School of Management.

JAMES M. AUSTIN

Technology and Culture Seminar

The Technology and Culture Seminar is a forum for the discussion of moral, social, political, cultural, and value issues raised by science and technology. Its evolving program is guided by a Steering Committee of faculty: Professors Elting E. Morison, Victor F. Weisskopf, Robert L. Bishop, Robert S. Morison, Leon Trilling; Associate Professors Jonathan A. King, Stephen D. Senturia, Judith Wechsler; and chaired by John Crocker, Jr., Episcopal Chaplain at M.I.T.

In 1975-76 the Seminar sponsored three programs, each unique at M.I.T. The first was a credit course coupled with a series of lectures on Simone Weil, which drew students from a number of colleges in the area as well as visitors from out of state. The course demonstrated the value of an inquiry focused on a personality but dealing with vital current issues through that personality. Among the six lecturers were Conor Cruise O'Brien and Robert Coles.

The second program was a luncheon seminar for faculty, staff, and employees entitled "Technology, Merit, and Equality," which critically explored the ways and degrees in which technologies affect the structure and ethos of society. A number of case studies and cross-cultural analyses kept the discussion practical and down to earth. The speakers and discussion leaders included Daniel Bell, Ivan Illich, and Richard J. Barnet, among a dozen others.

Provost

The third program was a weekly lecture series planned and led by Professor Wechsler, entitled "Humanitas: An Evolving Perspective." This was a major attempt at M. I. T. to describe the continuity and interrelationships among the variety of strands which have made up Western culture. The series focused largely upon images and ideas of humanity and "human nature" as seen from philosophical, theological, literary, artistic, and scientific perspectives. Among the lecturers were Nahum Glatzer, Leo Steinberg, Owen Gingerich, Frank Manuel, Isaiah Berlin, Erich Heller, George Steiner, and Robert Lifton.

Plans for 1976-77 include two lecture series, one on the cultural influences of the Darwinian revolution, and a luncheon seminar on "Energy for a Just and Sustainable Society."

JOHN CROCKER, JR.

Upward Bound Program

The M. I. T. /Wellesley Upward Bound program is a coed, multiracial, multiethnic educational program for Cambridge high school aged youth. Now in its tenth 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 additionally 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 a social sense, in a warm and personal, but structured environment. This development can be manipulated 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, is 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, the nature of prejudice, creative communication, world literature,

street law, pluralism in America, Spanish, American revolution and the Bicentennial, and the psychology of social settings. Science courses include biology, ecology, and cell biology, supported in part by a grant from Sigma Xi. Microscopes and other laboratory equipment are on loan to us from the Department of Biology. The Mathematics program includes an enrichment section for students who are going to take 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; as well as a computer programming course sponsored by IBM. IBM's sponsorship of these courses -- the teachers, computer terminals, and couplers -- follows several previous years of generous contributions supporting computer courses and of participation in our program.

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 to cope with the myriad academic, social, and family problems that confront him 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.

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

All 18 graduating seniors have been placed in colleges as follows: Boston College (3), Boston University (2), Bunker Hill Community College, C. W. Post College, Clark College, Coppin State College, Harvard University, Massachusetts Bay Community College (2), Morgan State College (2), Mt. Ida College, Norfolk State College, Salve Regina College, and Springfield College.

JOHN TERRY

Wellesley-M.I.T. Exchange Program

In 1975-76, the Wellesley-M.I.T. Exchange Program was in its third year as part of the regular academic program of the Institute. The pattern of cooperation between the two institutions continued to increase, with some signs that joint academic efforts may become even more substantial in the future.

The heart of the Exchange was still the cross-registration program, which allows students at either institution to register for subjects (courses) at the other. Interest among Wellesley students in enrolling in M.I.T. subjects reached an all-time high in spring, 1976 when one-fourth of the 1,700-member Wellesley student body applied to take one or more of their courses at M.I.T. The number of M.I.T. students registering for Wellesley courses was about the same as last spring (108). In order that the enrollment figures be not too far out of line with one another, the Joint Committee which oversees the Exchange recommended that Wellesley College limit its students to taking one M.I.T. subject. It is hoped that this restriction can be removed in the years ahead, when the diverse activities of the Exchange should keep the whole program in balance, even though the enrollment figures from each school may differ significantly.

One factor which has limited cross-registration by M.I.T. students is the new Institute Requirement in Humanities, Arts, and Social Sciences, which stipulates that three of eight required subjects in these fields must be selected from an approved list of "distribution subjects." Heretofore, no Wellesley courses have been on this list. Six Wellesley courses have now been approved for distribution credit for next year. This will help to reopen to M.I.T. students the enriched program which cooperation with Wellesley can provide.

Enriched opportunities for Wellesley students were begun in the past year, as the College made available funds for student participation in summer UROP projects at M.I.T. and the Urban Legal Studies Program.

The Exchange has continued to develop faculty cooperation and interaction between Wellesley and M.I.T. Several examples will give the flavor and variety of such cooperation.

The experiment in cooperative political science education begun last year will be tried in a modified form during the coming year. The cooperation involves two faculty members from each institution who present a package of four political science courses, utilizing the strengths of each faculty. Enrollment by M.I.T. students was not as high as had been hoped for during the first year, but the faculty members involved all thought the experiment worth repeating.

This year, a new member has been added to Wellesley's Chinese Department, specifically to teach Chinese on the M.I.T. campus. This addition should make this language more readily available to M.I.T. students than it has ever been.

A regular series of luncheons was held last year among faculty members from both institutions who are interested in curricular offerings dealing with Women's Studies. Posters were prepared which advertised the range of available offerings. Discussions will continue this year about more substantial types of cooperation for future offerings.

A joint Visiting Assistant Professor in French has been appointed for 1976-77. This is part of a continuing series of discussions and actions involving complete cooperation in faculty development and teaching in French language and literature.

Finally, a unique type of cooperation will begin this year -- the use of M.I.T. graduate students as laboratory assistants in Wellesley science courses. It is hoped that this will promote understanding and cooperation in some areas of science, while helping to support M.I.T. graduate students.

KENNETH M. HOFFMAN

School of Architecture and Planning

Calm and purposefulness have characterized the year 1975-76 for the School of Architecture and Planning despite some unfavorable circumstances. This year the School experienced budgetary cutbacks in general funds and virtual depletion of the departments' own special purpose funds. In addition the job market for graduates, especially those in architecture, has deteriorated sharply. Despite this, academic and research programs were more active than in recent years, and members of the School's Visiting Committee have noted that the morale in the School remained high.

Over the past decade, during a period of substantial growth, the School diversified its educational program and the composition of its faculty and student body. Currently, efforts are under way to give increasing order to the School's curricula and, where appropriate, to consolidate its subject offerings and other activities. Despite this move toward consolidation, several important programs and activities were launched in the last year, existing programs have been strengthened, and the administrative matters of the School have been handled with increased efficiency. Professor Langley Keyes began his second year as Head of the Department of Urban Studies and Planning, and Professor John Habraken assumed leadership of the Department of Architecture. The newly appointed School Council, composed of those who hold key administrative positions in the School, met regularly to review issues of School-wide importance such as the use of the Bemis Fund, Leadership Campaign activities, major research proposals, the Visiting Committee meeting, proposed appointments, and changes in academic programs.

TEACHING PROGRAMS

The teaching programs of both departments benefitted from curriculum development funds awarded by the M.I.T. administration for summer, 1975. A committee of Architecture faculty members studied the Level I Design Studio and recommended that all studio sections be taught collaboratively by members of the design faculty. The Committee advised that topics, some lectures, and the final reviews be coordinated to provide students with a common introductory base for further studies in the Department. The Committee for the Department of Urban Studies and Planning Ph.D. Program suggested that research clusters be organized around major areas of faculty interest to improve the quality, continuity, and accessibility of research. This plan was so successful that it is now being implemented in both departments.

Other innovations in the curriculum included the new Ph.D. program in the Department of Architecture and the new core in the M.C.P. program in the Department of Urban Studies and Planning (D.U.S.P.). The Ph.D. in Architecture, Art, and Environmental Studies program commenced in the fall with five students enrolled. This new degree program emphasizes the study of modern architecture, city design, art, and the history, theory, and method of these fields. The students' areas of study this year have been: the development of form in art and a specific study of Jaspar Johns, origins of modern landscape and town planning, history and theory of early 20th century architecture, theory and ecology of street networks, and structures of environmental experience and social theory.

Students beginning the M. C. P. program enrolled in a core of three required introductory subjects: The Planning Process, Urban Economics, and Analytical Methods for Planners. These subjects, the result of the recommendations of the 1974 Summer Study and a year of intensive development by the faculty, are intended to provide the graduates of the M. C. P. program with the knowledge and skills necessary to work effectively in a changing professional context.

The Policy Committee of the Department of Architecture, newly formed by Professor Habraken, is concerned with the Department's future direction as well as the interaction among its diverse groups and disciplines. Professor Habraken also has appointed a Program Committee for each of the Department's degree programs: undergraduate, M. Arch., M. Arch. A. S., and Ph. D. These new committees serve as forums where students and faculty can discuss goals, priorities, and recommendations for change in the degree programs.

During the year, plans were made for the Department of Architecture to offer the M. S., starting in 1976-77, to students whose advanced studies are outside the area of traditional architectural design.

Aside from its artistic accomplishments, the teaching role of the Center for Advanced Visual Studies, an Institute program closely linked to the Department of Architecture, continues to expand rapidly. This year members of the Center taught an all-time high of more than 200 students from throughout the Institute. In addition, the Fellows at the Center are involved directly in the teaching program and devote a large portion of their time to students.

Members of the D. U. S. P. and the M. I. T. administration evaluated and redesigned both the substance and the funding plan of the Community Fellows Program, established by the Department in 1971. The Program will include minority group leaders who work in both government agencies and minority communities. The program has been moved from the East Campus to Building 7 to maximize interaction with all members of the Department.

Eleven Fellows participated in the Special Program for Urban and Regional Studies of Developing Areas (SPURS) in the Department of Urban Studies and Planning this year to study problems of urban and regional change. Professor Lloyd Rodwin returned after a year of sabbatical leave to resume his position as Director of the Program.

During the Independent Activities Period, the Department of Architecture offered Advanced Computer Graphics, Electrographic Printmaking, and Rough and Ready Surveying. The Department also offered a two-week architectural design studio for employees. The activities of the Department of Urban Studies and Planning included *The City in the Age of Machine Politics*: James Michael Curley's Boston; *City Life in China*; and *The Future of American Cities*.

A number of publications originated in the School during the year. The two-year old Newsletter, published each term by the Dean's Office, covers student, faculty, and alumni activities. The Newsletter provides the School's major link with its nearly 3,000 alumni. The Architecture Machine Group, directed by Professor Nicholas Negroponte, began publication of Architecture Machinations, a weekly newsletter originally produced to encourage internal communication among members of the Group. It is now requested by many groups and individuals outside the Department and M. I. T. as a valuable source of information on computer aided graphics.

Professor Richard Larson's Innovative Resource Planning Project continued to produce the News Brief which disseminates the results of the project's research and presents summaries of project publications. News Brief, with 2,000 subscribers, only 200 of whom are at M.I.T., was published each month until January and less frequently since then as the scope of the project has been reduced.

Professor Robert Hollister launched a lively weekly, Know One City Well, with the Lilly Foundation Fellowship funds awarded in the fall. The publication was designed to alert members of the School, and others who might be interested, to places and events of special note in Boston.

Students in the Department of Architecture took the initiative this year in putting out several issues of a paper addressed to other students called Bullform. The D.U.S.P. continues to publish The Final Daze, a graduate student guide to the academic and research programs, administrative procedures, and who's who in the Department.

COMPOSITION OF THE SCHOOL

Faculty and Staff

Since 1970-71, the number of faculty in the School has increased from 52 to the present 80. However, the size of the 1975-76 faculty showed little change from last year. The Department of Architecture faculty increased from 40 to 42, and the Department of Urban Studies and Planning faculty increased from 39 to 40. Four professors held joint appointments in the two departments. The equivalent full time (E.F.T.) faculty count was 67 this year (as compared to 63 3/4 last year), with 35 E.F.T. faculty in Architecture and 32 E.F.T. faculty in the D.U.S.P. The number of women and minority on the faculty continued to grow steadily. There were 10 women on the faculty this year as compared to 8 last year, and the number of minority faculty members increased by 1 to 9. The School maintains its strong support of Affirmative Action policies.

Other academic staff in the School (Lecturers, Instructors, and Senior Lecturers) totaled 20 this year with 14 in Architecture and 6 in D.U.S.P. Of these, there were four women in Architecture and two minority persons in D.U.S.P. The total count is 12 less than we had last year, a reflection of the budget cuts taken by both the departments this year. The School's research staff totaled 10 this year, including one woman, a research associate. Of this total, there were three research staff members in each department and four in the Laboratory of Architecture and Planning.

Students

Student enrollment for 1975-76, based on a count taken during the fall term, was 504. A five year comparison with enrollment figures for 1970-71 shows an 11 percent increase over the total of 453 students that year. This increase reflects the growth of the number of students enrolled in degree programs from 403 in 1970-71 to 454 in 1975-76; the number of special (non-degree candidate) students was 50 for both academic years. (The Community Fellows Program, a non-degree program which usually has 10 to 12 minority students each year, enrolled no students during 1975-76.

Of special note is the increase in women students over the last five years. In 1970-71 there were 84 women students; in 1975-76, there were 147, an increase of 75 percent. Of the 147 women, 88 were in Architecture and 59 were in Urban Studies and Planning. For the School overall in 1975-76, women comprised 29 percent of the student body and members of minority groups comprised 13 percent. These percentages are about the same as last year's. In D. U. S. P. women made up about 35 percent of the student body and minority students made up 21 percent. In Architecture, 26 percent of the students were women and 9 percent were members of minority groups.

During 1975-76, the School enrollment was 5.9 percent of the total M. I. T. enrollment. The School contains 12 percent of the total number of women students enrolled in the Institute. A table of the School's 1975-76 student enrollment and composition is presented below.

STUDENT ENROLLMENT AND COMPOSITION 1975-76+

	<u>Total</u>	<u>Women</u>	<u>%Women</u>	<u>Minority</u>	<u>%Minority</u>
<u>Department of Architecture</u>					
Undergraduates	150	27	18.0	8(0)*	5.3
M. Arch.	110	40	36.4	22(5)*	20.0
M. Arch. A. S.	43	5	11.6	1(0)*	2.3
Ph. D.	5	2	33.3	-	-
<u>Special Students**</u>	<u>26</u>	<u>14</u>	<u>53.8</u>	<u>-</u>	<u>-</u>
Department Totals	334	88	26.3	31(5)*	9.3
<u>Department of Urban Studies and Planning</u>					
Undergraduates	53	16	30.2	6(4)*	11.3
M. C. P.	47	19	40.4	20(7)*	42.6
Ph. D.	46	17	37.0	8(4)*	17.4
Special Students**					
SPURS***	11	3	27.3	-	-
<u>Other</u>	<u>13</u>	<u>4</u>	<u>30.8</u>	<u>1</u>	<u>7.7</u>
Department Totals	170	59	34.7	35(15)*	20.6
<u>School Totals</u>					
Undergraduates	203	43	21.2	14(4)*	6.9
Graduates	251	83	32.9	51(16)*	20.2
<u>Special Students**</u>	<u>50</u>	<u>21</u>	<u>42.0</u>	<u>1</u>	<u>2.0</u>
TOTAL ENROLLMENT	504	147	29.1	66(20)*	13.1

+ Enrollment figures are a count of students registered in the fall.

* (Number of minority women)

** Non-degree candidates

*** Special Program for Urban and Regional Studies of Developing Countries

DEGREE PROGRAMS AND ADMISSIONS

The academic year 1975-76 saw a total of 1,010 applicants for 116 targeted places in the School. Actual enrollment of new students in the degree programs in the fall term totaled 111.

This year's total number of applicants increased by about 40 over last year's. The most notable increase occurred in the M.Arch.A.S. program -- from 86 to 130. The new Ph.D. program, which began this year, had 16 applicants for three targeted places. The number of applicants to the other degree programs held roughly even, for an overall School ratio of applicants to targeted places of about 9 to 1 over these last few years.

The September 1975, February 1976, and June 1976 records of degrees awarded to M.I.T. students show a total of 156 degrees awarded to 145 students in the School of Architecture and Planning. Certificates were awarded to the 11 Fellows in the Special Program for Urban and Regional Studies of Developing Countries (SPURS) for completing a year of study at the Institute. SPURS is a special non-degree program offered by the Department of Urban Studies and Planning.

The Department of Architecture's degree awards were as follows: 46 students received a B.S.A.D. and two received an S.B. as recommended by the Department of Architecture; 33 students received an M.Arch.; and 18 received an M.Arch.A.S. In its first year, Architecture's Ph.D. program conferred no degrees. In the Department of Urban Studies and Planning, 20 undergraduates received the S.B.; 35 students received an M.C.P.; of these, eight students received the joint S.B.-M.C.P. Two D.U.S.P. students received a Ph.D. Two students in the School were awarded both the M.C.P. and M.Arch.A.S., and one was awarded both the M.C.P. and M.Arch. Altogether, 145 of the 454 students enrolled in the School's degree programs this year received degrees.

RESEARCH

In June 1976, the School concluded a year of review and reorganization of its areas of research.

In an approach to foster more integrated and comprehensive research plans, the Laboratory of Architecture and Planning offered each department \$24,000 from the Albert Farwell Bemis Fund as seed money for faculty sponsored research projects which tie into the department's overall plans.

The Department of Urban Studies and Planning outlined broad clusters to serve as the substantive foci for faculty-student research activities. The following clusters have been awarded seed money from the Bemis Fund: Land Use and Environmental Policy; Formal Models in Planning, Regulation, and Evaluation; Land Development Policy in Developing Countries; Community Change and Neighborhood Quality; Urban Homesteading; and Informal Service Networks. The Department of Architecture is still exploring the research areas it expects to develop, and plans to complete its research agenda during the coming academic year. In light of these continuing efforts, the Laboratory awarded Bemis Fund money to a number of faculty whose research already is oriented to current teaching and research programs, including Professor Sandra Howell, for preparation of proposals related to her studies of residential buildings and user behavior, and Professor Anne Vernez-Moudon, for the analysis of rule systems for the design and development of the built environment.

The Laboratory again awarded Bemis Fund money to students for research proposals which were deemed to be both of high quality and relevant to existing curriculum or research activities in the School. A total of \$8,000 was awarded to 12 students.

Overall, the Laboratory continues to serve as a spur for the organized development of research in the School. In addition, it functions as an administrative center to help develop proposals and secure funding, and provides a general resource area for faculty and students. The Laboratory also continues to house a number of ongoing faculty-student research projects, including Innovative Resource Planning in Urban Public Safety Systems and the Arlington Project, and to administer others, including Solar Energy Research on the Exploration of Space Conditions with Variable Membranes, funded by the National Science Foundation, and the Overlap Project, funded by the Department of Defense.

A sampling of the intradepartmental research projects demonstrates that there has been a great deal of activity this year despite the energy that was channelled off to review and reorganize research plans. In D.U.S.P., Professors Suzann and Leonard Buckle began a two-year study of correctional strategies for female juvenile offenders, funded by the Massachusetts Committee on Criminal Justice. Professor Karen Polenske continued her Multi-Regional Input-Output project with funding from the US Department of Transportation. Professor Alan Altshuler, as Principal Investigator, began a project at M.I.T. to develop new perspectives on urban transportation, funded by the US Department of Transportation's University Research Program. In the Department of Architecture, Professors Howell and Chester Sprague received a curriculum award through a grant made by the US Department of Health, Education and Welfare to the Gerontological Society to develop teaching materials on human aging for use in design studios. Professor Negroponte continued to oversee the activities of The Architecture Machine Group, which has received new support from IBM, Bell Northern Research, Xerox, and other industrial sources. Student participation is an integral part of these and many other research activities of both departments.

Overall research funding in the School totaled almost \$1.6 million for 1975-76. The research volume in the Department of Architecture was almost \$500,000, and the volume in the D.U.S.P. was almost \$300,000. Research funding in the Laboratory of Architecture and Planning was \$800,000.

The M.I.T.-Harvard Joint Center for Urban Studies, a vital research unit located several miles from the main M.I.T. campus, continues its housing research and is investigating housing finance, instability in the construction industry, and problems of state and local economies. Current research projects involving members of the School's faculty include: Neighborhood Evolution and Decay (Senior Research Scientist and Lecturer David Birch); Police Reform: A Study of Institutional Change in Urban America: 1870-1970 (Professor Robert Fogelson); Family Income and Social Consumption (Professor Martin Rein); National Housing Goals (Professors Bernard Frieden and Arthur Solomon); Analysis of Land Use Policy Decisions (Senior Lecturer Francis Sargent and Professor Lawrence Susskind); and the Economy of Massachusetts (Professor Bennett Harrison). Professor Solomon has just completed his first year as Director of the Joint Center, and members of the Center's Faculty Executive Committee include Professor Keyes (vice chairman), Professors Altshuler and Frieden, and Dean William L. Porter.

SPACE ISSUES

The School invested much energy this year in developing space plans, both short-term and overall, for the main building complex. The major components of the School's space needs

and strategies have been identified, and requests for the necessary resources for these changes will be made through the M.I.T. Leadership Campaign.

Short term plans call for the acquisition of a number of relatively small spaces, most of them adjacent to current School space and for completion of renovations on the fourth floor of Buildings 3 and 10. About 5,000 square feet of space have been renovated for the School's Environmental Design Group, enabling both the Architecture and Urban Studies and Planning sections of the Environmental Design Group to be together for the first time. The space includes offices, studios, and a conference room, and affords a comfortable and workable area for faculty and students.

The overall plan calls for relocation and consolidation of the visual design section of the Architecture Department with the Creative Photography Laboratory and the Visible Language Workshop in the main complex. It provides for the continued expansion of the Rotch Library, now in quarters which fulfill less than half of its spatial requirements, and for the growth of D.U.S.P.'s offices/seminar/project complexes. Another aspect of the plan calls for the upgrading and renovation of much of the School's existing space which has not been improved since its construction in 1938.

SCHOOL NEWS

The School's Visiting Committee, chaired by I.M. Pei, met December 11 and 12, with 14 of the 18 members attending. The members met with the Dean, Department Heads, other members of the School Council, faculty, students, and Institute officials. The Committee reviewed the teaching and research programs of the School with faculty and students, and gave its support to the revised curriculum programs, the growing school-wide efforts in the area of environment and ecology, and the continued emphasis on research.

Technology Day marked another success in strengthening the ties between alumni and the School. The highlight of the day was the dedication of a new fund in honor of Lawrence B. Anderson, Dean Emeritus of the School. Dean Anderson -- architect, designer, educator, juror, photographer -- has been a guide, a leader, and a source of strength and support for members of the School for more than 40 years. At the Alumni Luncheon, Dean Porter announced the establishment of the Lawrence B. Anderson Fund, which totals about \$50,000, raised through alumni contributions, to be used to enhance the educational experience of students in the School through the support of projects which draw on both academic and nonacademic achievements. In commemoration, Dean Anderson was presented with a three-dimensional plaque made by Professor Maurice Smith.

Minor White, eminent photographer and Professor Emeritus of the School, died in June of this year. One of the most outstanding and creative members of the School over the past decade, he was instrumental in the establishment of the Creative Photography Laboratory, the development of several visual design subjects, and a display of major photographic exhibitions at M.I.T. His contributions and influence will continue to be felt by members of the School and the Institute.

Former Massachusetts Governor Francis Sargent was appointed Senior Lecturer in Environmental Studies at both the School of Architecture and Planning and Harvard University's Graduate School of Design. With the assistance of Lewis Crampton, former Commissioner of the Massachusetts Department of Community Affairs and presently a doctoral candidate in D.U.S.P., he led a series of seminars on land use planning and public policy at the M.I.T.-Harvard Joint Center for Urban Studies. He also is participating in shaping a major conference planned for the coming year.

The distinguished rank of Adjunct Professor was established a year ago at M.I.T. to join practice and theory within the educational programs. The first four individuals to receive this appointment in the School are: State Representative Mel King (Community Organization and Development), Department of Urban Studies and Planning; Edward Pincus (Cinema), Robert Newman (Architectural Acoustics), and Richard Tremaglio (Architectural Design), Department of Architecture.

A number of the School's faculty held appointments on the Institute's Standing Committees of the faculty during 1975-76. They are: Professor Judith Wechsler, Committee on Curricula; Professor Gary Marx, Committee on Educational Policy; Professors Wayne Andersen and Thomas Nutt-Powell, Committee on Graduate School Policy; Professor Leon Groisser, Committee on Nominations; Professor Fogelson (Chairman), Committee on Staff-Administration; and Professor Kevin Lynch, Committee on Student Environment.

In a continuing attempt to upgrade its space and resources, the Rotch Library has moved its visual documents collection to renovated space in Room 7-304, somewhat easing the crowded situation in the Library's main headquarters. The new room, a visual resource center for students and faculty, houses slides, photographs, and selected drawings, as well as facilities for viewing videotapes and slides. A naming ceremony and open house to formally introduce the new facility are planned for next year.

Overall, the School Council and other members of the School spent much of the year planning the School's future direction. The departments continued to review and revise their curricula. Space planning centered around both immediate and long-range needs, and the major goals of the Departments, the Laboratory of Architecture and Planning, the Rotch Library, and the Joint Center for Urban Studies have been set out in detail for use in the M.I.T. Leadership Campaign.

The School is now looking toward the Leadership Campaign as a source of much needed financial support. With recent cuts in general funding and depletion of most of the School's special purpose funds, the future promises little in terms of increased diversity or even continuation of some existing programs without a major infusion of new funds. Professorships, seed funds for research, and support for enlarging and renovating the Library and other space represent the School's major needs. As well, there is great need for support of the activities which put students in contact with practicing members of the professions for which they are preparing. The School is looking forward to working closely with members of the M.I.T. administration and the Resource Development Office to realize the goals of the Leadership Campaign.

WILLIAM L. PORTER

Department of Architecture

The Department of Architecture has both expanded and consolidated its programs and activities in 1975-76, despite tightening financial resources. New formats for decision making have been introduced, faculty have developed new areas of interest, the Master of Science and Ph.D. programs have begun, and application and enrollment figures continue to grow.

Flexibility and breadth of interest continue to characterize the departmental programs. Studios are enriched by the presence of undergraduate students; these B.S.A.D. candidates prepare for the studios through undergraduate subjects in Visual Studies, History, Theory and Criticism, and Technology. The increasing interest of freshmen and sophomores in the Department's offerings is evident after registration day when several subjects are oversubscribed. Thus, it is important that we continue to examine and develop the undergraduate program in order to ensure that we can meet the demand for undergraduate offerings while maintaining high standards of education.

The Department is formulating plans to expand its research activities. The problems in the future of the built environment, in this country and abroad, offer a challenge to faculty and students to extend research.

This year the National Architectural Accrediting Board made an interim visit to the Department. The visiting delegation included John Amundsen, American Institute of Architects (AIA), and Earl Flansburgh, Fellow of the American Institute of Architects (FAIA), ('57). Their report to the Institute endorsed continuance of accreditation for the Master of Architecture program.

Under the new Department Head, Professor N. John Habraken, a number of changes in departmental organization and decision making were implemented this year. Ann Beha, Class of 1975, was appointed to the new position of Assistant to the Head of the Department. Ms. Beha's responsibilities include much of the organizational work for the Policy Committee, the main decision-making body in the Department. The faculty is organized into four Discipline Groups: Architectural Design, Design Technology, History, Theory and Criticism, and Visual Studies. Each of these groups is represented on the Policy Committee. In addition, the Policy Committee contains representatives from the Degree Committees. Composed of student and faculty members, these committees represent each departmental degree program.

The Head of the Department and the Executive Officer serve on the Policy Committee as well as senior and junior faculty members and students. While these latter members do not act as trustees of a constituency, they explain and discuss the decisions of the Committee to the groups with which they work.

The Policy Committee has dealt with issues including the needs for reorganization of the Visual Studies program, the development of flexible faculty positions within a restrained economic climate, and the roles that different areas of the curriculum play in the degree programs. At the close of the year, the Degree Committees submitted reports and recommendations for their programs, some of which the Policy Committee implemented.

In 1975-76, 150 students registered for the Bachelor of Science in Art and Design, and 153 registered for graduate programs. Of the graduate students, 110 were candidates for the M. Arch. degree, 43 for the M. Arch. A. S., 5 for the M. S., and 5 for the Ph. D. One student registered for a joint M. Arch. /M. C. P., and 2 for the M. Arch. A. S. /M. C. P. Forty-four percent of the registered students were women and minorities. The M. Arch. program had 56 percent women and minority enrollment.

The Admissions Committees for the professional programs were composed of students and faculty. For the M. Arch. program, 400 applications from outside M. I. T. were received. Of these, 34 students were accepted, 53 percent of whom were women and minority students. The M. Arch. A. S. program received 143 applications, and 36 were accepted. Thirty-two percent of the accepted M. Arch. A. S. students were women and minority students. The newer M. S. and Ph. D. programs received 24 and 34 applications, respectively. Thirteen students were admitted to the M. S. program, 5 to the Ph. D. program.

There were five doctoral candidates in the Ph.D. in Architecture, Art, and Environmental Studies program which commenced this fall. The Department of Architecture's new degree program emphasizes the study of modern architecture, city design, and art (18th century to present), the theory and method of these fields, and the theory and method of historical and critical studies. The intention is to have a few doctoral candidates working closely with the faculty on mutual research programs when appropriate. Regular faculty in the program are Professors Wayne V. Andersen, Stanford O. Anderson, Judith Wechsler, Dolores Hayden, Henry Millon (on leave), Donald Preziosi, Whitney Chadwick, and Lecturer Gunter Nitschke.

The first five candidates for the new Master of Science program were enrolled in the Department in January 1976. Two students were admitted to the Film program, one to Computer-Aided Design, and two students to Visual Studies.

Space and Facilities

New space has been added to the Department for a variety of M. Arch. related programs. The Environmental Design section of Architectural Design has recently moved into about 5,000 square feet of studio and office space, close to most of Architecture and Urban Studies and Planning facilities. New studio facilities also have been added in Buildings 3 and 10, on the third and fourth floors, adding approximately 3,000-4,000 square feet of additional studio and thesis space.

A new library facility, the Visual Documents Collection (V.D.C.), is housed across from Department Headquarters, in 600 square feet on the third floor of Building 7. This has lightened the burden of the Rotch Library on the second floor, making all slides, photographs, and drawings easily accessible. The V.D.C. also has facilities for viewing videotapes, an increasingly important visual tool.

The Department currently shares Machine Shop facilities with the Department of Ocean Engineering. Instruction and modernized equipment are available, but the shop is still operating in a very limited framework relative to the needs of the School.

Film Section

Lecturer Anne McIntosh received a grant from the Alternate Media Center at New York University to support her work as an intern with the Revere cable TV system. A group of M.I.T. students worked with her on video programs dealing with the current primary elections. Video artist David Cort worked this spring with advanced video students from the M.I.T. community on the construction of video environments, which culminated in a public exhibition in May. This project was funded by a joint grant from the National Endowment for the Arts and the M.I.T. Council for the Arts. Among student projects were an "obituary" of the old Albany Street Draper Laboratory, which formerly housed a shoe polish factory and a documentary on a Logan Airport disaster drill. The section itself has received an \$82,000 grant for three years from the Louis B. Mayer Foundation, for further research on the use of Super 8 and 16mm films in combination with video technology, and for support of film and video artists in residence.

Urbino

Seven students from the graduate school have been selected to participate in the first session of the International Laboratory of Architecture and Environmental Design at the University of Urbino, Italy, next fall. Accompanied by Professor Julian Beinart, they will join about

40 students from Belgium, Spain, Switzerland, and Yugoslavia. The group will work under the direction of Professor Giancarlo de Carlo, an architect from Venice, concentrating on specific problems of architecture and environmental design in areas surrounding Urbino.

Lecture Series

The first annual Lawrence B. Anderson lecture was delivered on May 12 by Josep Lluís Sert, Dean Emeritus of the Graduate School of Design at Harvard University. Dean Sert's topic was "A Habitat Bill of Rights," and the lecture drew more than 400 students, visitors, and invited guests. Deans Sert and Anderson were honored at a reception following the lecture. The series has been established to honor Dean Emeritus Anderson by bringing an outstanding leader in architecture to M. I. T. each year.

Invited speakers from this School in the Department's regular Lecture Series included Professor Donlyn Lyndon, to speak on the Pembroke dormitories; newly appointed Associate Professor Kyu Sung Woo, to discuss the Urban Development Corporation Roosevelt Island Competition; and Research Associate Eric Dluhosch, to discuss Russian Constructivist Architecture. Several members of the School's Visiting Committee spoke about their work and the realities of architectural practice in the 1970s.

Architectural Assistance Program

The Architectural Assistance Program (A. A. P.) continues as a student-run job placement center, primarily for Master of Architecture students. Jobs with private and community clients are advertised and filled through A. A. P. Jobs are generally short term (a few months of part-time work) and paid by the client. The program was directed by M. Arch. students William Sloan and Barbara Putnam.

Level One Studios

Last summer, a study of Level 1 studios was undertaken, funded by curriculum development funds, to develop a comprehensive, integrated introductory program at the studio level. Changes in studio structuring and counselling were implemented this year.

Independent Activities Period

In addition to the wide range of activities offered by the Department for students during the January I. A. P., a special design studio was offered for employees. Professor Jan Wampler, along with teaching assistants P. Nicholas Elton and David Mullman, taught an innovative studio for the secretaries, administrative assistants, and librarians of the greater Department of Architecture (including the Dean's Office, Rotch Library, and several sections of the Department itself). The studio started with 15 students meeting every day for an extended lunch hour from 11 a. m. to 1 p. m. The project was to design a summer house for Professor Leon Groisser, Executive Officer of the Department of Architecture. The course was tailored to this special set of students to guide them through an intensive process of completing a full set of house plans and a model.

Humanitas Seminar

A weekly seminar entitled "Humanitas: An Evolving Perspective" was held throughout the year on Thursdays. The seminar, organized by Professor Wechsler, presented ideas and images of humanity and how they have changed in the development of Western civilization. Professor Wechsler also arranged a symposium on "Science as Drama" at the American Association for Advancement of Science annual meeting in Boston on February 21.

Arts Environments Study

Under direction of Professor Lyndon, the Arts Environments Study has generated a number of proposals for integrated development of arts environments and curriculum at M.I.T. Sponsored by the M.I.T. Council for the Arts, the study has involved the work of a Level III studio and research and design assistance from M. Arch. students over the past three years.

RESEARCH

The Department of Architecture was awarded a grant of \$12,000 from the National Science Foundation to continue research into the heating and cooling of buildings with solar energy. The program is concerned with developing variable building skins which continuously control the amount of solar and thermal radiation entering and leaving a building. These skins also offer the user control over the visual environment through varying the proportions of transparent wall areas to opaque wall areas. This year, researchers concentrated on developing lightweight thermal storage materials that double as structural elements of the building. The materials will store the sun's energy as it streams directly into the interior. Research Associate Timothy Johnson and Professor Sean Wellesley-Miller are co-investigators on the project, and students from the Departments of Architecture and Mechanical Engineering are working with them. The studios generated by the research in this area have been at Level II, introducing a specialized yet evolving technology as an element in the design process.

Under the direction of Professor Nicholas Negroponte, the interests, equipment, and support of the Architecture Machine have continued to expand. Sponsorship by the National Science Foundation, private industry, and government agencies has resulted in an annual operation of \$500,000. This year, the Architecture Machine made an active commitment to links between computers and the Arts.

Professor Anne Vernez-Moudon is conducting an investigation into changes in built environments within specific time frames. Her study, which focuses on Victorian architecture in San Francisco, investigates the extent of physical change over time and the impact of zoning and building regulation of change. The initial phase of the study was supported by the Bemis Fund and staffed through the UROP program. The study will continue in the coming year under a \$10,000 matching grant from the National Endowment for the Arts.

A curriculum development award was provided to Professors Sandra Howell and Chester Sprague to develop teaching materials on human aging for use in Level I design studios. The award was made possible through a grant from the US Department of Health, Education and Welfare to the Gerontological Society (the national association of professionals working in the field of aging). During the 1975-76 academic year, two architecture students assisted Professors Howell and Sprague in designing and testing formats which will illustrate the range of lifestyles and special housing needs of people from middle age on. After testing the formats

in teaching contexts in terms of their impact on design solutions, they will be made available to professionals in the housing industry as well as to other architecture schools. The project is an outgrowth of two years of specialized research on housing experiences of the elderly by Professor Howell and of studio activities by Professor Sprague which included design problems specifically concerned with the older resident/client.

A study sponsored by HUD of the industrialized sector of the building industry was completed under the direction of Professor Arthur Bernhardt, assisted by M. Arch. students. The findings of the study have impacted the curriculum through seminars and studios taught by Professor Bernhardt.

Research Associate Dluhosch is assisting Professor Habraken in developing a research agenda in the housing area on the Stichting Architecten Research (S. A. R.) within a structure of research topics which will be developed in cooperation with the Department's faculty. Among the topics are the application of the urban tissues theory to existing historical urban settings in US cities, and an exploration of new methods for modular coordination in the light of conversion to the metric system, with funding from the National Bureau of Standards.

FACULTY

Three individuals have been appointed to the rank of Adjunct Professor: Richard C. Tremaglio, Adjunct Professor of Architectural Design; Edward Pincus, Adjunct Professor of Cinema; and Robert B. Newman, Adjunct Professor of Environmental Controls. This new faculty position will allow the Department to provide professional expertise within the academic setting.

A number of new staff joined the Department this year, and several appointment changes were made. Anne Vernez-Moudon was appointed Assistant Professor of Architecture to teach design studios and share responsibility with Professor Habraken for a seminar on housing and S. A. R. methodology. Kyu Sung Woo was appointed Associate Professor of Architecture, and taught two studio subjects on mass housing. Glean Chase was Visiting Professor in the Department, and taught a seminar on Urban Phenomena in the Built Environment and a design studio. Michael J. Underhill was promoted to Assistant Professor of Architecture, and served as Chairperson of the Master of Architecture Committee. Jan Wampler received tenure as Associate Professor of Architecture. Eric Dluhosch was appointed Research Associate in the Department of Architecture.

Professor Lyndon was appointed Visiting Professor of Architecture at the University of Maryland. Professor Edward Allen spent a sabbatical leave as a Visiting Professor at the University of Liverpool, England. Professor Beinart continued his research in the Architecture Education Study, funded by the Andrew Mellon Foundation.

Gyorgy Kepes, painter, designer, author, educator, and Director Emeritus and founder of the M. I. T. Center for Advanced Visual Studies, was named the Second Compton Lecturer for the 1975-76 academic year. Professor Kepes discussed "Means and Meanings in Today's Art" in Kresge Little Theatre on December 28.

Artist Otto Piene, Director of M. I. T. 's Center for Advanced Visual Studies, was among the panelists who discussed "Arts and Campus: A National Perspective" at a joint meeting of the American Association of State Colleges and Universities and the International Association of University Presidents.

Muriel Cooper, Media Director of the M.I.T. Press, and Lecturer in the Department of Architecture, has been elected as a judge on a panel of clients and graphic designers to choose the winning entry in an architectural firm brochure competition.

Professor Hayden was awarded a National Endowment for the Humanities Fellowship, from July 1976 to June 1977, to work on a book, Architecture of American Fourierism and Its Influence. She will look at asylums, jails, public park systems, tenement houses, and corporate towns built in the United States between 1840 and 1900.

Professors Allen, Tremaglio, and Millon were on leave. Professor William H. Brown retired from the faculty after more than 30 years of service. He was most recently coordinator of the AIA Scholarship Program and taught a course in production of working drawings.

The Department noted the passing of an instrumental and admired leader, Professor Emeritus Minor White. Professor White died on June 24, 1976, after a long illness. His activities as a photographer and a teacher won him great recognition, and he shaped and nurtured the M.I.T. Creative Photography Laboratory for over 10 years.

On May 12, 200 guests gathered at the Pierce Boat House to honor the 70th birthday and retirement of Dean Emeritus Anderson. The Boat House, designed by Dean Anderson, was transformed into a dinner setting for the occasion, and Dean Anderson, a Francophile and collector of maps, was presented with a book of plans of the city of Paris by Turgot, an 18th Century French cartographer.

STUDENT AWARDS

In December, the School Council awarded \$8,000 from the Albert Farwell Bemis Fund, over \$4,000 of which went to students in the Department of Architecture. Proposals were solicited in November from students for projects to be done in 1976. Criteria for evaluating student proposals included benefits to the School through the development of curriculum material or potential applicability of the research, quality of the proposal, and the ability of the proposer.

The AIA First Prize was shared by Bruce Barker and Julian Smith; hence a second AIA Prize was not awarded. The Alpha Rho Chi medal was awarded to Margo Jones, the Chamberlain Prize to Sam Van Dam, and the Chandler Prize was shared by Rodney Parker and Linda Tuttle. Graham Fund awards were made to Kathleen Born for a study of industrial forms in architecture, Douglas Mahone for a study of buildings on ground, and Robert Osten for a study of log cabin architecture. The Albert P. Hinckley, Jr. Traveling Fellowship was shared by Abraham Ford, Susan Myers, and Denice Wagner.

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N. JOHN HABRAKEN

Department of Urban Studies and Planning

The report of the Department of Urban Studies and Planning (D.U.S.P.) for the 1975-76 academic year emphasized three themes: 1) a need to review the curricula of our three degree programs, 2) an intellectual and financial urgency to develop a sponsored research base within the Department, and 3) a concern to formalize the Department's governance and management processes. These three themes have continued to be the focal points of departmental activity in the 1975-76 academic year and have consumed energy and attention within a context of ever increasing budgetary constraint.

Once again the problem of paying faculty and staff, and providing financial assistance to students and support for departmental activities has consumed extensive energy and time. While D.U.S.P. shares this problem with every other department at M.I.T., the degree to which the financial bind affects the daily life and long term planning of the Department is high. "Creative coping" describes our situation with, hopefully, emphasis on the adjective and not the noun. The report that follows underlines those elements of creativity and of coping which the Department is putting in place within the context of the three major themes outlined above.

The academic year was one in which the curriculum planning of the previous year began to pay off. The core curriculum of the professional degree program, developed in 1974-75, was implemented in fall, 1975 under the guidance of Professor Thomas Nutt-Powell and the M. C. P. Committee.

A study of the Department's doctoral program carried out during summer, 1975 under the direction of Professor Aaron Fleisher resulted in recommendations that research be clustered to improve its continuity and accessibility to doctoral students, and that the faculty advising role be more formalized and broadly based. During 1975-76 the Doctoral Committee under Chairman Professor Donald Schon implemented these proposals.

The Undergraduate Program under the leadership of Professor Robert Hollister instituted a new combined program with Civil Engineering in environmental management, transportation, urban public systems, and project construction and management.

Governance Processes

A major concern has been in opening up the governance process to ensure full debate and discussion on major issues in the Department, including financial aid, admission processes, new appointments, and course requirements. The Policy Committee, made up of representatives from the major committees in the Department, has served as the forum for discussions and resolution of such items. The major topic during fall, 1975 was the development of alternative long range plans for the Department. It had become increasingly clear that without such a document discussions of the next year's budget had no framework within which to operate. In order to get a sense of the issues that the Department would have to confront under different assumptions, it developed alternative five year plans -- one assuming limited growth, the other significant expansion.

The process of planning the two scenarios with financial implications of each was important in alerting faculty and students to the financial limitations of the Department. On the other hand, the process indicated areas where the Department could realistically expand its efforts, and provided a context for the realization of those efforts.

Financial aid for graduate students in both the M. C. P. and Ph. D. programs was a major issue for the Policy Committee during 1975-76. With both M. I. T. and outside funding increasingly constrained and with rising tuition and living costs, the Department is only able to offer entering students minimal financial aid. An indepth review of present financial aid policies resulted in the retention of the "equity" policy adopted in 1973. The resulting level of aid was insufficient, however, particularly in view of reduced availability of outside funding to students in the field of urban studies and planning. The issue of tuition costs and financial aid, particularly for students in the doctoral program, remains an important problem which must be addressed again in 1976-77.

Undergraduate Program

At the start of 1975-76 there were 53 undergraduates majoring in Urban Studies. Eleven received the S. B. in February and May, and 7 received the S. S. and M. C. P. simultaneously through the Department's five-year Bachelors-Masters program.

The program terminated the concentration that it had offered in Health Care Delivery. The remaining four concentrations were broadened to make them more appropriate areas of specialization for undergraduates. Important additions to the curriculum included: 11.142 Introduction to Community Development taught by Professor Frank Jones and 11.197J State

and Local Politics Internships taught by Professors Alan Altshuler and Martha Weinberg (Political Science) and Lecturer Mel King.

A number of students enrolled in the new combined S.B. program in Urban Studies and Planning and Civil Engineering. Participants are awarded a degree in one department or the other, and they receive a letter confirming that they have completed the requirements of both departments.

A committee of Architecture and D.U.S.P. faculty began organizing a School-wide undergraduate program in Environment and Policy that will build on existing strengths in the Departments. It will help students whose interests cross-cut architecture and urban studies. Next year students in either department will be able to pursue a specialization in Environment and Policy.

Extensive surveys of alumni and present undergraduates guided program improvement efforts during the present year. (Complete reports on the surveys are available.) The alumni survey inquired into the post-M.I.T. employment and education of D.U.S.P. majors who graduated between 1971 and 1975. It documents the variety of fields that graduates have entered. Eighty percent have received, or are enrolled in, advanced degree programs. Sixty percent entered graduate school immediately upon completion of their S.B., and the rest worked for a year or more before entering graduate school. Thirty percent have received or are presently working toward advanced degrees in urban planning, 22 percent in law, 10 percent in business and management, 10 percent in medicine, and 28 percent miscellaneous. Employment rates have been high even during the recent economic recession, with an average first salary of \$13,600 for graduates with an advanced degree, and \$10,300 for S.B. only in both the public and private sectors.

Priority issues on the 1976-77 agenda of the faculty-student committee which oversees the undergraduate program include: a review of the present scope of the program; inquiry into how it presently serves students taking a Humanities concentration in Urban Studies; consideration of alternative ways to improve Humanities concentrations, and review and improvement of student research and fieldwork activities.

M. C. P. Program

In 1975-76, after a year and a half of planning, the M.C.P. curriculum was initiated. Entering M.C.P. students were required to take three core courses in fall, 1975: The Planning Process, Economic Analysis for Planners, and Methods for Urban Studies and Planning. At an open review session held in January 1976, it was concluded that core courses prepared M.C.P. students in basic knowledge and the ability to apply such knowledge in a planning context.

The planning process course required each student to prepare a plan for personal professional development. Within this context students and advisors developed specializations within each of the three program groups. As might be expected with a group of students with diverse interests and backgrounds, a broad array of specializations developed.

Guidelines for the M.C.P. thesis were revised and published during fall, 1975. The new guidelines were written to encourage professional degree students to write theses linking their academic activities to professional practice and their own field experience. The thesis activities of second year M.C.P. students were monitored in a study undertaken by Professor Nutt-Powell with support from the Lilly teaching program. Professor Joseph Ferreira conducted a study of the M.C.P. admission process in order to refine admission criteria. The Department received 267 applications to the M.C.P. Program, 160 from men,

107 from women, 57 foreign, and 56 minority. Thirty-eight offers for admission to the M. C. P. Program were made. Of those offers 22 were to women, 16 to men, 25 to minorities, and 3 to foreign students. Two students were admitted to the S. B. /M. C. P. Program for the coming fall by the S. B. /M. C. P. Committee. Additionally, six students were approved for admission to the joint degree program.

In the fall, 47 students were enrolled in the M. C. P. Program, 20 of whom were minority, and 10 from foreign countries.

Ph. D. Program

The year 1975-76 was a significant one for the doctoral program. It was a year in which some of the benefits and costs of new directions were discerned and new issues of the Department identified. The Summer Study of 1975 had proposed several measures to strengthen the program: 1) to tighten up requirements so as to support students in moving expeditiously through the program; 2) to build research clusters which would become foci for student/faculty inquiry; 3) to increase the scale of the program and the research interest groups; 4) to facilitate informal support groups among doctoral students.

The first-year seminars are solidly established. Student response is more positive than negative, but the negative voices are important and should be taken into account in future design of the seminars.

Future progress depends on the ability to grapple with two concerns. The first need is to define the program's substantive directions. Individual programs are still custom made. Some argue that the lack of defined direction fosters freedom of inquiry and is good. But there is a real danger that, in failing to engage the problems of direction and design, it will not be possible to integrate individual interests into a unified doctoral program in urban studies and planning. The development of the research cluster may help in this endeavor. Second, the Doctoral Program may well be facing a crisis of financial aid. Progress depends on maintaining or even increasing present scale, without reducing quality. The Rodwin report on applications and acceptance, the Nutt-Powell report on enrollment growth, and the Doctoral Committee's report on Leaves of Absence help to define the related issues. Salvation lies in finding ways to reduce tuition burden on thesis writers, to increase the level of reimbursement available to graduate students working on Institute research projects, and to draw new research and training money into the Department.

The Department received 98 applications to the doctoral program for 1976-77, 72 from men, 26 from women, 40 foreign, and 24 minority. Twenty-five offers of admission were made. Of those 9 were to women, 16 to men, 5 to minorities, and 9 to foreign students. Nineteen accepted admission, 7 women, 12 men, 7 minority students, and 7 foreign students.

During 1975-76 there were 46 students enrolled in the doctoral program. An additional 30 degree candidates, although on leave of absence, are anticipated to complete their dissertations.

Community Fellows Program

The Community Fellows Program (C. F. P.), a special non-degree program in the Department of Urban Studies and Planning for minority community activists and government officials, was inoperative during 1975-76, while a funding strategy was being implemented to give this unique mid-career program greater permanence at M. I. T. Recently the Rockefeller

Foundation awarded a two year grant amounting to \$200,000 to M.I.T. for continuation of the program. These funds will carry C.F.P. forward, while M.I.T. raises a \$4 million Social Equity Fund. The Fund, part of the Institute's Development Fund Drive, also will provide money for other minority programs at M.I.T.

The basic mission of C.F.P. remains unchanged: to provide the 10 or 11 Fellows with an opportunity to use the full range of resources available in the Department and at the Institute.

Using both human and technical resources at M.I.T., the Fellows work on a development-research project relevant to their "back home" situation, supervised by faculty members. Critical to the success of C.F.P. is the time provided each Fellow for reflection, reading, and resource exploration. Time for these activities is especially rare for community activists, who often are immersed in crisis-ridden projects and events.

Approximately one half of the Fellows will be minority government officials whose work is related to the development needs of minority communities in America. These will include persons both from administrations headed by black mayors and other state and federal agencies. Mutual learning for minority government officials and community activists is critical if public funds are to be distributed effectively to develop organizations in minority communities.

The major modifications in C.F.P. for the coming year will be in its composition and physical location at M.I.T. C.F.P. will be located on the Main Campus, in Building 7, Room 341. This change will give the Fellows, D.U.S.P. students, and faculty greater access to one another and should solidify the Fellows' presence in the D.U.S.P. family. The August orientation program will be lengthened to include mini-courses in management, communications, economics, and leadership development.

SPURS Program

The Special Program for Urban and Regional Studies of Developing Areas (SPURS) is completing its ninth year. The program started as an experiment funded by the Ford Foundation, and the Department has now absorbed the full faculty costs of the program.

To date, the Program has served 105 Fellows and 10 Associates from 42 different countries. Forty-four of the Fellows had backgrounds in City Planning and Architecture, 42 in Economics and Social Sciences, and the remainder came from Engineering (11) and other fields (8).

The program's four main accomplishments have been: to provide qualified and experienced professionals with an opportunity to deepen or broaden their skills and perspectives by spending one year at M.I.T.; to ensure adequate recognition by the Department of the social and professional importance of the urban and regional problems in developing countries; to enrich the experience of our regular degree students, especially of those who plan to specialize in problems of less developed countries, and to increase SPURS visibility during its early formative years.

This year, out of the three women and eight men from nine countries who participated in SPURS, nine were Fellows from Ghana, Nigeria, the Phillipines, Colombia, Saudi Arabia, Mozambique, and Kenya. The two Associates were Yevgeni Malinin from the USSR and Ricardo Diaz-Zoido from Spain. A goal of the SPURS program is to raise funds for five SPURS fellowships each year. In addition, SPURS will admit an equal number of persons financed by their own governments or by international agencies. Financial support also

would make it possible to give firm and independent support to those back-up services which are so important to the program.

Program Groups

The three program groups -- Public Policy Analysis, Environmental Planning and Design, and Community and Regional Development -- continued to provide impetus to the activities of the research clusters, develop new courses, and review applications for the two new faculty positions.

The search to fill full-time junior appointments in the Environmental Planning and Design Community and Regional Development groups is still in progress. Development economist Alan Strout has been appointed lecturer for academic year 1976-77. He will teach in the area of rural development and development project analysis.

Independent Activities Period

Professor Kent Colton undertook planning and coordination of the Department's I. A. P. program during January 1976. High points of I. A. P. included mini-courses on City Life in China and the Future of American Cities, and a series of lectures and films examining the James Michael Curley era in Boston history coordinated by Professors Hollister of the D. U. S. P. and Martha Weinberg of the Department of Political Science.

A day long workshop sponsored jointly by M. I. T. and the Massachusetts Foundation for the Humanities and Public Policy focused on the issues of Growth Policy and Land Use Management in Massachusetts and utilized the extensive film and cable television capabilities of the Center for Engineering Studies.

RESEARCH

The School Council decided this year to utilize the Bemis Fund for research seeding in the School's two departments. The Fund previously focused on student and joint student-faculty research proposals, but the new direction will be to use the funds as leverage for proposal writing and funding for more structured, department-wide research activity. Six of the research clusters which emerged from the process and requested funding were Land Use and Environmental Policy; Formal Models in Planning, Regulation, and Evaluation; Land Development Policy in Developing Countries; Community Change and Neighborhood Quality; Urban Homesteading; and Informal Service Networks.

The first real return from the seeding occurred in the Land Use and Environmental Policy group which, under the direction of Professor Lawrence Susskind, was awarded a three year contract with the Energy Research and Development Administration in spring, 1976 to study the "Environmental and Community Service Impacts of Energy Facilities." The cluster concept should result in a higher level of research funding and then help to ease the current financial pressure on faculty and students.

Major research in the Department included a project headed by Professor Colton sponsored by the National Institute of Law Enforcement to study uses of the computer by police departments. Sponsored by the Massachusetts Committee on Criminal Justice, Professors Leonard and Suzann Buckle evaluated several programs for female juvenile offenders. Professor

Thomas Willemain, under the auspices of Boston City Hospital, did research on modeling of medical care delivery systems. Professor Karen Polenske continued her Multi-Regional Input-Output research project with funding from the United States Department of Transportation. Professor Richard Larson completed his major research project with the National Science Foundation on Innovative Resource Planning in Urban Public Safety Systems.

In addition to the above contracts and grants which were carried out under the auspices of the Department, individual faculty were engaged through the Joint Center for Urban Studies and the Transportation Center.

FACULTY

Professor Alcira Kreimer joined the faculty in September 1976, teaching courses in Environmental Design with a joint appointment in the Departments of Urban Studies and Planning and Architecture.

Professors Colton, Ferreira, Michael O'Hare and Gary Hack were promoted from Assistant to Associate Professor. Lecturer Mel King was appointed Adjunct Professor. Professor Robert Fogelson was promoted from Associate to Full Professor.

Department faculty continue to participate in the activities of the American Institute of Planners and the American Society of Planning Officials.

Awards

Professor Philip Clay	Lilly Teaching Fellowship
Professor Kent Colton	White House Fellowship US Treasury Department Meritorious Service Award
Professor Joseph Ferreira	Class of 1922 Assistant Professor, July 1974-June 1976
Professor Bernard Frieden	Guggenheim Fellowship, 1975-76, at the University of California, Berkeley
Professor Frank Jones	Doctor of Humane Letters, May 23, 1976, Trinity College, Hartford, Connecticut
Professor Hubert Jones	American Civil Liberties Union Alper Award for Distinguished Public Service Massachusetts Association for Retarded Persons Public Service Award

Lecturer Mel King

Roxbury Action Program

Massachusetts College of Art
Student Award

Assistant Professor Thomas Nutt-Powell

Lilly Teaching Fellowship

Associate Professor Mary Potter

Distinguished Lecturer at the
University of Richmond, Virginia

FUTURE PROSPECTS

The year has been one of consolidation and reflection upon the directions in which the Department should move in an era of scarce resources. The energy spent developing alternative five-year plans is indicative of this concern. Reflections upon the future were made even more urgent this year by the realization that 21 (well over half) of the Department's faculty would come up for tenure review during the next seven years. What emerged in the formulation both of the five-year models and a review of the 21 individuals by the senior faculty was recognition of the need to strengthen the Department's resources in its traditional center of activity, namely urban growth and land use policy, and to extend these resources into emerging issues of environment, energy, and development planning. A systematic look at the area of faculty expansion during the late 1960s and early 1970s showed evolving strength among tenured faculty in the public policy analysis area. Yet at the same time, with the retirements of Professors John Howard and Fred Adams and the promotion of Professor William Porter to Dean, the environmental design and policy area was significantly reduced at the senior level. Issues of urban growth and the environmental impact of built facilities always have been central to the Department's mission. There are increasing societal needs and demands to deal with these issues.

A major conclusion then of the Department's self analysis has been a recognition of the need 1) to deepen our efforts in the environmental area, 2) to bring to bear the Department's competence in analytic techniques and knowledge of institutional behavior on issues of urban growth and control, 3) to find ways of cutting across program group lines within the Department to focus more explicitly on environmental issues, and 4) to search for new ways of extending across departmental boundaries to link into the environmental focus of other departments, primarily Civil Engineering and Political Science, in addition to the existing links with Architecture.

A year ago, there was a sense of excitement about core courses and the consolidation of the curriculum in the Department. That positive atmosphere is still present. But what is needed now is a sense that the research clusters can pay off in dollars for high priority problems. Some major successes are needed in this area. Professor Susskind's ERDA contract is a major first step. There is a commitment to do all that is possible to bring in research funds, but beyond a certain point the Department is hostage to the research environment. Hopefully there will be a renewed commitment at the national level to the problems of the urban environment and thus a basic change in the availability of financial resources. Scrambling for research dollars has become an integral part of life in an academic institution. The Department's hope is that it can not only be successful in that scramble but also maintain the quality of life in the process.

LANGLEY C. KEYES

Laboratory of Architecture and Planning

This was a year of reflection and redirection for the Laboratory of Architecture and Planning, a year not of growth, but of planning for growth, a year of redefinition of goals and purposes. With the guidance of the new School Council, the Laboratory became better integrated with the programs of the departments, which in turn organized themselves around the research goals that the Laboratory is designed to foster.

For the first two years of the Laboratory's existence, the Albert Farwell Bemis Fund was used to make grants to faculty and students in the School, and to raise the awareness of members of the School about the potentials of research in architecture and planning. This year the fund was used as an inducement to the departments to direct research in a more formal way. Each department was offered \$24,000 as seed money for research projects on the condition that the department produce and implement a long-term research plan which would relate well to the instructional program and would involve a large portion of the faculty and graduate students. The potential of the plan to attract outside support for research was also deemed important.

The Department of Urban Studies and Planning developed a number of research clusters, groups of faculty and graduate students with interests in a particular area or topic of research, each of which was given a Bemis award.

Developing Countries Cluster: Land Development Policy in Developing Countries, coordinated by Professor Ralph Gakenheimer - the analysis of the match between objectives and consequences of applying land development policies and controls.

Public Policy Cluster: Informal Service Network, coordinated by Professor Hubert Jones - the study of the long overlooked networks of social services provided without the aid of government or organized sponsorship.

Environmental Design Cluster: Community Change and Neighborhood Quality, coordinated by Professor Alcira Kreimer - focusing on the notion of neighborhood, the consideration of the quality of life in a particular neighborhood as it is tied to regional conditions and historical changes.

Housing Cluster: Evaluation of Urban Homesteading, coordinated by Professors Lloyd Rodwin and Ian Donald Turner - the description and evaluation of urban homesteading experiences and the analysis of federal, state, and local homesteading legislation.

Land Use and Environmental Policy, coordinated by Professor Lawrence Susskind - to focus on the institutional aspects of land use and environmental policy formulation and implementation.

Formal Models in Planning, Regulation, and Evaluation, coordinated by Professors Joseph Ferreira and Thomas Willemain - to study the role of formal models in planning by considering issues in the regionalization of health services, the examination of a range of regulatory questions to determine which are most amenable to formal analysis, and the evaluation of field experiments in policing.

The Department of Architecture did not organize research clusters this year, but made a commitment to do so in 1976-77. Faculty members in Architecture who received Bemis awards were:

Professor Maurice Smith - to develop a "Built-Form Manual" which would classify and illustrate a design vocabulary for architectural design students.

Professor Sandra Howell - for the preparation of research proposals to analyze existing residential environmental data by systematically describing similarities and differences in residential buildings relative to user behaviors, the development of a spatial typology for intersite comparison, and the generation and testing of specific hypotheses based on unique spatial configurations within each building.

Professor Anne Vernez-Moudon - to analyze the establishment of rule systems (the themes, the grammar or organizing principles) for the design and development of the built environment. Bemis funds will supplement a grant from the National Endowment for the Arts for fiscal year 1976-77.

Professor Jan Wampler - for the study of growth patterns in vernacular buildings.

Professors Tunney Lee and Anne Vernez-Moudon - for an historical analysis of physical change in the North End of Boston, an inventory of its activities and social institutions, and an identification of the internal and external forces acting on the community.

In addition, 12 Bemis awards were made, totaling \$8,000, for student projects which included:

Rasit Raci Bademli, D.U.S.P. - for the completion of his Ph.D. dissertation, "Petty Production in Underdeveloped Countries."

Margaret Dewar, D.U.S.P. - for a study of the effectiveness of enabling legislation for agencies which issue industrial revenue bonds.

Dana Driskell, D.U.S.P., and Wesley Henderson, Architecture - for the development of a conference on minority students and practitioners in the architecture and planning professions.

H. Bin Kang and Jonathan Mathews, Architecture - to investigate the evolution of the Spanish grid in colonial Latin American cities.

Sheldon Klapper, Architecture - to study the role of the building inspector in the development of self-help housing.

Jennie Lew, D.U.S.P. - for the production of a videotape documentary on the problems of Boston's Chinatown.

Micheline Papadakou, Architecture - to investigate the environmental, social, physical, and economic criteria for success of streets in residential areas.

Alison Quoyeser, Architecture - to trace the evolution of nineteenth century American and British concepts of insanity and treatment of the insane through the study of the design of asylums.

William Ronco, D.U.S.P. - to explore how small, worker-controlled organizations execute theories of shared control and participation.

Ellen Shoskes, Architecture - for the production and evaluation of a health education film to promote consumer participation in a Boston Community Health Center.

Tomasz Sudra, D.U.S.P. - for the completion of his Ph.D. dissertation, "Low Income Housing System - User Priorities and Existing Supply, the Case of Mexico City."

William Tibbs, Architecture - for the documentation of the physical and architectural environment of Boley, Oklahoma, an all-black town founded at the turn of the century.

Newly funded and ongoing research projects in the Laboratory include: the Overlap Project, directed by Dean William Porter, with John Klensin, of the Division for Study and Research in Education, and D.U.S.P. Lecturer Wren McMains as investigators, had a volume this year of more than \$480,000, mostly sponsored by the Department of Defense. The project is continuing a program of research in interactive computer tools for data analysis. The system, designed so that all its facilities can be used together and so that it can be extended in needed areas (the Consistent System), includes: the DISCOURSE urban data management language; a powerful data management and analysis facility for survey data, called JANUS; and extensive, statistical, linear programming and automatic text analysis facilities. This system is unique in that it permits the handling of many complex problems that would otherwise require special purpose programming. Several problems of this sort which recently have been explored include: joint use of geographic and survey-like data bases to prepare for a linear optimization problem in full supply management, and the use of relational capabilities to link the results of several surveys on educational effectiveness in combination with the advanced statistical analysis tools.

The Innovative Resources Planning Project, funded by the National Science Foundation (NSF), this year with a volume of \$145,000, is using operations research techniques to examine resources allocation problems in urban police, fire, and health service systems. This project, directed by Professor Richard Larson, is expected to be completed in the next fiscal year.

Solar energy research on the Exploration of Space Conditions with Variable Membranes, directed by Professor Sean Wellesley-Miller and Research Associate Timothy Johnson, is funded by the NSF with an 18-month grant of \$112,000. The program is concerned with developing variable building skins which continuously control the amounts of solar and thermal radiation entering and leaving a building. These skins also offer the user control over the visual environment through varying the proportion of transparent to opaque wall area.

The Architectural Education Study, funded by the Mellon Foundation, directed by Dean Porter and Dean Maurice Kilbridge of the Harvard Graduate School of Design, is a project undertaken by a consortium of eight east coast architectural schools to analyze existing approaches to architectural education and to develop a basis for innovation.

The Cambridge Urban Observatory, jointly sponsored by M.I.T. and the City of Cambridge, is a collaborative effort to provide research capability for Cambridge. Professor Aaron Fleisher is studying the deployment of police in response to patterns of demand and some unique goals set for the Cambridge Police Department. Professor Willemain is examining the roles of Cambridge's Neighborhood Health Center with respect to the out-patient services provided by the Cambridge City Hospital.

The Arlington Project, a planning venture within the Citizens Involvement Committee of Arlington, directed by Professor Lawrence Susskind, is an effort to develop new modes of broad-based participation in local planning decision making.

WILLIAM L. PORTER

School of Engineering

During the 1975-76 academic year, the School of Engineering continued the development of its primary goal of furthering, through research and education, the evolution of the engineering profession -- the state of the art of engineering and the foundations upon which engineers build. This year's report touches only briefly upon major developments and instead addresses the growing constraints which seriously hamper our work and place increasing strain on students and faculty alike.

During the past five years, the student body of the School has grown in number by 19 percent, and recently at an increasing annual rate. This must be seen in a long term perspective of a 25-year time frame. The School's undergraduate enrollment grew rapidly in the early 1950s, reaching a high of about 1,700 toward the end of that decade. It then dropped just as rapidly, reaching a level of about 1,200 in the early 1960s and held this level through the end of the decade. The undergraduate enrollment then dropped again reaching its minimum of about 1,100 in the 1971-72 academic year. Since then the enrollment has grown to almost 1,500, a compound growth rate of almost 7 percent per year. Graduate enrollment increased steadily from about 800 in the early 1950s to about 1,600 in 1965, and then held constant until the 1973-74 academic year. Since then, the School's graduate enrollment has grown to exceed 1,700. During the fifties, the size of the School's faculty grew rather steadily from about 220 to 336, and has fluctuated around this level for the past decade.

Looking at the recent past, we see that in the 1974-75 and 1975-76 academic years, the School's undergraduate enrollment increased by 11.3 percent and 6.4 percent respectively. In 1975-76 the School enrolled 48.9 percent of the Institute's designated undergraduate students and 47.9 percent of its graduate students. At the same time as this substantial increase in student enrollment was occurring, the School also experienced a 20 percent increase (current dollars) in research funding attributable to its faculty members.

The increase in undergraduate enrollment was due in part to growing interest in engineering, particularly among sophomores. In the academic years 1973-74, and 1974-75, 35 and 36 percent, respectively, of all sophomores chose to enroll in one of the departments of the School of Engineering for their major course of study. In the 1975-76 academic year, 43 percent chose engineering. The other primary factor associated with this increase resulted from an Institute decision to increase the total undergraduate enrollment by about 10 percent over a four-year period. As a result of this, the number of sophomores increased from 980 in academic 1974-75 to 1,156 in 1975-76.

The largest percentage growth in undergraduate enrollment was in the Departments of Chemical Engineering (47 percent), Civil Engineering (15 percent), and Mechanical Engineering (15 percent). The largest jumps in graduate enrollment were in Aeronautics and Astronautics (25 percent) and Nuclear Engineering (32 percent). The increase in Nuclear Engineering partly resulted from a special program to educate 20 Iranian students in nuclear engineering.

Based on trends in research volume and undergraduate student interest, it is anticipated that the School's enrollment will continue to increase substantially during the next few years. About 1,800 undergraduate students, a reasonable expectation for the 1978-79 academic year, would be the School's highest enrollment in the last 25 years. Trends of the research volume suggest that the number of graduate students will stay at the present level or even increase.

SCHOOL-WIDE EDUCATIONAL ACTIVITIES

This increase in enrollment must also be attributed, in part, to the recent evolution of the educational programs of the School. Changes made on departmental programs are reported by the individual departments. In addition, the Office of the Associate Dean for Educational Programs served as a focal point for a number of School-wide educational activities including 1) curriculum development, 2) resource development for support of students and faculty, 3) development of the student pool, 4) liaison between the Office of the Dean and the faculty, and 5) alumni programs.

Curriculum Development

The School's Self-Appraisal Study identified action items appropriate to the Office of the Associate Dean for Educational Programs. Chief among these were a School-wide dual degree program and a School-wide cooperative education program. The dual degree program is intended to be an enhancement program in which S. B. degree candidates who satisfy the requirements of two departments in the School would receive a single bachelor's degree with specification of the two fields of study. A proposal for implementation of the program was presented to the Committee on Educational Policy and was favorably received except for the ad hoc nature of the program. To protect the students enrolled in such a program and to ensure the quality of the program, it was recommended by the C. E. P. that specific curricula be given in detail in the catalogue. Negotiations are currently under way between pairs of departments that wish to develop such programs. These include Mechanical Engineering with Materials Science and Engineering and Civil Engineering with Ocean Engineering. A finalized program will be presented to the C. E. P. in fall, 1976.

In recent years both industry and students have shown growing interest in cooperative education programs. Based principally on its long experience with such a program in the Department of Electrical Engineering and Computer Science, the School of Engineering recognizes the significant educational benefits to be derived from this mode of education. In order to extend these benefits to the other seven departments, Engineering Council decided to develop a School-wide program of cooperative education, but discovered that the detailed procedure for the implementation of such a program had not been considered. To begin with, there is little agreement between the departments as to what a program of this type should entail. It is generally recognized that the student should obtain some professional experience, but each department views the nature of this experience differently. Some departments feel this experience should be research oriented, while others regard the design experience as more valuable. Still others view the experience of "practice" as more valuable.

To further complicate this situation, there is clearly no one style of operation that will suit the needs and the lifestyles of all departments. One department feels that each participating company should have a faculty liaison, while another feels that its faculty resources are already too heavily stressed to provide such supervision. Companies consulted on the matter were nearly evenly divided, with some wanting close faculty contact and others regarding it as an intrusion. The departments also differ in their views of the extent of the work assignment. Some feel that assignments should be six months in length while others feel that their inability to provide substantial subject offerings during the summer months necessitates limiting work assignments to the summer only. Companies consulted on this matter shared this spectrum of view.

Thus it appears that while the concept of a School-wide cooperative program is good in principle, it is virtually impossible to implement. Alternatively, this office therefore has

served to coordinate the various cooperative programs developing in the departments, and made available a common pool of resources to assist the departments. For example, it has been instrumental in bringing Draper Laboratory together with the Departments of Civil Engineering and Mechanical Engineering for the development of a cooperative program. Also Ford Motor Co. and Schlitz Brewing Co. are being brought on board for the Department of Mechanical Engineering.

In other matters of curriculum development, this office established a faculty committee, chaired by Professor Klaus-Jurgen Bathe of the Department of Mechanical Engineering, for development of a School-wide subject in the computer modeling of engineering systems. Interest in this subject was stimulated by its commonality among the departments and the need for the departments to share responsibility for instruction instead of dropping the burden on one single department. The objective of the subject is to educate students in the area of computer simulation and computer modeling and to demonstrate the broad applicability of the basic engineering sciences. A syllabus of instruction and possible staffing arrangements have been developed. The subject will be offered in spring, 1977.

The growing involvement of School faculty in the field of bioengineering and the rapid growth of the field itself, have led to the development of a new graduate curriculum in Medical Engineering and Medical Physics. This five year doctoral program is intended to educate the engineers who will be working side by side with physicians in the delivery of health care and in the generation of new knowledge relevant to health care delivery. Leading to a doctorate granted by the Program in Health Sciences and Technology, the new program differs from present bioengineering degree programs in that it is more highly structured in terms of subject requirements and has a larger life science component. In the first two years of the program (which is yet to be approved by the appropriate faculty bodies), students will work on an S. M. degree in one of the eight engineering departments. Two years will be required to complete the S. M. degree because of the additional life science requirements imposed by the program. At the end of the two years, students passing the qualifying examinations in the Program in Health Sciences and Technology will begin a year of clerkships in a hospital setting. The fourth and fifth years of the program will consist of thesis research. School of Engineering faculty participating in the development of this program are Professors Gordon L. Brownell (Nuclear Engineering), Clark K. Colton (Chemical Engineering), Roger G. Mark (Electrical Engineering and Computer Science), Charles M. Oman (Aeronautics and Astronautics), and Laurence R. Young (Aeronautics and Astronautics).

In the field of energy, curriculum development was enhanced by the recent institutional grant from the Energy Research and Development Administration. Given the modest funds made available from this grant for educational programs, only two efforts could be started, both under the direct supervision of an Institute-wide faculty committee chaired by Professor Kent F. Hansen of Nuclear Engineering. This committee has reviewed the subject descriptions of all subjects offered at the Institute in the general area of energy. Voids and weaknesses were identified and two areas for curriculum development were selected. In the first of these, Professors Mildred S. Dresselhaus and David Adler, both of the Department of Electrical Engineering and Computer Science, and Professor H. Kent Bowen of Materials Science and Engineering, are developing a subject on Materials for Energy Technology. In the second effort, Professor Patrick M. Hurley of Earth and Planetary Sciences is developing a subject dealing with energy resources. Both subjects will be offered in the 1976-77 academic year.

A special summer program entitled Energy for Energy Decision Makers has been developed. Drawing its faculty from five of the School's eight departments, the subject is intended to present a holistic view of energy issues to individuals involved in the decision-making process in the field of energy. Registrants drawn from eight different countries include senior administrators from ERDA, FEA, the U.S. Regulatory Commission, and the major government laboratories and their counterparts abroad.

Technology and Policy Program

The new Master's Degree Program in Technology and Policy successfully completed its initial year in 1975-76. A cooperative venture between each department in the School and colleagues in the social sciences, it represents one of the School's tangible efforts to create integrated educational activities between the social sciences and engineering. Much of the first year's effort was devoted to developing and expanding the program's necessary core subjects in systems analysis, policy-making processes, and the Proseminars. The Alfred P. Sloan Foundation extended and renewed its supporting grant this year.

Resource Development for Support of Students and Faculty

This office has taken the initiative to develop resources to provide greater support for students and faculty in the educational programs of the School. For example, the office supervises the General Motors Scholars Program in which each year 10 second-year undergraduates, principally from the School of Engineering, are selected on the basis of merit for full tuition support for the third and fourth undergraduate years with summer employment at General Motors between those years.

The office also negotiated a graduate fellowship program with the Weyerhaeuser Corporation. Each year one first-year graduate student from the Department of Mechanical Engineering and one from the Department of Chemical Engineering will receive three-year fellowships in the amount of \$10,250 per year. Negotiations are in progress for a more modest program sponsored by the Grumman Corporation.

At the postdoctoral level, the School of Engineering supervises jointly with the School of Humanities and Social Science, the Mellon Postdoctoral Fellowship Program. This program is intended to provide support for scholars working at the interface between engineering and the humanities and social sciences. During academic year 1975-76, the program supported four fellows, all recent recipients of the doctorate in humanities who wished to deal with issues central to the engineering professions. For the 1976-77 academic year, it was decided to seek holders of engineering degrees who wish to work at this interface, especially those already involved in programs of the Institute. Four such candidates have been selected for appointment as Mellon Fellows and await confirmation by their respective departments.

Development of the Student Pool

In recent years, the engineering professions have been in a growth mode, as reflected in the increasing undergraduate enrollments in the eight engineering departments. Despite this trend, the pool of students from which the School draws its enrollment and the professions draw their engineers may not be as large as it could be. M.I.T.'s School of Engineering as well as the professions recognize their responsibility to inform young people of opportunities in the engineering professions, so that young people can make rational decisions concerning career options.

The School has established two programs directed toward this end at the high school level. The first, the Minority Introduction to Engineering Program, is specifically designed for minority students showing skill in mathematics and science and who might be interested in engineering as a career. This two-week program introduces 40 selected minority high school students to the eight fields represented by the departments in the School and exposes them to the nature of engineering practice. It is sponsored jointly by the Engineer's Council for Professional Development and the School of Engineering. The second program is directed toward a broader audience and is intended to introduce high school students to the design aspect of engineering. With the assistance of Professor Woodie Flowers of the Department of Mechanical

Engineering, a two-week summer program was developed to teach high school mathematics and science instructors to integrate subject material through design contests. The program teaches the basics of engineering design and successful techniques for running design contests. At the end of the program teachers return to their respective schools with a teaching kit that enables them to introduce their students to some basic engineering principles. Support is being sought for this program from the National Science Foundation.

To increase opportunities for women and minority students, two new programs are being introduced at the graduate level. A cooperative program has been established with the Charles Stark Draper Laboratory for 10 minority students who have completed the third year of undergraduate work in an engineering program at a predominantly minority institution. During the summer following their third year of study, these students will work at the Draper Laboratory, where they will meet with M.I.T. faculty to learn of the opportunities at the graduate level in the various departments. Upon returning to their home institutions in the fall, they will be encouraged to apply for graduate work in one of M.I.T.'s engineering departments; those accepted are guaranteed research assistantships supported by the Draper Laboratory. The program is scheduled to begin in summer, 1977.

A second program in its early stages of development focuses on women students who have demonstrated ability in undergraduate mathematics and the physical science programs at colleges with predominantly female enrollments. Through workshops held on the M.I.T. campus, we intend to introduce these undergraduates to the opportunities for women in the engineering professions. Although details remain unsettled, the plan is to secure early admission to graduate programs in the several engineering departments. This program is being developed jointly with Dean Kenneth Wadleigh of the Graduate School and Dean Emily Wick, Dean of the Faculty at Mount Holyoke College.

Alumni Programs

The School's Self-Appraisal Study recognized that students and faculty alike need stronger contact with industry to provide the proper balance to our educational programs. The alumni of the School represent one possible link between industry and our institution. To this end, this office is working closely with a group of alumni chaired by Claude Brenner, Course XVI, Class of 1947, who seek to establish a way to utilize this important educational resource. Each of the School's departments now has an alumnus responsible for liaison with alumni resources appropriate to that department. Examples of possible alumni involvement in our educational programs which are now being developed include: alumni participation in doctoral thesis committees; alumni sponsorship and partial supervision of graduate theses done off campus; provision of summer job opportunities for students and faculty; and career orientation for our students. Several programs have been initiated and will be reported at the Alumni Officers Conference September 18, 1976.

PERSPECTIVES FOR THE FUTURE

During the past five years, with net budget reductions of more than 10 percent and overall enrollment increasing 19 percent, expansion of the School's activities and accommodation of the larger enrollment were only possible through internal shifts in the distribution of budgetary resources to the several departments, and within the individual departments, in response to changing enrollments and priorities.

During the past two years, the School also systematically has sought cost-effective means for delivering the education programs. The School's Self-Appraisal Study, which was reported

in last year's Annual Report, helped raise cost consciousness in the School of Engineering. Associate Dean James D. Bruce developed the M.I.T. Departmental Profiles which give statistical information for all departments and schools and are crucial for rationalizing resource allocation decisions. The School also changed its budgeting system for the departments to a zero-base budget, which provided greater insight into the operation of each department.

In October 1975, a special meeting was held with the chairmen of the School's Departmental Visiting Committees to provide them with an overview of the School of Engineering and its recent developments and aspirations, including perspectives for engineering as a profession in a changing world, the forces to which the engineering profession will be subjected in the decades to come, and the responses required from engineering education if it is to develop engineering leaders for the future. At this meeting results of the Self-Appraisal Study also were presented, as well as information on the performance of the School during the past five years. The need to broaden the scope of the School and to make changes in its pattern of operation were discussed.

Based upon experience gained during the last five years and the results of the Self-Appraisal Study, the Committee on Engineering Education was established early in December 1975. This committee is chartered to recommend policy and provide leadership for educational reform as well as to insure that the School's undergraduate and graduate programs meet the School's long-term educational goals. Engineering Council envisioned this Committee's role as being a catalyst in the evolution of the educational programs of the School, and particularly of the common elements in engineering education. The Committee functions in the interspace between the existing departmental curricula committees and such standing committees of the M.I.T. faculty as the Committee on Educational Policy, the Committee on Curricula, and the Committee on Graduate School Policy, and serves as the focal point for interaction on educational programs between the School of Engineering and the Institute's other four schools. This Committee's members are Professors Hansen, Chairman; Hermann A. Haus; Fred Moavenzadeh; Henry M. Paynter; Kenneth A. Smith; and Leon Trilling. In addition, Professor Ernest G. Cravalho, Associate Dean for Educational Programs, is an ex officio member of the Committee.

In response to the Self-Appraisal Study's conclusions that organizational changes were required for the School of Engineering, a working paper "Proposed Changes in M.I.T.'s School of Engineering" was developed. The paper recommended establishing larger operating units by consolidating those departments with substantial similarities in terms of their professional thrusts as well as their underlying disciplines. It was postulated that such larger units would provide greater flexibility in the evolution of educational programs as well as in faculty development. It was envisioned that the present degree programs would continue, taking advantage of common core curricula where appropriate, and that increasing cooperation across organization lines was necessary to retain critical size in individual science and engineering science disciplines, and to facilitate development of new fields. This working paper was forwarded to the School's faculty by the Dean as a first step in seeking the faculty's ideas and suggestions concerning how the School should organize itself for the future.

During January and February, the Dean met with the faculty of each of the School's eight departments and presented the working paper's background and discussed intellectual challenges for the School as well as the financial pressures on the Institute. These meetings also provided opportunities for engaging the departmental faculties in discussion. Constructive proposals were made regarding the proposal for establishing and formally recognizing organization units which cut across departmental lines to form "disciplinary commons."

More recently a working paper, "The School of Engineering (Recent Past and Future)," was prepared to serve as a baseline document for the two-year planning and budgeting cycle

which the President and Chancellor have announced. This paper provides a frame of reference for discussion of the School's goals and aspirations as well as its resource requirements with the School's departments and centers on one hand and the administration on the other. Its ideas, including inputs from the Committee on Engineering Education, will be considered in the two-year planning and budgeting process which began near the end of this academic year.

THE NEED FOR SUPPORT

The School's present operation is seriously affected by developments of the past few years. First, ever rising enrollments and the growing complexity of preparing proposals for an increasingly diversified research program have resulted in a substantial increase in faculty workload. Second, the impact of budget reductions has been amplified by an even greater reduction in funds available for new ventures, particularly for curriculum and faculty development and acquisition of modern facilities for experimental research in new fields of engineering. Third, inflation has decreased the real value of the income received from the School's endowed professorships. The combination of these developments makes it impossible for the School to accommodate the increasing workload and to simultaneously carry out the systematic development of the broader base required to retain the School's leadership position in engineering and engineering education.

The School will be able to progress further during this critical period only if

- 1) its general budget is increased to recognize the enrollment which is expected to continue to climb for the next few years and,
- 2) special support is made available to guarantee continuity in the systematic evolution of the School programs through:
 - a) the resynthesis of our engineering educational programs, particularly the introductory undergraduate and graduate subjects; development of new curricula related to the broader dimensions of engineering, including design, invention, entrepreneurship, technology and policy, technology and law, and bioengineering; and exploring new approaches to continuing education;
 - b) the systematic pursuit of studies of broad sociotechnical systems (particularly transportation, energy, communication, manufacturing, and construction) and their relations to regulatory and policy issues;
 - c) systematic efforts to facilitate the transition from scientific and technical opportunities envisioned by faculty and students at M. I. T. to the establishment of new technologies including their transfer to practical applications;
 - d) the recognition of leaders of established engineering fields; the attraction of leaders in new, important areas; and the support of junior faculty development, as well as of career change for senior faculty members; and
 - e) the provision of better equipped laboratories and facilities for the School's research and teaching activities.

FACULTY

During the past year, many of the School's faculty received special recognition for their professional accomplishments:

Professor Manson Benedict was selected to give the National Academy of Engineering's Founder's Lecture. He also has been selected to receive a National Medal of Science and has been named by President Gerald Ford to membership on the Presidential Advisory Committee on Anticipated Advances in Science and Technology.

Professor Walter A. Rosenblith, Provost, was named to membership in the National Academy of Science, as a charter member of the Institute of Medicine, and a member of the National Research Council's Governing Board.

Professors Fernando J. Corbato, Ira Dyer, Merton C. Flemings, Hermann A. Haus, Joseph H. Keenan, and John P. Longwell were named to membership in the National Academy of Engineering.

Professors Stephen H. Crandall, Merton C. Flemings, and Donald R. F. Harleman were named to Ford Professorships in the School of Engineering.

Professor J. Herbert Hollomon was named to the newly established Japan Steel Industry Professorship. Professor Hollomon also has been named by President Ford to membership on the Presidential Advisory Committee on Contributions of Technology to Economic Strength.

Professor Norman C. Rasmussen, who headed the Nuclear Reactor Safety Study for the Atomic Energy Commission, received a special award from the American Nuclear Society for his work in the field of reactor safety. In addition, he was awarded one of the two Distinguished Achievement Awards by the Health Physics Society and also was named to membership on the Presidential Advisory Committee on Contributions of Technology to Economic Strength.

Professor Nicholas J. Grant was named Abex Professor for Advanced Materials.

Professor Jack L. Kerrebrock was named Richard Cockburn McLaurin Professor of Aeronautics and Astronautics.

Professor Alan V. Oppenheim was appointed Cecil Green Professor of Electrical Engineering for two years.

Professor Woodie C. Flowers was named to the Class of 1922 Career Development Professorship for two years. Professor Flowers also received the Everett Moore Baker Award for "extraordinary interest and ability in inspiring undergraduate interest in, and understanding of academic work."

Professor John G. Kassakian was named the first holder of the newly established Carl Richard Soderberg Faculty Development Chair in Power Engineering.

Professors Robert E. Cohen, Alan J. Grodzinsky, and David G. Holmes were named to Esther and Harold E. Edgerton Career Development Professorships for two-year periods.

Professors Keith D. Stolzenbach and Alician V. Quinlan were named to Arthur D. Little Professorships in Environmental Engineering.

Professor John K. Vandiver was awarded, for a period of two years, an M.I.T. Sea Grant Doherty Professorship for junior faculty development; Professor Francois M. M. Morel's appointment as an M.I.T. Sea Grant Doherty Professor was extended to a third year.

In our report of last year, we noted Professor Peter S. Eagleson's resignation as head of the Department of Civil Engineering. He has been succeeded by Professor Frank E. Perkins. This year, we must report that Professor Raymond F. Baddour has resigned as Head of the Department of Chemical Engineering. While a nationwide search is being conducted for Professor Baddour's successor, Professor Kenneth A. Smith has assumed the responsibilities of Acting Department Head.

Finally, I am happy to report that Professor Ernest G. Cravalho, who is highly regarded as a teacher and widely noted for research on the application of cryogenics to biology and medicine, has been appointed Associate Dean for Educational Programs.

ALFRED H. KEIL

Department of Aeronautics and Astronautics

Undergraduate enrollment in the Department is rapidly approaching the point where two sections of the required courses may be desirable. Spring estimates based on course designations and actual fall sophomore enrollments for the last three years show the following pattern:

	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>
Spring designations	22	14	18	38
Fall actual	19	19	26	?

Graduate School enrollment followed a somewhat similar trend, up from 130 in 1974 to 163 in 1975. Because of the smaller graduating classes in aerospace from all schools this year, it is not expected that the trend will continue next year and it is probable that at least for the immediate future the Department will settle down to a Graduate School level of about 150-160 students per year.

Last year the basic sophomore course, Unified Engineering, enrolled 39 students including five from other departments and eight juniors. This compared with 25 in 1974 and 20 in 1973. In light of this growth the faculty has continued its reappraisal of the undergraduate program in order to ensure quality of education and the goals of this core program. In particular we are exploring means whereby the basic aerospace disciplines can be taught in the necessary depth while still maintaining the students' motivation to learn through emphasis on the engineering application of these disciplines. At the same time it is believed necessary to expose the student to the broader societal implications of engineering through the systems approach. Such exposure at this stage is important in order that systems engineering be perceived in the context of the scientific disciplines without which it becomes a meaningless manipulation of questionable assumptions.

Total research volume in the Department continues its upward trend, with a 1976 forecast of \$3.4 million compared to \$3.0 million in 1975. The Department also has generated a substantial amount of research now administered by the special laboratories, in particular, the Transportation Center, the Energy Laboratory, and the Research Laboratory for Electronics. It is estimated that the volume generated by Department faculty in 1976 will be

close to \$4 million. Equivalent full-time faculty in the Department are less than 60 percent of the 1969 level, at which time the total research volume was \$2.6 million. Clearly, the present research budget represents a substantial increase in faculty load, though the teaching load has not fallen with the decrease in student enrollment since the departmental course offerings had to be maintained. A reduction in student population is reflected simply in reduced class sizes. Consequently the Department's teaching and research load carried by the shrinking faculty continues to be heavy.

In an attempt to improve instruction efficiency, the Department has made a practice of canceling courses with a small population when a reading course could handle the material. Many courses are now taught jointly with other departments or on a rotating basis. These efforts have been successful with graduate courses, but efforts to extend this policy to undergraduate courses have met with only limited success. We continue to search for means of cooperating with other departments in order to increase efficiency without sacrificing quality and special needs.

The Department offers opportunities to undergraduate students for hands-on experience through several engineering projects. Undergraduate involvement in departmental research is particularly encouraged with 23 students involved in the UROP program. The Man-Powered Aircraft continues as an exciting program with eight students involved. The Penultimate Sailplane program under NASA sponsorship provides undergraduates with design, testing, and manufacturing experience on an advanced structural concept using composite materials. The Innovation Coop, a lively experiment in creativity and entrepreneurship, involves several of the Department's faculty.

The Department's small but select undergraduate student body is one of its most important assets. Hopefully its exceptional enthusiasm and community spirit will spread to the expanding undergraduate population.

In January, Val Heinz received first prize at the American Institute of Aeronautics and Astronautics (AIAA) National Student Conference in Washington for the best paper in the Undergraduate Division. David Maass received first place in the Undergraduate Division of the AIAA Northeast Regional Student Conference, and David Thompson tied for first place in the AIAA New England Section Student Award.

Edward F. Crawley, Michael J. Graves, David P. Maass, David W. Thompson, and John H. Wendell won the Henry Webb Salisbury Award; David P. Maass, John H. Wendell, and Edward F. Crawley the James Means Memorial Prize; and Edward F. Crawley, Peter D. McQuade, David W. Thompson, and Judith C. Thompson the Luis de Florez Award.

As usual, the Student Chapter of the AIAA in the Department assisted in organizing student activities on undergraduate social occasions and during the academic midway activities.

A review of departmental teaching and research activities may best be detailed by the following brief descriptions of the activities of the various divisions of instruction.

Instrumentation, Guidance and Control

This division continued to enroll the largest number of graduate students, 42 percent of the total. Enlarged enrollments in many of the graduate subjects resulted from this growth in student numbers and from the serious shrinkage of faculty due to the loss of three members. At the same time the importance of the education provided by the division to the Department was certainly not decreasing. There is every indication that the subjects of automation and data processing will become increasingly important as demands on the human operator increase.

An attempt is being made to identify young faculty members who will be competent in the application of modern control theory and microprocessing in aerospace applications. The emphasis is on application rather than development of the underlying theory which is felt to be a function of the Department of Electrical Engineering and Computer Science.

Of particular interest is the development of fault tolerant systems and the management of redundancy. Other applications involve the use of estimation theory for strapped down inertial systems. At the present time the Draper Laboratory provides support for close to 40 percent of the students in this division, a valuable educational resource for the Department.

Recognizing the increasing importance of automation in aerospace applications, the Department has organized a new undergraduate program in Avionics to prepare students for careers or graduate work in aerospace electronics, instrumentation, guidance and navigational control. Course requirements include core curriculum subjects from both Electrical Engineering and this Department and will be offered for the first time in 1976-77. It is hoped that if a dual major program is approved by the faculty, the course will eventually become an offering of both Course XVI and Course VI.

A new development has been the installation of a PDP 11/10 as a small computer facility designed primarily for interaction in real time with external equipment in order to provide a laboratory environment for developing automation concepts. This versatile facility is heavily used by many research project groups and in course work, and it is hoped that this use will increase with familiarity.

The Laser Laboratory continues to operate at a high level of activity involving many graduate and undergraduate students. Among its contributions are the development of a long-term stabilized laser for application in earth-strain seismometry, optimal communication, precision spectroscopy and fundamental measurements in experimental relativity, with the precision of several parts in 10^{12} . The Laboratory also has conducted research on ultrahigh resolution spectroscopy using molecular beams to measure molecular hyperfine structure with unprecedented precision. A new program involves the development of an optical rate gyroscope using a passive ring Fabry-Perot interferometer as rotation sensing element. Finally a new technique for two-dimensional flow field measurements has been developed using an argon laser beam converted to a thin two-dimensional sheet propagated across a laboratory-built wind tunnel. Light scattered from liquid droplets shows both the direction of the flow and the velocity. Such techniques are of great interest for the examination of flows such as boundary layers without requiring injection of mechanical devices which could alter the flow.

The Measurement Systems Laboratory continued at a low level of activity, with research in dynamical astronomy and with a new experimental study of the electric field of earth. It is hoped that activities of this laboratory will increase, for it represents a valuable departmental facility for instrumentation research and teaching.

During the past year the activities of the Man-Vehicle Laboratory and department teaching in Bio- and Human Engineering grew to be considered a separate graduate topic. Research support for the Man-Vehicle Laboratory is limited only by the faculty supervision available. Work continues in two directions, biological and medical engineering, and man-machine systems and analysis of the human operator as a controller. Research continues on the integration of visual and motion cues for flight simulation and ride quality investigation, on habituation to novel visual vestibular environments with particular reference to space flight, and on analysis of a pilot's cognitive and decision process. A project on clinical vestibular testing was initiated, and work continued on studying and understanding the physiology of the physio-motor integration in vertebrates using the fish as an experimental paradigm. An investigation of applications of a theoretical approach to some simple models of higher abstract thought in humans focused on

children learning mathematics with particular emphasis on the "learning disabled." Finally a small program continues on the etiology of ski accidents with particular reference to the influence of the ski binding.

A major proposal is being written for vestibular experiments to be conducted on Space Lab. The work is to be done jointly with the Canadians and could provide major activity for the laboratory for the next several years.

Structures, Materials and Aeroelasticity

As in other divisions, teaching and research remain heavily intertwined, with major emphasis on finite element analysis, structural dynamics, fatigue, and design of advanced composites. An example of a new course based on previous and continuing research efforts is 16.252 Structural Response to Severe Transient Loads. Taught during the spring term, it attracted nine students from Civil, Mechanical, Nuclear, and Ocean Engineering, and nine from the Department.

Teaching is closely coordinated with other departments in the scheduling of graduate courses in plates and shells, finite elements and structural dynamics. Comparable courses are called to the students' attention in the catalogue and these courses are taught alternatively by different departments.

Research was primarily concentrated in the Aeroelastics and Structures Research Laboratory, where the assumed stress hybrid finite element formulations have been developed to study transient loading in multilayer laminated structures and to analyze the large deflection static behavior of thin, elastic structures. This technique has also been applied to creep analysis.

Impact studies on containment of fragments in burst aircraft and power turbine rotors extended to include work on the crashworthiness of rail car and rail car components. Continued work on composites includes study of the fracture characteristics of boron/aluminum symmetric laminate in the presence of holes and a study of the behavior of unidirectional graphite epoxy under static and cyclic compressive loading. A modified hybrid finite element approach has been successfully applied to anisotropic fracture mechanics with various crack geometries for several graphite/epoxy and boron/aluminum laminates. Finite element computer code applications were extended to the study of the fatigue life of the outer rubber covering of large printing press rolls and to machine tool design.

An experimental study was made of the purely torsional stall flutter of a two-dimensional wing, and studies continued on the gust response and its alleviation for hingeless rotor helicopters and tilt rotor aircraft. Numerous wind tunnel tests examined the intensity of wind at various locations around high buildings and in areas of expected frequent pedestrian use. Such work aids the design of building structures and the avoidance of undesirable ground effects.

Aeroelastic studies of wind energy conversion systems have been conducted through the Energy Laboratory for NSF and ERDA. Emphasis in these programs is on studying the coupling between the electric power generating system and the rotor aeroelastic characteristics, on the fatigue loads acting on the rotor in the presence of the earth's boundary layer and on the nonlinear dynamics of a rotor operating in the presence of gravity and cross flows. Theoretical and experimental studies were carried out, and a wind turbine model was built for test in the wind tunnel under simulated gusts and boundary layer shear flows.

Energy Conversion and Propulsion

There is continued growth of student interest in research activities of the well funded division dealing with gas turbine and MHD power generation. Other areas such as chemical rocket propulsion and space propulsion are less well covered than in the recent past, but efforts are being made to restore activity.

The Gas Turbine and MHD Laboratories and the interdepartmental Energy Laboratory are the site for the division's research on dynamic energy conversion covering a wide range of disciplines and devices including fluid mechanics, solid mechanics, plasma physics, heat transfer, and numerical computation. Motivation stems from application to gas turbines both aircraft and stationary, MHD power generators, high powered lasers, and fusion reactors.

Substantial progress was made in the understanding of transonic compressors with the completion of detailed time resolved measurements of the flow fields, gas-fluorescence measurements of the intra-blade density field, and three-dimensional computations of the transonic flow field in the M.I.T. Blowdown Compressor Rotor. These techniques are being extended to the unsteady flow field of a fluttering rotor, and also are being applied to a full compressor stage.

In the area of turbine aerodynamics and cooling, research addresses the key problems of cooling optimization in very high temperature turbines, of increased work per stage and on the effects of three-dimensional flows on heat transfer characteristics. Studies of cooling covered air film effectiveness and a fundamental study of turbine cooling by liquids for application to a combined gas turbine/steam turbine power plant burning coal. A study has been initiated of the effects of periodic unsteadiness on the aerodynamic performance of turbine blades. In the area of MHD power generation a new facility for material and fluid mechanics investigation is now in operation and has yielded excellent results in the evaluation of electrode materials developed at M.I.T. In the experiment built at the National Magnet Laboratory a disk generator with swirl has been tested, showing remarkable results close to theoretical values with electrical efficiencies up to 60 percent compared to the same generator without swirl at 30 percent.

Mechanics and Physics of Fluids

Research continued on a variety of topics of fundamental interest directed towards important applications. These included studies of the instabilities of confined high-speed rotating flows, the stability of aircraft trailing vortices and vortex rings, development of a dynamic model for the role of wave-interactions in the maintenance of turbulent flow (including an explanation of the drag reducing effects of polymers), studies of the unsteady aerodynamics of flapping flight, prediction of the three-dimensional flow field for wings with strong leading-edge vortices, and the detail structure of thin layers of molecules with particular application to the formation of ice crystals in the upper atmosphere. Anisotropic radiation coupled gas dynamics work resulted in a new method for such fields as an extension of the classical differential approximation. Gas surface work involved consideration of multiple interactions between gas and surface particles using threshold energy collisions as a measure of reaction probabilities. A second effort relates to proper interpretation of molecular beam data when monitoring a desorbed stream for finite target, chopper, collimator and detector systems. Preliminary research also was carried out for wave rider and star section configurations involving a numerical analysis for conical flow wave riders having nonplanar cross-section faces and detached shockwaves, as expected under off design conditions. A separate study explores limitations for generalized conical flow wave riders.

The magnetic balance system at the Aerophysics Laboratory was used effectively for wake studies and for studies on the magnus force and spinning and coning motions of bodies. Further

work in the laboratory treated the shock attachment to a nozzle nose. Studies also were conducted on boom propagation through a nonhomogeneous atmosphere and on the generation of aerodynamic noise from rotor blades.

Aeronautical and Astronautical Systems

The Department continues to place major emphasis on relating the rigorous engineering disciplines of aerospace to the development of operating systems designed to provide a useful service to society with a minimum use of resources and a maximum degree of environmental acceptability. Such instruction is embodied in several systems engineering courses covering both space and air transportation activities and has also been introduced at the sophomore level as part of the Unified Engineering core subject.

In the undergraduate Space Systems Engineering course, a broad study of the most cost effective orbital transport to satisfy the requirements of developing solar satellite power systems was interlaced with a detailed analysis of the thermal protection system required for reentry and of a propulsion system for exoatmospheric flight. In the undergraduate Aircraft Design course the class entered the 1976 AIAA Bendix Design Competition with a design of a quiet, energy efficient, four place general aviation aircraft that will meet the new noise and emission requirements and still be competitive in terms of speed, cost and load carrying capability. In the graduate Space Systems Engineering course a study of a permanent 1,000 person colony in space considered such problems as thermal equilibrium, structural design for maximum safety, and the dynamics of orientation to capture the required solar energy. It is hoped that growing interest in the concepts of space manufacturing and space solar power systems will eventually lead to development of a research program in this area in collaboration with the Center for Space Research.

Much research in the division is concentrated in the Flight Transportation Laboratory (F.T.L.), which works closely with the Transportation Center of the Institute. One new thrust of F.T.L. has been in the area of demand forecasting, a neglected activity which is basic to the rational prediction of future requirements. A three-day seminar on the subject was held in Washington, D.C. by F.T.L. under NASA sponsorship. This led to the award of a NASA Research Grant.

A major project concerns levels of airport activity under FAA sponsorship, which uses existing F.T.L. airline scheduling models to study several forecast scenarios to the year 2000 as part of a series of cost benefit studies of the upgraded third ATC system. A research contract from Schiphol Airport Authority in Amsterdam to study airport capacity, with a new triple parallel runway as a proposed alternative to a second major airport for Holland, provides an excellent case study for the airport capacity delay methodology developed by the laboratory. In collaboration with the Draper Laboratory, a study has been conducted of the application of fault tolerant microprocessors to future air transport aircraft.

The laboratory is increasing its emphasis on attempts to improve general aviation safety, with initial focus on development of an Omega navigation system, a low cost device with worldwide coverage ideally suited to general aviation application. This NASA sponsored work involves flight testing of a prototype low-cost receiver.

Finally, in collaboration with the Center for Transportation Studies, the laboratory is reviewing the impact of alternative regulatory policies on intercity transportation. A second contract involving the Operations Research Center as well points towards developing new network analysis methodology for freight flow on networks and for solution of the multi-fleet airline routing problem.

FACULTY

Professor Eugene Covert continued to chair the Undergraduate Committee and Professor Harold Wachman took over as Chairman of the Graduate Committee from Professor Wallace Vander Velde. Professor Winston Markey chaired the intradepartmental doctoral program in Instrumentation; Professor John Dugundji chaired the Doctoral Committee; and Professor Henry Whitaker continued to supervise the Engineers degree program and to chair the Freshman Orientation Committee. Professor Markey organized a series of departmental seminars which 27 students took for credit. Professor Manuel Martinez-Sanchez assumed major responsibility for the Experimental Projects Laboratory. Professors Emmett Witmer and Markey received Outstanding Teaching Awards from the M.I.T. Graduate Student Council.

Professor Laurence Young continues to be occupied in the Health Sciences and Technology Program, running several committees and serving on four ad hoc search committees. He was invited to serve on the editorial board of the new journal Neuroscience. Professor Shaoul Ezekiel organized a successful international symposium on resonant light scattering at M.I.T. Professor Jean Louis continued as a member of the Steering Committee of the US/USSR Cooperative Program on MHD, and chaired the working group on MHD generators within this effort.

Professor Y.T. Li gave four talks in the People's Republic of China and five talks in Israel, emphasizing the importance of innovation in the engineering process. Professor Marten Landahl was invited to give the opening lecture at the IUTAM's Symposium Transsonicum II in Gottingen, Germany, and to give lectures at Tel Aviv University and the Ben Gurion University of the Nagiv in Israel. Professor Elmer Larrabee contributed four monographs at the NASA Industry/University General Aviation Workshop.

Professor John McCarthy supervised the design of an M.I.T. exhibit for the US Bicentennial Exposition on Science and Technology at the Kennedy Space Center in Florida, the only university exhibit to be included.

The Department welcomed Professor David Jansson as new Assistant Professor in the Guidance and Control Division. Professor Jansson recently has been awarded two patents in connection with his work on respiratory protective devices for fire fighters.

Professor John Wiley was among the first three in the Institute to receive the appointment of Adjunct Professor. He recently completed a series of lectures at Polytechnico at Milano on planning and design of airport systems and airport operation and management.

Professor Amedeo Odoni was on leave of absence in Athens, completing a new text on Urban Systems Analysis and participating in plans for airport revisions in Athens.

R.H. MILLER

Department of Chemical Engineering

Departmental activities continued at a high level throughout the year. Increased enrollment and expanded research activity placed heavy demands on the faculty. The new Ralph Landau Building, completed in January, has provided excellent facilities and is a major contribution to the effectiveness of the Department in meeting its goals.

Undergraduate Program

Changes in the undergraduate program initiated by the faculty last year proved effective. Two new introductory subjects in chemical engineering, 10.13 Mass and Energy Processing and 10.14 Thermodynamics, have been developed further by Professor Michael Modell and have attracted students from other disciplines as well as chemical engineering.

The new senior subject, 10.32 Chemical Engineering Operations, complements the curriculum changes made last year in the sophomore year. It was developed by Professor C. Michael Mohr, who also continued to develop new case problems for use in 10.10 Process Synthesis, a subject especially designed for freshmen.

In response to demand, Professor Robert E. Cohen has expanded the Polymer Science Laboratory which he developed in 1973-74.

Undergraduate enrollment increased to 189 from 126 in 1974-75.

Graduate Program

Graduate enrollment in the Department totaled 159, of whom 44 were doctoral candidates. Thirty-four students attended field stations of the School of Chemical Engineering Practice under the direction of Professor Donald B. Anthony at the Bound Brook Station and Professor Michael P. Manning at the Oak Ridge Station. Operations at the Bound Brook Station terminated in December, and a search for a new location is in progress. Demand for the Practice School program continues at a high level.

Two new subjects in surface and colloid chemistry were offered by Professor Richard G. Donnelly. The first, 10.611 Physics and Chemistry of Surfaces, is a self-paced study program based on videotaped lectures by Professor J. T. G. Overbeek of the University of Utrecht and Visiting Professor of Chemical Engineering at M. I. T. During his visit to M. I. T. in the fall term Professor Overbeek presented a series of lectures on electrode chemistry. Professor Ronald A. Hites developed and offered a new graduate subject, 10.23J Chemical Measurements (A), jointly with Professor Klaus Biemann of the Department of Chemistry, which attracted graduate students from several departments.

Professor Robert C. Armstrong arranged a series of graduate school seminars. Among the professors visiting M. I. T. in this series were Morton Denn, University of Delaware; Paul J. Flory, Stanford University; E. N. Lightfoot, University of Wisconsin; J. H. Seinfeld, California Institute of Technology; A. W. Westerberg, University of Florida; and L. E. Scriven, University of Minnesota.

FACULTY

Professor Clark K. Colton was promoted to Professor, and Professor Hites was promoted to Associate Professor. Professor Armstrong received the Outstanding Faculty Award in the Chemical Engineering Department for 1976 and the duPont Young Faculty Grant for 1975-76. Professor Cohen received a two year appointment as Esther and Harold E. Edgerton Assistant Professor of Chemical Engineering. Professor Christos Georgakis received the Ph.D. from the University of Minnesota and joined the M. I. T. faculty in September 1975, as Assistant Professor of Chemical Engineering.

Professor Kenneth A. Smith was appointed Associate Director of the M.I.T. Arteriosclerosis Center.

Professor Colton served on the National Science Foundation Graduate Fellowship Evaluation Panel of the National Research Panel and on the editorial board of the Journal of Membrane Science. He was appointed Assistant in Chemical Engineering (Anesthesia), Massachusetts General Hospital and a Consultant in Medicine at the Peter Bent Brigham Hospital.

Professor Janos M. Beér, former Head of the Department of Chemical Engineering and Fuel Technology at the University of Sheffield, joined the faculty in January as Professor of Chemical Engineering. His participation will contribute to the expanding activities of the M.I.T. Fuels Research Laboratory.

In addition to Professor Overbeek, Visiting Professors in the Department this year were Paul J. Flory of Stanford University, John P. Longwell of Exxon Research and Development Company, James E. Mark of the University of Michigan, Martin V. Sussman of Tufts University, and Robert E.C. Weaver of Tulane University.

Dr. Chomiak, head of the combustion research section of the Institute of Aeronautics, Warsaw, Poland, has been visiting in the Department under an NSF Senior Foreign Energy Scholarship. He has contributed to the teaching and research activities of the Fuels Research Laboratory in the field of turbulent combustion.

Professor Emeritus Hoyt C. Hottel received the first Farrington Daniels Award of the International Solar Energy Society, and the Royal Society Esso Award for 1975. He served on three new National Academy-National Research Council Committees dealing with the energy crisis, and gave invited lectures at Capetown, South Africa; Cambridge University; the American Academy Symposium on Arid Zone Development; and the ERDA Symposium on Fluidized Coal Combustion.

Professor Edward W. Merrill attended the Seventh Annual Meeting of the International Society of Hemorrhage and Thrombosis in Paris to report work on platelet activation by polymers accomplished by Professor Merrill's group and Dr. E.W. Salzman's laboratory at the Beth Israel Hospital.

Professor Adel F. Sarofim and Professor Smith attended the Fifth International Symposium on "Fresh Water from the Sea" to present results of research on the freezing process.

Professor Charles N. Satterfield served as a member of the ad hoc Panel on Direct Combustion of Coal of the Commission on Sociotechnical Systems of the National Research Council.

Professor Raymond F. Baddour, Head of the Department since 1969, resigned from the headship to return to teaching and research effective June 30, 1976. Professor Smith will accept leadership of the Department as Acting Head. Professor J. Edward Vivian will continue as Executive Officer during the transition.

RESEARCH

During the year research volume increased to more than \$1.6 million from approximately \$1 million in recent years. When interdisciplinary activity is included, the volume approaches \$2 million. While research continued to cover a wide range of activity, energy related projects and biochemical and biomedical studies accounted for a major portion.

Professor Armstrong completed a two-volume graduate level text on polymer fluid dynamics. Entitled "Dynamics of Polymeric Liquids," it should be available at the end of 1976. His collaborators were Professors R. B. Bird, O. Hassager and C. F. Curtis of the University of Wisconsin. Professor Armstrong's current research includes study of vortex inhibition, the effect of a pure straining motion on the conformation of an isolated macro-molecule, and the kinetic theory of dilute macro-molecular solutions.

Professor Lloyd A. Clomburg, Jr. continued his study of the complex heat flow problem encountered in the industrial glass melting tank. Professor Clomburg and Professor Nigel Curlet obtained good agreement between measured and predicted temperature and velocity profiles. A novel feature of the flow, the onset and growth of longitudinal roll cells analogous to Rayleigh-Benard cells, has been identified.

Professor Cohen continued his research in the Polymer Science Laboratory on viscoelastic polymers. Current projects include study of elastomer blends and filled elastomer networks. Christopher J. Hooley, a Kennedy Scholar from Oxford University, worked in Professor Cohen's laboratory during the past year.

Professor Colton continued research on the development of an enzymatic ATP regeneration process for use with cell-free enzymatic syntheses. This work is part of a collaborative, interdisciplinary effort with Professors D. I. C. Wang in the Department of Nutrition and Food Science and G. M. Whitesides in the Department of Chemistry. Work during the past year concentrated on development and analysis of immobilized enzyme reactors for ATP regeneration.

Professor Donnelly supervised projects directed at fundamental heterogeneous catalysis, focusing on the identification of the chemisorbed species which are active in the catalytic reaction. Temperature programmed desorption is being used to obtain information on the energetically discrete surface species which form during a catalytic reaction. In a parallel study under Professor Donnelly, the properties which contribute to the instability of emulsions and suspensions are under investigation. A better understanding of the irreversible processes of coagulation and coalescence could answer important industrial problems.

Professor Lawrence B. Evans and Professor Myron Tribus, Director of the Center for Advanced Engineering Study, received a grant from the National Science Foundation to develop a new approach to continuing education based upon the modular system instead of the course as the unit of instruction. The project will be conducted over a three-year period with the collaboration of other universities, industry, professional societies, and government agencies. Dr. Dominick Sama has been appointed Executive Officer of the project.

A team of investigators led by Professor Evans are planning a major research project for the development of an advanced computing system for chemical process engineering. Such a system is expected to play a major role in developing new energy conversion processes in the 1980s. Professors James Porter and Georgakis are participating in the project.

Professor Evans and Professor Jack B. Howard have a project under investigation to model a tube-wall methanation reactor for the manufacture of synthetic pipeline gas. Fundamental studies of the mass and heat transfer phenomena together with associated chemical kinetics on the porous wall catalyst are of primary concern.

Professor Georgakis's research activities in the areas of design modeling, analysis, and control of chemical processes range from fundamental studies developing new mathematical techniques for analysis of large scale systems to the applications of existing techniques to mission oriented problems. A doctoral student supervised by Professor Georgakis is investigating new design methodologies including dynamical considerations for chemical plants. A related project is concerned with energy economy and conservation in chemical processing.

Professor Hites is directing a major activity covering a wide range of studies of environmental organic chemistry. Studies toward formulating effective, yet realistic, regulations for the control of release of organic chemicals to the environment are an important part of these projects, as is investigating the progress and synthesis of organic chemicals in the environment. This work involves the development of equipment and techniques for the detection and quantitative evaluation of trace compounds, including polycyclic aromatic hydrocarbons, a major problem in environmental control.

Professor Jack Howard is supervising projects related to coal conversion for energy and fuel production. In association with Professor Herman P. Meissner, he is studying rapid coal pyrolysis and hydrogasification for the production of clean gaseous fuels. With Professors Meissner and Baddour he is directing a project using plasma heating in a novel process to produce acetylene and calcium carbide in a bench scale apparatus. Professors Howard and Longwell are conducting a project focusing on the assessment of technical and economic feasibility of carbonizing coal in the presence of sulfur accepting materials to produce clean fuel gas for use in gas turbine generators during peak load demand. The fluidized bed combustor (FBC) is applied in this project.

Professor Merrill continued research on polymer chemistry with a view to developing biomaterials suitable for contact with blood. A number of transformed polymers are being studied as materials to which the anticoagulant heparin can be covalently bonded. Professor Merrill is working with Professors Smith and Armstrong in studying drag reduction in the flow of polymer solutions due to the extension of polymer molecules in dilute solution undergoing extensional flow. Light scattering techniques are used to monitor molecular behavior in the extensional flows. In a related study Professors Merrill and Armstrong are developing a theoretical model of polymer behavior in a flow field. Professor Merrill also is supervising a project aimed at understanding the modes of degradation of commercially important polymers such as polystyrene under ionizing radiation at elevated temperatures and under high rates of strain with a view to evaluating the feasibility of monomer recovery from polymers in waste material.

In collaboration with Dr. Salzman, Professor Merrill supervised a study of the interrelation of erythrocyte sedimentation rate (ESR) of blood as determined in the clinic to red cell volume, plasma fibrinogen level, and principal gross rheological characteristics. This work clearly showed the origin of the difficulty of interpreting the usual clinical ESR test. Professor Merrill continued his research in the application of therapeutic aerosols in the treatment of hyaline membrane disease, giving special attention to coupling aerosol generator and patient.

In association with Professor John Trump of the Department of Electrical Engineering and Computer Science and Professor A. Sinskey of the Department of Nutrition and Food Science, Professor Merrill is investigating effects of electron irradiation of sludge at a pilot facility at the Deer Island Sewage Treatment Plant. This study aims to develop agricultural use of the treated sludge.

Professor Porter is developing computer analysis systems for fossil fuel power systems and is supervising projects to develop high temperature sulfur removal from stack gas by limestone and dolomite. It is expected that this research, in which Professor Georgakis and Professor John F. Elliott of the Department of Materials Science and Engineering participate, will shed new light on heterogeneous reaction phenomena.

Professor Robert C. Reid co-directs the Liquefied Natural Gas (LNG) Research Center and, in collaboration with Professor Smith, supervises projects exploring safe practices in handling cryogenic fluids, including accidental spills from barges and tankers. The rate of

The search process and internal discussion preceding this appointment afforded the faculty an opportunity to assess and reassert their goals and objectives for the Department. In brief, these discussions reaffirmed our belief that the Department must be concerned with education and research in two complementary areas: the broad policy issues and socio/environmental impacts of constructed facilities; and the more traditional realm of understanding and modeling the physical behavior of various components which make up or interact with these facilities. Each area is important to the other and to the future of the Department, so mechanisms must be sought to provide a healthy climate and adequate resources for both to interact and flourish. During these discussions there appeared a growing awareness that the process of design (interpreted in the broadest possible sense) is an essential element if these two departmental objectives are to be viewed as complementary rather than competing. This issue will receive increased emphasis in the future.

Undergraduate Program

Undergraduate enrollment continued in its upward trend of the past decade, reaching 162 students in the spring semester, a 20-year peak.

Among third- and fourth-year students who have chosen their primary area of study, the structural and building systems options are most popular, being chosen by almost half the students. Three other primary options, transportation systems, geotechnical, and water resource systems, account for a majority of the other students.

The concentration of student interest in the structural and building systems areas is consistent with the Department's desire to increase interactions with the Department of Architecture. Professor James M. Becker initiated a new subject, Design of Building Systems, and has been invited to spend a portion of his time next year teaching a subject in the Department of Architecture.

Exploratory talks began with the Department of Ocean Engineering with the objective of establishing a joint undergraduate option in civil and ocean engineering. It appears that this option can be developed using the Department's undesignated degree option as was done a year ago in setting up the joint program with the Department of Urban Studies.

The Undergraduate Committee of the Department studied the possibility of establishing a cooperative program similar to that in the Department of Electrical Engineering and Computer Science. Concluding that such a program is highly desirable, the Committee is now drawing up guidelines for its implementation. However, it was felt that the program should focus primarily on finding appropriate summer positions which could provide both employment and academic credit, an issue which will be handled initially on a case-by-case basis.

Undergraduate subjects in the Department continued to attract large numbers of students from other departments. Of the 1,022 student registrations in 33 undergraduate subjects (averaging 31 students per subject), 164 registrants (16 percent) were first-year students, and 224 registrants (22 percent) were from other departments at the Institute, most frequently the Department of Architecture.

First-year students continued to be attracted to the Department's introductory subject in information systems. Because the Department's general introductory subject, Introduction to Civil Engineering, became an elective rather than a required subject, enrollment dropped significantly from 80 to 28; but its intended new role as a first-year elective was enhanced with 19 of the 28 registrants being first-year students.

The Graduate Program

A total of 225 regular graduate students enrolled during the past year, a new high, up 6 percent from the previous year, and generally considered to be too high for the available faculty resources. Of this group, 18 (8 percent) represented various ethnic minorities, and 22 (10 percent) were women.

Graduate student support for this past year and three previous years has come from the following sources:

	<u>1972-73</u>	<u>1973-74</u>	<u>1974-75</u>	<u>1975-76</u>
Fellowships and Traineeships	46	43	60	76
Research Assistantships	114	98	87	92
Teaching Assistantships	18	20	19	19
Other (including self-support)	<u>17</u>	<u>43</u>	<u>45</u>	<u>38</u>
TOTAL	195	204	211	225

During this period dependence on research assistantships declined from 58 percent to 41 percent of the total, while fellowship and traineeship support increased from 24 percent to 34 percent. These trends are the source of much discussion within the Department and are consistent with the increased use of professional research staff on sponsored research projects.

The total number of applicants to Department graduate programs declined by 15 percent from an unusually high number in the preceding year. A total of 335 applications were received, 158 offers were made, and 86 acceptances were received. The number of foreign students offered admission increased to 50 (32 percent of total offers made), and 38 accepted. This increase in foreign student offers resulted from a conscious policy decision based on: increased research supported by and/or centered in foreign countries; the pressing importance of civil engineering education and research in many foreign countries; and recognition of the high qualifications of many foreign student applicants.

The impact of this policy decision will be monitored during the next year.

Doctoral programs and the Civil Engineer Degree were among the chief issues addressed by the Department Committee on Graduate Students chaired by Professor Robert D. Logcher. Policies and procedures for doctoral programs were clarified to make candidates more aware of the decision process and expectations. Also, in response to student concern about the heavy emphasis and pressure associated with the General Examination, the Committee decided to ease this pressure by eliminating the secrecy associated with it. Past General Examination questions are now generally available to students.

Efforts continued to upgrade the stature of the Civil Engineer Degree. In this regard an attempt was made to interest other engineering departments in adopting a new set of unified degree requirements and a new degree name on a School-wide basis. After some initial success this effort encountered departmental differences in objectives and style which have not yet been resolved.

The Deepwater Ports Office of NOAA sponsored an evaluation of techniques for predicting behavior of surface oil slicks. This study brought together groups from hydrodynamics, coastal and environmental engineering areas, and involved Professors Jerome J. Connor, Bryan Pearce, Ole S. Madsen, and Keith D. Stolzenbach. Research collaboration between the faculty of the Department of Civil Engineering and the Energy Laboratory increased in the area of waste heat management. For example, Professor Doanld R.F. Harleman studied the dynamics of shallow cooling ponds with support from the NUS Corporation under contract to Commonwealth Edison of Chicago.

FACULTY

Professor William H. Matthews, who was on leave this academic year at the International Institute for Applied Systems Analysis (IIASA) in Vienna, submitted his resignation as of June 1976. Professor Matthews will continue his work at IIASA and with the United Nations Environmental Program.

Professor Stephen F. Moore has resigned as of September 1976 to devote time to consulting engineering practice and part-time teaching at the University of California at Davis.

Three faculty members were on sabbatical leave during the entire academic year. Professor Peter S. Eagleson was at the California Institute of Technology conducting basic research in the field of hydrology. Professor Manheim spent the year in Paris as scientific advisor to the Institute of Transportation Research. Professor Ladd remained in Massachusetts to work on proposals for research in new areas. In addition, Professors Charles L. Miller, Wayne M. Pecknold, William W. Seifert, and Veneziano took professional or personal leave for a major portion of the past year.

Three new faculty members will join the Department in September 1976. Dr. Oral Buyukozturk, who received his Ph.D. in Structural Engineering from Cornell in 1970, has worked in industry since that time, and is currently Chief of Structural Mechanics at Marc Analysis Research Corporation in Palo Alto, California. He will work in the area of analysis and design of reinforced concrete structures. Dr. Sallie W. Chisholm received her Ph.D. in Aquatic Ecology from the State University of New York at Albany in 1974, and is currently a Research Biologist at the University of California, San Diego, Institute of Marine Resources. She will participate in teaching and research in aquatic biology and ecology. Dr. Rafael L. Bras received his Ph.D. from M.I.T. in 1975, and is currently Assistant Professor of Civil Engineering at the University of Puerto Rico. He will work in the area of stochastic hydrology and water resource systems.

Professor William A. Litle resigned as Head of the Constructed Facilities Division at the end of this past academic year. He will be replaced by Professor Connor who has been serving as Associate Head of the Water Resources and Environmental Engineering Division.

Professor Ladd received the 1976 Normal Medal of the American Society of Civil Engineers for his paper, "New Design Procedure for Stability of Soft Clays" with Dr. Roger Foote.

Professor Morel was reappointed to the Doherty Chair in Ocean Utilization for a third year.

Professor Stolzenbach was appointed Arthur D. Little Assistant Professor of Environmental Science and Engineering for a term of 18 months.

Professor Moore received a Lilly Foundation Faculty Teaching Fellowship to develop innovative teaching/learning methods.

Professor Biggs received the Department's annual Conspicuously Effective Teaching Award.

Books published included Professor Michael S. Baram's Environmental Law and the Siting of Facilities: Issues in Land Use and Coastal Zone Management, Professor Moshe E. Ben-Akiva's A Disaggregate Travel Demand Model with Martin G. Richards, and Professor Connor's Analysis of Structural Model Systems.

Professor Harleman, together with Professor Stolzenbach and Drs. Gerhard H. Jirka and Eric E. Adams, presented a summer course on "Engineering Aspects of Heat Disposal from Power Generation." A European version of the course was presented by Professors Harleman, Stolzenbach, Marks, and Dr. Jirka at the Delft Hydraulics Laboratory in the Netherlands.

Professor Sussman hosted a three-day conference at M.I.T. for the railroad industry on the subject of freight car utilization. Professor Moavenzadeh organized and chaired a conference on "Transportation Planning in Developing Countries" in Addis Ababa, Ethiopia. Professors Manheim, Roberts, and Sussman participated in a 10 day series of seminars on "Transportation Systems" in the USSR under the auspices of the National Science Foundation and the National Bureau of Economic Research. Professor John L. Wilson served as Chairman of the Wellesley Conservation Commission Groundwater Task Force whose charge is to develop recommendations for groundwater management in the Commonwealth of Massachusetts.

FRANK E. PERKINS

Department of Electrical Engineering and Computer Science

The past academic year witnessed growing student interest in electrical engineering and in computer science, resulting in greater teaching activity than ever before despite budget pressures that prevent any significant increase in the size of the teaching staff.

The Department maintained its emphasis on high quality undergraduate instruction by doing more teaching in undergraduate subjects than any other department, including those with large responsibility for freshman subjects. This commitment led to a reorganization and consolidation of educational computer facilities and a study of the feasibility of a major enhancement in the availability of educational computation.

Department administration emphasized prudent fiscal management, even though cost of instruction was lower than most departments at M.I.T. Presently, the Department has the lowest (deflated) cost of instruction that it has had in the last decade.

Undergraduate Program

The trend of increased undergraduate enrollment in electrical engineering and computer science continues at a somewhat accelerated pace, as approximately 750 undergraduates enrolled in the Department. Projections based upon numbers of entering sophomores and transfer students indicate that the enrollment should increase to about 800 during 1976-77.

As part of the Department's continuing review of its academic programs, the common core curriculum was re-examined in light of experiences with it over the past two years. An ad hoc committee on the common core, chaired by Professor Paul Penfield, Jr., met this summer to project student needs in the next 10 to 15 years. Hopefully a clearer charter for the common core will emerge from these deliberations.

The special tutorial program which was started on an experimental basis last year was continued and expanded to assist in common core subjects students having difficulties due to inadequate preparation prior to entering the Department. Approximately 20 students have used it. Feedback from participants will help to pinpoint specific kinds of deficiencies which we might be in a position to remedy.

For the outstanding undergraduate thesis in Electrical Engineering, the Ernst A. Guillemin Prize was awarded to Larry R. Carley of Poughkeepsie, New York.

Graduate Program

Full-time graduate student enrollment rose to 470 students in September. Of this number, 184 were Research Assistants and 110 were Teaching Assistants or Instructors. In addition, 132 were supported by fellowships, traineeships, industry, foreign governments or foreign universities, while 44 students provided their own support.

The Department received more than 1,100 applications for graduate school during 1975-76, and expects approximately 150 new students to enroll in September for a total of about 480 graduate students.

Outstanding teaching by graduate students was recognized by teaching awards of \$500 each, to Peter W. Dietz, Theodore M. Lyszczarz, Charles W. Sabolis, and Richard T. Wong (all receiving the Supervised Investors Services, Inc. Teaching Award); to Philip W. Herman, David P. Reed, and Christopher J. Terman (all Department of Electrical Engineering and Computer Science Teaching Award); and to Lynette L. Linden the Carlton E. Tucker Teaching Award.

Co-operative Program (VI-A)

Student enthusiasm for the VI-A Program reached an all-time high in the spring when 140 students applied for the Program. Of these, 136 were allowed to interview the companies, representing 56 percent of the sophomore class in Electrical Engineering and Computer Science. This was the largest number and percentage of students ever to apply for the Program, comparing with 42.3 percent in 1975, 41.7 percent in 1974, and 37.7 percent in 1973.

Seventy-one of the applicants were selected for the VI-A Class of 1976, equaling the largest previous entering class of 1956 (when only 79 applied). The new VI-A Class represents 28 percent of the sophomores enrolled in Course VI and 52 percent of those who applied for the Program. Of the 71 new students, 48 registered in Program 1, 21 in Program 3, while two were "Undesignated."

To select this year's new class, the participating VI-A companies conducted a total of 714 half-hour student interviews during four days in March, a period extended from the two days of previous years. The previous high in total interviews was 608 in 1974.

VI-A enrollment in 1975-76 was 130, or 10.2 percent of the Department's total enrollment, and 23 VI-A students received the combined S.B./S.M. degrees under the 5-year plan, whereas 14 received only the S.B. degree. With the new VI-A Class of 1976 on board, enrollment in VI-A for summer, 1976 will be up to 160.

RESEARCH

Most research is performed in departmental or interdepartmental laboratories. A few results are noted briefly here. More complete information appears in portions of this report dealing with the following laboratories: the Electrical Power Systems Engineering Laboratory (EPSEL), the Research Laboratory of Electronics (RLE), Laboratory for Computer Science (formerly Project MAC), the Artificial Intelligence Laboratory, the Energy Laboratory, the Electronics Systems Laboratory, the Operations Research Center, and the Center for Materials Science and Engineering (CMSE).

Optics of Dielectrics

Professor Cardinal Warde developed the theory pertaining to the operation and applications of a new modified version of the Lummer-Gehrcke interferometer. The modified interferometer was shown to be a powerful tool for simultaneously studying optical constants and performing spectroscopy of thin dielectric films, in situ, during growth.

Optical Communications

Professor Warde also developed an interferometric technique for measuring the resolution-of-voltage-addressed electrooptic devices to be used for phase compensation. The theory describing the fringing fields in anisotropic electrooptic materials was developed and confirmed experimentally. A single-scatter, small-absorption model for optical communication systems operating in the middle ultra-violet was proposed and solved by a technique involving prolate spheroidal coordinates.

Asynchronous Process Control

Professors Ronald L. Rivest and Vaughan R. Pratt have been working on synchronizing unreliable processes by means of read and write operations on shared memory using neither P's or V's nor "test and set" primitives. Even repeated failure and restarting of any process cannot deadlock the system or impair the coordination of the remaining processes.

Computational Complexity Theory

Professor Rivest's work has resulted in a proof that any algorithm on a random-access computer for determining whether a pattern P occurs in a string S must in the worst-case examine at least $|S| - |P| + 1$ characters in S. Furthermore, it is demonstrated that this is the best possible result. This result, obtained by generalized parity arguments, shows that the recent Boyer-Moore algorithm cannot be improved to yield "sublinear" worst-case pattern-matching algorithms.

Further research resulted in an analysis of the worst-case number of probes required to retrieve a key from a hash table in which the arrangement of the keys has been optimized using an algorithm for the assignment problem. It is shown that a worst-case retrieval time of $O(\log_2 n)$ can be expected, given n keys in a table of size n.

Public Attitudes about Blood Donation

Professor Alvin W. Drake and his students completed relatively extensive fieldwork to determine how people learn about blood needs and decide whether or not to donate. The work included

surveys of the general public, frequent donors, former donors, and high school students. Early results cast doubt on the popular notion that the reluctance of the public to donate provides the primary limitation on the blood supply.

Remote Sensing of Atmospheric Data

In June 1975, the first imaging microwave spectrometer was launched into earth orbit for mapping atmospheric temperatures over the entire globe with ≈ 150 km resolution every 12 hours. Professor David H. Staelin (principal investigator) and Dr. P.W. Rosenkranz are collaborating with others in refining the microwave spectroscopic properties of the atmosphere, and the mathematical procedures for determining not only the atmospheric temperature profiles but also the distributions of atmospheric water vapor and liquid water, snow and ice cover, soil moisture, and other parameters. Similar instruments patterned after this experimental unit will be used on operational weather satellites beginning in 1978.

Properties of Graphite

Graphite intercalation compounds recently have received considerable attention because of observations of room temperature in-plane electrical conductivity exceeding that of copper. In the past two years Professor Mildred S. Dresselhaus and her students have studied the electronic, lattice, and structural properties of these graphite intercalation compounds using the magnetoreflexion, Raman scattering, and electron microscopy techniques in order to obtain a microscopic understanding of the intercalation phenomenon. Of particular interest are 1) the report of the first observation of Landau level transitions in graphite intercalation compounds, 2) the identification using Raman spectroscopy of lattice vibrations specific to carbon atom modes and others specific to modes associated with the intercalate species, and 3) the studies of the effect of intercalation on the graphite a-faces using electron microscopy techniques.

Digital Signal Processing

Professor James H. McClellan has two projects under way in the area of two-dimensional digital signal processing. First, a general framework for the unified characterization of one-dimensional and two-dimensional digital filter realizations has been developed. Using this new description, existing structures can be analyzed and new structures developed. Second, work has begun on applying the method of reconstruction from projections to the problem of inverting seismic data to estimate the earth's velocity structure.

Library Information System

At the Electronic Systems Laboratory, the Computer Applications group continued research in information processing. The information-network project under the leadership of Professor J. F. Reintjes completed an experimental version of a computer interface which links five bibliographic information retrieval systems located in Palo Alto and El Segundo, California; Gaithersburg, Maryland; Albany, N. Y.; and Cambridge, Mass. Although all five systems have special access and protocol requirements, the interface gives the appearance of homogeneity to end users. Thus, a single virtual system of uniform characteristics is presented to end users. It is expected that the virtual-system concept will ultimately enable individuals to gain access to millions of computer-stored bibliographic references directly rather than through a professionally trained intermediary.

Amorphous Semiconductors

In collaboration with Professors Marc Kastner in Physics and Hellmut Fritzsche of the University of Chicago, Professor David Adler's group developed a model for amorphous semiconductors which successfully accounts for all unique physical properties of many of these materials. This model explains the physical mechanism for threshold switching in chalcogenide glasses. A model also has been proposed for recovery of the OFF state after the voltage is removed. Finally, they have derived an expression for the current gain in the hybrid transistor developed here last year. The theoretical predictions agree with the experimental results.

Solar Cells

Workers in Professor D. Adler's solar cell project produced a transparent conductor, rf-sputtered indium oxide doped with tin (ITO) with the very low sheet resistance of $6\Omega/\square$. This material shows promise for the development of low-cost photovoltaic conversion by using the Schottky barrier between it and sputtered semiconducting films.

Data Communications

Professors Robert G. Gallager, Nils R. Sandell, Jr., Adrian Segall, and John M. Wozencraft are studying the dynamics of data communication networks. Unlike telephone traffic (which must be delivered at the same rate at which it is generated), data can be stored and forwarded from origin to destination in accordance with a wide variety of strategies. Emphasis thus far has been placed on devising adaptive routing procedures which reduce congestion and delay.

Large Scale Systems

Professor Sandell's research concerned development of control strategies for large scale systems. These systems are characterized by multiple controllers choosing different control variables acting on the basis of different information, and often having conflicting goals. Theoretical results were achieved using perturbation theory to obtain decentralized, hierarchically structured controllers. A new solution concept in stochastic differential games was developed. In addition, application of previously developed control methodologies to the routing problem in data networks, and to the dynamic stability problem in electric power systems was begun.

Electromagnetic Waves

Professor Jin Au Kong and his students researched applications of the electromagnetic wave theory. They examined various antenna configurations in geophysical subsurface probing using the electromagnetic interference fringes technique, developed theoretical models that are essential to the interpretation of microwave remote sensing data, and investigated optical diffraction and guidance by spatially periodic media for the application of electrooptical modulators in integrated optics.

Spark Plug

A new spark plug has been developed by Professor George W. Pratt, Jr., capable of providing a very long spark at ordinary ignition system voltages; gaps greater than 0.125 inch have been

fired using a conventional ignition system in an operating automobile engine. This new design has been tested by a major car manufacturer and found to be especially effective in igniting very lean air-fuel mixtures.

Force Plate

Professor Pratt's group also has developed a force plate system capable of detecting momentum changes imparted to the blood by heart action. From this ballistocardiogram, which is a non-invasive measurement, approximate cardiac outputs can be derived. By using two plates and noting the difference between the time-varying forces exerted by the subject's legs, forces associated with posture control can be observed. Characteristic abnormalities in these posture-control forces are seen in people with diseases of the nervous system.

Optical Transistor

The Professor's group also has proposed an optical transistor capable of transistor action, in which light signals replace electronic signals. The device uses the strong dependence of second harmonic generation on the index of refraction. A strong laser pump signal is directed into a nonlinear optical medium and a second harmonic signal is derived from it. A weak optical signal capable of altering the medium's index of refraction acts like the base signal of the electrical transistor; small index perturbations cause very large changes in the second harmonic signal emitted from the optical medium. The significance of an optical transistor has been investigated from the viewpoint of the optical circuits that can be derived from it; optical logic gates, flip flops, and the like can be constructed, leading to the possibility of optical data processing.

Programming Language Development

Professor Barbara Liskov and her group are researching design of the CLU programming language and study of techniques for specifying the intended behavior of programs. The goal in designing CLU is to aid in the construction of programs that are reliable, understandable, and relatively easy to modify and maintain. During the past year they have studied various issues of programming language design, including exception handling mechanisms, iteration methods and polymorphic functions. One accomplishment is the discovery of how controlled access to shared data can be achieved statically by means of declarations within programs.

Medical Assistance

Professor Peter Szolovits and the Clinical Decision Making Group developed a program to advise non-expert physicians on the administration of digitalis and digoxin to patients with cardiac arrhythmias or congestive heart failure. After interaction with the physician, this program uses a patient-specific pharmacokinetic model to suggest an initial dosage regimen and then, as opposed to earlier programs, it guides the physician through the feedback loop of adjusting the drug dosage based on the patient's clinical response. In an informal clinical trial performed on the Cardiology Service of the New England Medical Center Hospital in January 1976, the program's performance was encouraging. Its dosage recommendations usually agreed with the physicians' and it successfully predicted future drug toxicity in the four patients who developed that problem.

Crystal Physics Research

In the Crystal Physics Laboratory, directed by Professor David J. Epstein and Dr. A. Linz, studies of energy transfer in optically pumped lasers have uncovered important physical processes that limit the performance of present laser materials. D. E. Castleberry, in a recent doctoral thesis, showed that "up-conversion processes" can drain energy from the desired laser levels, thereby reducing the efficiency of laser action. This research establishes general guidelines for materials synthesis that will overcome these difficulties. A specific application of this work has been the development of miniaturized lasers that are usable in optical communication systems.

Professor Chenming Hu and a student developed a novel thin film dye laser that operates in a miniaturized cavity etched into a single crystal of silicon. By use of photolithographic methods and selective etching techniques, a rectangular cavity with straight parallel sides is produced in a silicon wafer; the cavity is then filled with a polymer carrying the laser dye. The sidewalls provide the necessary reflectivity for laser operation in a Fabry-Perot mode.

MACSYMA System

Academic year 1975-76 saw a major transition in the development of the algebraic manipulation system, MACSYMA, by Professor Joel Moses and his Mathlab Group at the Laboratory for Computer Science. Support for the group was transferred from ARPA to a consortium of agencies, principally ERDA's Controlled Thermonuclear Research Division, NASA, and the Navy. The consortium is expected to fund the continued research on algorithms and their development for symbolic manipulation, and its members intend to use the evolving MACSYMA system for their symbolic work over the ARPA computer communication network. To this end ARPA purchased a powerful DEC KL-10 computer system which represents an upgrade of a factor of five in computer power for the Mathlab Group.

Nonlinear Wave Interactions in Plasmas

Professor Abraham Bers and his group achieved a better understanding of how plasmas may be heated with the use of high-power microwave sources. Part of a continuing theoretical project concerning nonlinear wave interactions in plasmas, this work is important to the current quest for achieving controlled thermonuclear fusion as a new means for energy generation.

High Voltage Laboratory

A 100,000 gallons-per day research facility for the disinfection of municipal sludge by high energy electron treatment was brought into operation and dedicated on May 19, 1976, at Deer Island, the site of Boston's largest wastewater treatment plant, according to Professor John G. Trump.

Supported by the NSF/RANN program, this sludge disinfection system is an extension of the high energy electron studies of the High Voltage Research Laboratory on the treatment with electrons of superficial malignancies and the sterilization of surgical materials. It appears capable of providing a new economic alternative to the application of municipal sludge on land as a plant nutrient and soil conditioner.

Detection of failures in dynamic systems

Over the past year Professor Alan Willsky and his group have continued their study of the generalized likelihood ratio technique for the detection of abrupt changes in dynamic systems, with applications to ECG analysis, aircraft control systems, and freeway control.

FACULTY

Faculty promotions include Alan V. Oppenheim, James K. Roberge, Jerome H. Saltzer, David H. Staelin, and Gerald L. Wilson to Professor; and Carl E. Hewitt, Berthold K. Horn, Vaughan R. Pratt, and Alan S. Willsky to Associate Professor. Also, Professor Oppenheim was named the Cecil M. Green Professor of Electrical Engineering, replacing Richard B. Adler in that chair, and Assistant Professor John G. Kassakian became the first Carl Richard Soderberg Assistant Professor of Power Engineering.

After three years as Executive Officer of the Department, Professor George C. Newton, Jr., decided to return to teaching and research. Professor Fred C. Hennie replaces him. After 15 fruitful years as Director of the Research Laboratory of Electronics, Professor Henry J. Zimmermann resigned that post, which was assumed by Professor Peter A. Wolff of the Department of Physics. Professor Gallager was appointed Associate Director of the Electronic Systems Laboratory, effective April 15, 1976, as Professor Leonard A. Gould has asked to be relieved of his duties in that position, so he can devote more time to activities as Undergraduate Officer in the Department.

The Department was pleased to welcome the following Visiting Faculty during the academic year: Francesco Bacchialoni, formerly of the Lincoln Laboratory staff, and now of the Lowell Technological Institute faculty, worked in control applications in the Electronic Systems Lab. Dr. Chi-Hau Chen, of the Southeastern Massachusetts University, spent the fall working in statistical pattern recognition with Professor Murray Eden. Professor Hansgeorg Jeggle, of the Mathematics Department of the Technical University of Berlin, was with us until late March researching numerical methods for solving optimization and optimal control problems in ESL. We had two visiting faculty in the Artificial Intelligence Laboratory, Dr. Zenon W. Pylyshyn of the University of Western Ontario, Canada, and Dr. Charles J. Rieger of the University of Maryland.

Department faculty members taking working sabbaticals this year included Professors Peter Elias, Stephen Senturia, Barry Blesser, Fred Schwegge, and Ted Young. Professor Elias went to Imperial College of Science and Technology in London to do research on applications of information theory to computational complexity problems. Professor Senturia was at the Technical University of Denmark in Lyngby working on the effect of impurities on nuclear magnetic resonance in solids. Professor Blesser took the spring term to research the audio field. Professor Schwegge spent the fall term at the University of New South Wales, Sydney, Australia working in the field of control, operation, and security assessment of electric power systems. Professor Young was Visiting Professor at the Technological University of Delft, the Netherlands, continuing his work on pattern recognition problems related to the shapes of blood cells.

Professors Fernando J. Corbato and Hermann A. Haus were elected to the National Academy of Engineering. Professor Michael L. Dertouzos became a Fellow of the Institute of Electrical and Electronics Engineers. Professor Walter A. Rosenblith, Provost, received triple honors: Charter Member of the Institute of Medicine, Member of the Governing Board, National Research Council, and Member, National Academy of Science. Professor Willsky received the Twelfth

Annual Donald P. Eckman Award presented to persons under 30 for outstanding research contributions to the field of automatic control and also the M.I.T. Graduate Student Council Award for excellent teaching. Professor David Adler was elected Member-at-large of the Executive Committee, Division of Solid State Physics, American Physical Society. Professor Mildred Dresselhaus became Chairman of the Nominating Committee of the American Physical Society. Professor Kenneth N. Stevens was made President of the Acoustical Society of America.

Professor S.S. Patil left the Department faculty to accept an offer from the Department of Electrical Engineering and Computer Science at the University of Utah, Salt Lake City. Professors M.D. Schroeder and Clarence Ellis resigned to accept positions with Xerox Corporation in Palo Alto.

Professor Liba Svobodova joined the faculty after a year of teaching at Columbia University; she works in the areas of computer architecture and performance evaluation. Dr. James McClellan of Lincoln Laboratory's Group 24 became an Assistant Professor of Electrical Engineering, specializing in applied signal processing.

WILBUR B. DAVENPORT, JR.

Department of Materials Science and Engineering

Changes of the last year should be viewed against the background of a 10-year development of the Department. Driven by the need to concentrate on materials science for aerospace and related advanced technological developments, the build-up of research funds and graduate students reached its peak about 1968. Thereafter, the rapid decline of the space program, following passage of the Mansfield Amendment, and the general disenchantment with basic science were felt throughout the Institute, but effects were particularly marked in departments such as ours, with strong applied science and research orientation. This sharp change in the fortunes of the Department coincided with two developments in the early seventies: a major restructuring of the organization and content of the graduate program, resulting from reassessment of the objectives of our educational activities, and the start of the increase in academic and research resources devoted to problems related to energy and materials production and utilization. The post space-program decline reached a low point in 1973. Thereafter, with the steady expansion of the new programs, every index of productivity has increased.

These trends describe the overall picture, but hide the major internal changes in the nature of work and distribution of effort and resources occurring during these years of transition. The focus of attention has moved toward the engineering end of the spectrum. Now there is much emphasis on materials design -- the optimization, technologically, economically and socially of a total materials system -- and on national materials policy. There is less emphasis on basic physical science. So strong has been the shift that nurturing our materials science programs has become a matter of major concern. The interest in classes of materials also has changed, most dramatically away from electronic materials toward ceramics. These changes in support produced problems for some members of our faculty and long-awaited opportunities for others.

Curriculum Development

The departmental Graduate Committee was reorganized to act as the coordinating and administrative unit for the program. Since their establishment, each of the five faculty panels has considered the exact definition of the contents of their individual disciplines. During the Independent Activities Period all-day study groups addressed these problems. Probably the clearest definition of the coverage of each field is to be found in the range of questions asked in the oral and written parts of the graduate General Examination. Certainly from the student's point of view this is the most practical aspect of this apparently academic exercise. Earlier in the year we held the first full round of General Examinations. Oral and written examinations were taken by 24 students: six in Ceramics, five in Materials Engineering, six in Materials Science, six in Metallurgy, and one in Polymerics. All passed with the exception of one in Ceramics, one in Materials Science, and one in Materials Engineering. Perhaps of equal importance, it emerged that in the opinion of the faculty and the students the examinations were fair and representative of the separate fields. There is, however, a general feeling that we should attempt a more precise and extensive definition of the coverage of each field than exists at the present time.

Undergraduate Program

The total number of undergraduates rose close to the peak of 50 reached in 1968. The large increase in the number of sophomores electing to major in Materials Science and Engineering was particularly encouraging. In February 1976, 17 sophomores indicated that they will register for Course III. This is twice the number of sophomores indicating this preference a year earlier. We expect to graduate 17 seniors in June.

Graduate Program

The number of graduate students reached a maximum of 162 in 1968. In the post-Apollo years, as research funding declined and major agencies eliminated graduate trainee programs, the number of graduate students in the Department decreased, reaching a minimum of 122 in 1973. The suddenness with which support was withdrawn is illustrated by the number of NSF traineeships held in the Department. In 1969 there were 10, in 1974 there was one, and today there are none. Until this year, the number of graduate students has been tied closely to the resources available to support these students. The first self-supporting student appeared in 1974. Today six students support themselves. In 1973, the first hopes of increased research funding through the Energy Laboratory at M.I.T. and the newly established Energy Research and Development Administration (ERDA) in Washington appeared. Later the number of research assistants who could be supported increased until this year we were able to provide research assistantships for 88 graduate students. Sixty-seven percent of our students are now supported by research assistantships, a proportion reminiscent of the situation in the late 1960s. The steady rise in the total number of graduate students reached 140 this year.

One reason why the total number of graduate students increased less rapidly than we had planned is that the number of teaching assistantships fell sharply from 20 to 15, by our own decision. As part of the faculty development plan, we decided to assign the teaching of recitation sections in the large (more than 400 students) freshman chemistry subject (3.091 Introduction to Solid-State Chemistry) to faculty members. To do this we appointed six additional untenured faculty members, and paid them partly from the increased research volume and partly by dropping from the budget five teaching assistantships previously assigned to 3.091.

RESEARCH

Research volume in the Department increased by more than 30 percent.

For many years there has been a strong effort in the thermochemistry and kinetics of steel making and other extraction processes directed by Professors John F. Elliott and Thomas B. King. Their group is directing its efforts towards the major problems of modern steel makers, particularly the removal of sulfur and the control of oxide inclusions. The thermodynamic basis for understanding the stability of inorganic metallic compounds has proven valuable in the study of high-temperature oxidation, a prominent problem now that efforts are being made to push thermal machinery to higher temperatures. Professor Elliott has joined with some of the faculty in Ceramics to launch a new study of high-temperature oxidation.

On the physical metallurgy side, an effort has been launched to study phenomena in high-strength, low-alloy steels which are important in the controlled rolling and subsequent heat treatment of these steels. These low carbon medium manganese steels with controlled small additions of columbium, vanadium, and molybdenum find widespread application in arctic pipelines and similar large structures. The studies at M.I.T. are being directed by Professors Morris Cohen, Walter S. Owen, and John Vandersande. This group is joined by Professor Roy Kaplow for the study of many aspects of the martensitic transformation. Recently we have concentrated on the remarkable work hardening that can be obtained at high strength levels by inducing the martensite to form in an external strain field. It is thought that this unusual form of work hardening will lead to interesting applications for high-strength steels which are required to absorb large amounts of plastic energy. A related topic is the cyclic hardening in steels containing manganese. These steels also harden by the formation of strain-induced martensite. Professor Regis M.N. Pelloux is studying this cyclic behavior and the related phenomenon of fatigue crack growth in these unusual metals.

Ceramic research included the long-standing program on oxides used in nuclear fuels and the newer program on the mechanical strength of laser windows. The most exciting project of the year concerned the design, development, and fabrication of a ceramic material system for high-temperature, high-current electrodes to be used in coal gasification MHD plants. Its success led Professors W. David Kingery, Robert L. Coble, Kent Bowen, Rowland M. Cannon, and Bernhardt J. Wuensch to establish a laboratory devoted to studies of advanced techniques for processing ceramics.

Professor Donald R. Uhlmann is continuing his work on glassy polymers. Professor Frederick J. McGarry is working on composites involving polymers, and with Professor David K. Roylance, on fracture and mechanical behavior.

Professor Keith H. Johnson's catalysis research began with exploring applications of a highly theoretical technique for computing bonding energies in solids. It has since developed into a powerful tool for understanding interactions between atoms and molecules on the surfaces of solids and it is expected that these studies will make a large contribution to the important science of catalysis. Professor Kaplow devoted efforts to developing material systems using new materials for the direct conversion of solar energy into electrical energy. Professors Cohen, Owen, and John W. Cahn, who are interested in theoretical aspects of the martensitic transformation, examined thermoelastic martensitic growth associated with the phenomenon of shape memory. Shape-memory alloys are now considered for such applications as gripping devices in places to which access is difficult, thermal engines producing mechanical work directly, and acoustical damping alloys. We also are attempting to lay the groundwork for the successful commercial development of copper base shape-memory alloys.

In Materials Engineering, Professors Michael B. Bever and Joel P. Clark have completed a number of studies including one on technological and economic direction of the production and exploitation of manganese nodules mined from the deep oceans. This work was carried out in collaboration with faculty members from the Department of Ocean Engineering and the Department of Economics. Several material system studies of the feasibility of substitution and scrap recovery of certain materials also were completed. The most recent activity is a study of the impact of new technologies on the extraction and fabrication of magnesium.

Professor Merton C. Flemings continued his development facets of the rheocasting process to achieve satisfactory castings in steels. For a number of years Professor Nicholas J. Grant, with the help of Professors Pelloux and Vandersande, worked on rapidly cooled metals known under the generic name of metallic glasses. These amorphous materials have remarkable magnetic and mechanical properties. An international conference on metallic glasses was held at M.I.T. earlier this year. This area is moving into a new phase as it has now been demonstrated that very fine grain-size materials can be produced by radically new powder techniques. These fine grain materials, although not completely amorphous, have many interesting properties of metallic glasses and undoubtedly will increase the technological options in this area.

It is our intention to increase the effort on super fine-grained and glassy materials in the near future.

FACULTY

Professor Grant was named to the newly established Abex Professorship of Advanced Materials, and Professor Flemings was appointed Ford Professor of Engineering. Professor Pelloux was promoted to full Professor and Professor Bowen simultaneously received tenure and was promoted to full Professor. Professor Heather Lechtman earned a tenured appointment jointly with the School of Humanities.

Persons from outside M.I.T. are rarely offered full professorships within the Institute, though Professor Julian Szekely, Director of the Center for Process Metallurgy at the State University of New York at Buffalo, received and accepted such an offer. He is a materials engineer specializing in heat and fluid flow, the mathematical modeling of metallurgical processes, and materials systems analyses.

During the year a number of new Assistant Professors joined the faculty: Dr. Cannon and Dr. Harry L. Tuller in Ceramics, Dr. Clark in Materials Systems, and Dr. Gregory J. Yurek in Metallurgy.

Assistant Professors C.S.P. Sung in Polymerics and Tom Eager in Materials Engineering will join the Department at the start of the next academic year.

One of the first three adjunct professors ever to be appointed by M.I.T. was Dr. Richard Charles who is manager of the Ceramic Division of the General Electric Company's Research and Development. He will help to develop our new teaching and research program in ceramic processing.

Professor Flemings was elected to the National Academy of Engineering.

WALTER S. OWEN

Department of Mechanical Engineering

The 1975-76 academic year witnessed continued growth and new program development in the face of further reductions in the financial resources available to the Department. Undergraduate enrollment underwent another substantial increase in size, almost reaching that of the graduate student body for the first time in more than three decades. Research volume remained steady following a 21 percent increase last year, but research per faculty member increased by 38.6 percent, reflecting increased participation of our faculty in the interdepartmental centers and laboratories. The Departmental Planning Committee completed its work of the last year. Its recommendations were adopted formally by the faculty as departmental policy guidelines, and implementation of the recommendations began. New developments occurred in the Department's research programs in the areas of mining and resource recovery, polymer processing, energy conversion, environmental engineering, and biomedical engineering. The Department again ranked first among all the mechanical engineering departments in the country in the latest five year survey.

The organization of the Department continued around three major disciplinary areas: Mechanics and Materials, Fluid and Thermal Sciences, and Systems and Design. The Heads and Associate Heads of the three divisions were, respectively, Professors Ali S. Argon and Nam P. Suh; Joseph L. Smith, Jr. and Ain A. Sonin; and David Gordon Wilson and Henry M. Paynter. The Steering Committee, consisting of the Department Head and the above six faculty members, set Department policy and advised the Department Head on matters of personnel, program development, and internal resource allocation.

Regular departmental faculty meetings were held to discuss problems facing the Department and the Institute in an effort to enhance communication and find feasible solutions. Notable this year were meetings with the Chancellor to discuss the Institute's financial problems and with the Dean of Engineering to discuss a potential restructuring of the School of Engineering.

The Department began to develop closer ties with its alumni. A newsletter published in the spring contained an historical sketch of the Department, an overview of the Department today, and highlights of several new research and educational programs. About 4.7 percent of the Department's 6,083 US and foreign alumni returned the enclosed reply cards with comments and suggestions, news about themselves, and/or donations to the Department. Reaction to the newsletter was positive and the Department hopes to continue it as an annual publication. In addition, a well-attended alumni-faculty reception held on June 4 in connection with Technology Day provided a time for familiarizing alumni with the present status of the Department and its plans for the future.

In 1974-75, Department Head Herbert H. Richardson appointed a Planning Committee to formulate goals and plans for the Department for the coming years, taking account of the future needs of the profession, the changing aspirations and attitudes of the students, the future needs for research, and the continuing shortage of financial resources at M. I. T. The Committee was chaired by Professor Smith, and included Professors Sonin, Suh, John B. Heywood, Robert W. Mann, Warren M. Rohsenow, James H. Williams, Jr., and David N. Wormley. Following deliberations and discussion with other faculty and staff, the Committee's recommendations were accepted as policy guidance for the Department by vote of the faculty in February 1976, and published in the "Report of the Mechanical Engineering Department Planning Committee." The report defines these departmental goals:

to educate students (the primary mission to which all activities should be directly or indirectly related); to expand the frontiers of knowledge and advance engineering methods and techniques; to develop subject matter and methods for mechanical engineering education; to provide academic and research experience to junior faculty and staff; and to supply expert technical services to industry, government, the professions, and society.

The report recommended that the faculty be encouraged to conduct basic research and to lead in the formulation of new or developing disciplines, even though this type of work is not currently popular with many funding agencies. At the same time it should pursue goal oriented research toward the needs of society, concentrating primarily in biomedical engineering; energy conversion and conservation, and environmental engineering; manufacturing and materials processing; and human services such as transportation, health care delivery, and waste management.

Major development programs and facilities recommended included: establishment of a biomechanics and rehabilitation laboratory for research in human mobility (Building 3); development of a center for engineering design, primarily for teaching, by major physical renovation of existing space on the fourth floor of Building 3; creation of a new manufacturing and processing laboratory to enable consolidation and expansion of activities in this area as a major thrust for the Department; expansion of the Cryogenic Engineering Laboratory into a new interdepartmental cryogenics and applied superconductivity laboratory; and upgrading of the Sloan Automotive and Gas Turbine Laboratories (Building 31) to create a new Fossil Fuel Research Facility in cooperation with the Energy Laboratory and the Departments of Chemical Engineering and Aeronautics and Astronautics.

The Committee found the undergraduate curriculum healthy and vigorous, but recommended a comprehensive review of the graduate curriculum and the formation of a graduate executive committee to coordinate and monitor the quality of graduate subject offerings. It also recommended seeking closer ties with industry and government by expanding the cooperative program to the S. M. level, seeking collaborative research and design activities with industry, offering selected graduate subjects at times attractive to special students from industry, and exchanging staff with government and industry.

Undergraduate Program

Following the trend of the past four years, undergraduate enrollment in mechanical engineering continued to increase in 1975-76. The increase of 12 percent between 1973-74 and 1974-75 was exceeded by further growth of 14.5 percent, bringing enrollment to 243. The sophomore class increased from 63 last year to 86 (a 36.5 percent increase), with 85 juniors and 72 seniors registered. At present the undergraduate population has become approximately equal in size to the graduate student body, and next year will exceed it for the first time in more than three decades.

Historically, class size grows by 15 to 20 percent by graduation. If this trend continues, the undergraduate enrollment will reach 300 to 350 within three years, or more than twice that of 1971-72. Part of this rising enrollment can be attributed to increases in the size of the Institute freshman classes, but the major reason appears to be a growing awareness and appreciation by students of the Department's program and career opportunities. Significant factors are the curriculum revision implemented in 1974-75 and the policy of assigning the Department's most outstanding teachers to the undergraduate core program. This conclusion is reinforced by the fact that enrollments of non-mechanical engineering students in subjects offered by the Department also have increased markedly during the past two years.

The Department is proving increasingly attractive to women and black students. Last year their numbers grew to about 10 percent of each class. This year they comprise just over 20 percent of the sophomores (15 percent women and 5.8 percent blacks), 12 percent of the juniors and slightly more than 15 percent of the seniors. Overall, the undergraduate population now includes 11.5 percent women and 5.3 percent blacks. The Department plans to encourage these students to consider graduate education, which we believe is one of the best means of increasing the pool of women and blacks qualified for future positions in research and engineering education.

The Course II-A program, which offers an S.B. degree without specification, with a home in the Mechanical Engineering Department, continues at a level of about 25 students per year. Professor C. Forbes Dewey, Jr. serves as Course Officer and advisor. Program curriculum may be specifically tailored to meet special educational goals not coinciding with the S.B. requirements in Mechanical Engineering. Students use this program to specialize in one facet of mechanical engineering; to study interdisciplinary fields such as electromechanics, air and water pollution, or biomedical engineering; and to prepare for professional education in law or medicine.

Beyond these statistical trends, the Department has found the interests of undergraduates to be shifting toward design, experimental engineering, and solution of the practical problems of industry.

Now in its third year of operation, the Undergraduate Office had its first change of leadership in January 1976, when Professor Stanley Backer, Undergraduate Officer, and his Assistant, Dorothy Eastman, transferred their duties to Professor Peter Griffith and Peggy Garlick. The office is a focus for all undergraduate matters, and combines functions previously requiring the services of three faculty members and their secretaries. It coordinates undergraduate registration, maintains undergraduate statistics and student files, collects and publishes thesis and project topics, coordinates senior thesis review, provides services for the student evaluations of teaching, manages summer job placement, provides counseling, and handles faculty teaching assignments and work load reports for graduate as well as undergraduate teaching. In addition, the office has served as an effective link to the students on all undergraduate administrative matters.

During the past year Professor Griffith has planned a more formal industrial summer jobs program both to replace the present undergraduate cooperative Course II-B and to provide a greater selection of relevant summer experiences to the students.

The Undergraduate Enrollment Committee, which is responsible for presenting the Department and its programs to prospective students, was continued under Professor David C. Gossard and Departmental Instructor David E. Hardt. This year the Committee organized a "Mechanical Engineering Sampler," which included a series of interesting displays and demonstrations to give freshmen and other undesignated students a view of the scope and flavor of the field. The program attracted more than 100, and the same presentations were provided to the public at the M. I. T. Open House in spring, 1976.

The Undergraduate Committee, which provides a forum for discussion of all undergraduate affairs between students and faculty, was chaired this year by Professor Dewey in the absence of the regular chairman Professor Borivoje B. Mikic, who was on sabbatical leave.

The Committee discussed and acted upon several issues concerning departmental operations and policy. Students objected to the cancellation of certain popular subjects (e. g., 2.101 Computer Models for Physical and Engineering Systems, which was dropped because of shortages in staff) and expressed concern about the increasing class sizes (often 40 to 50

students) resulting from enrollment growth without adding more class sections. William J. Mazzei, a junior class representative, initiated a review and update of the curriculum planning guides for sophomores and juniors.

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 Project Laboratory. These subjects require extensive facilities including machine tools, mechanical testing machines, electromechanical devices, and electronic and mechanical instrumentation, but much existing equipment is outdated and subject to increasing failure, which frustrates students and in some cases presents safety hazards. The electronic instrumentation is in especially short supply both because existing equipment is old and unreliable, and because the large increases in enrollment in the laboratories place heavy demands on the equipment. Some relief was achieved this year when new equipment was purchased under a 1975-76 NSF Instructional Scientific Equipment Grant with matching funds from M.I.T. However, the Department's need to upgrade and augment its laboratories of instruction remains pressing.

The two major student organizations, Pi Tau Sigma (National Honorary Fraternity) and the American Society of Mechanical Engineers (ASME) Student Section, continued their outstanding service to the Department. Pi Tau Sigma annually performs course and instructor evaluations, and this year organized several student-faculty social functions. The ASME Student Section hosted the Northeastern Regional ASME Student Paper Contest, where eight papers were presented by students from schools within New England. Planning and operation of the conference was carried out by the M.I.T. Chapter Officers.

BlackME, an organization of black students in mechanical engineering, was originally formed as a social group, but reorganized to provide self-help and improved channels of communication between black students and between the students and the faculty. The group was assigned a room which they renovated for group study, tutoring sessions, meetings, and social events. Professor Stephen H. Crandall was chosen by the group as the first faculty advisor. In its new form, BlackME proved successful in improving both the morale and the academic performance of the Department's black students.

Professors James C. Keck and Leon Trilling of the Department of Aeronautics and Astronautics combined subjects 2.404 Molecular Theory of Materials and 16.01 Physical Properties of Gases to increase teaching efficiency and broaden the scope of the material covered. Their objective is to provide undergraduate students with the physical insight into the molecular and statistical mechanical theories of materials necessary to deal with advanced engineering problems.

Another recent joint offering is 2.071J/13.10J Introduction to Structural Mechanics, taught by Professor Williams, with the collaboration of Professor John K. Vandiver of the Department of Ocean Engineering. This advanced undergraduate subject leads to graduate study in elasticity and/or numerical analysis of structures.

Professors Alician V. Quinlan of our Department and John M. Edmond of the Department of Earth and Planetary Sciences are collaborating on a series of subjects and seminars in Environmental Ecology. Subjects 2.131J/12.003J and 2.132J/12.004J Environmental Ecology I and II concentrate on modeling of ecosystems and how man can disrupt these environmental regulatory mechanisms. Two consecutive seminars, 2.133J/12.081J and 2.134J/12.082J Environmental Problems Seminar, will examine the scientific, engineering, medical, legal, economic, political, and social consequences of man's impact on specific aquatic systems such as watersheds, aquifers, and coastal zones. Attention will then shift to terrestrial environments such as forests, tundra, and deserts. The seminars will serve as a forum

for students and faculty from diverse but complementary disciplines to share their special knowledge.

These three new ventures demonstrate the Department's continuing initiatives to collaborate with other departments in teaching interdisciplinary subjects or disciplinary subjects of common interest. Other examples of cooperative subject areas include systems analysis, biomedical engineering, dynamics, polymers, thermodynamics, materials science, and management in engineering.

Graduate Program

Graduate applications in 1975-76 fell to 209 from 264 in 1973-74, with about 69 new students enrolled. Total graduate enrollment as of September 1975 rose by 12 to 250, including Special Students. About 25 percent of the current graduate students were M. I. T. undergraduates; 51 percent came from other US colleges and universities; and 24 percent have foreign educational backgrounds. Although enrollment of full-time graduate students dropped slightly because of shortage of funds for research assistants and reduction in the number of industrial and federal fellowships, we do not expect this trend to continue. One major problem facing the Department is finding ways to support outstanding applicants in a time of declining financial resources. The number of assistantships awarded by the Department decreased from 151 last year to 132 this year and unless research funding increases, it will decline again next year. The number of fellowships, which some students prefer to assistantships, also fell from eight last year to six this year. A concerted effort is being made to improve this situation.

During 1975-76 the Department awarded 58 masters' degrees, 7 S.B./S.M. degrees, 15 Mechanical Engineer degrees, and 24 doctorates.

In response to a recommendation of the Planning Committee, an ad hoc subcommittee of the Graduate Committee was formed under the chairmanship of Professor Heywood to study ways of improving the acceptance rate of the top applicants to the Graduate School. The answer to this problem is early, firm offers of financial support. In the past, offers (especially research assistantships) have been made by individual faculty as research support becomes available for the next academic year, so that many outstanding students did not receive offers of support until the end of the spring term or later. Faced with this uncertainty, many top students accepted earlier offers at other schools. Thus, schools making early offers enjoy a competitive advantage, and the Department feels its graduate student quality suffers as a result.

As remedy, the ad hoc committee proposed the establishment of a departmental pool of research assistantships based on the average number of offers made to new students each year. These would represent firm as well as projected research assistantship availabilities from which firm offers to a pool of new students would be made. Specifics of the research work for each offer would be left somewhat open until the particular proposal involved was accepted. The Department would make the commitment, however, that all students offered support would receive it even if not from a specific research grant or contract.

The new system worked well when used in the 1975-76 admissions process. Offers of support were made to outstanding students soon after they were admitted and the objective of fewer rejections seems to have succeeded without placing a financial burden on the Department.

In the area of curriculum, the Planning Committee recommended a comprehensive review of the graduate programs to facilitate closer association between graduate fields of study and associated curricula, a review of core subjects and core subject sequences for content and

coherence, future staffing needs to maintain and improve core subject as well as all graduate teaching, a system for updating graduate student information guides, and a review of the examining process for higher degrees. Work will be initiated in this area during summer, 1976.

Professor Thomas B. Sheridan is pursuing a new area of study in the form of a Proseminar in Technology and Public Policy I and II. This core subject in the new interdepartmental program in Technology and Public Policy leads to a master's degree in technology and policy. It is designed to provide practical experience in problem definition, analysis, synthesis, presentation, and evaluation in a variety of case studies and projects involving large-scale technological systems and public or corporate policy. Problem emphasis includes risk acceptance and public policy (with cases in nuclear energy, highway safety, liquefied natural gas transport, fluorocarbons and ozone), and socio-cultural effects of new technology (with cases in coal mining, electronic word processing in the office, offshore oil and mineral development, manufacturing automation, and educational technology).

Professor Quinlan is participating with Harvard Professor James N. Butler in Chemical Models of Natural and Polluted Water: Biosphere Dynamics, offered under 2.996 Advanced Topics in Mechanical Engineering. The subject brings together science and engineering students at M.I.T. and Harvard, and teaches them to pool their special knowledge and skills to organize a concerted attack on complex environmental problems.

Dr. Michael P. Cleary has modified the content of 2.072 Mechanics of Continuous Media to cover the principles and practical application of the continuum concept in dealing with solid, fluid, or multiphase bodies undergoing deformation, and failure or separation. This new approach consolidates various field theories (elasticity, plasticity, creep, diffusion) of mechanics into a single presentation with one basic notation.

Visiting Professor Giuliana Tesoro introduced 2.925 Textile Fibers: Structure and Chemical Modification, a subject dealing with essential molecular properties of fiber-forming polymers, development of fibrous structure and the processability of the fibers in the context of textile products (yarns and fabrics).

Graduate students in the Department remained active as a group and as individuals. Max Donath, after completing his term as Graduate Student Council President, received a Karl Taylor Compton Prize for this and other outstanding services to the Institute. The Goodwin Medal, given for "conspicuously effective teaching" by a graduate student instructor, was presented to Douglas A. Limbert.

David E. Hardt, Departmental Instructor for 1975-76, will return to full-time doctoral study next year with a Health Sciences Fund Fellowship in the area of biomechanics.

RESEARCH

The volume of sponsored research administered through the Department remained approximately constant at a projected value of \$3.72 million following a 21 percent increase from FY74 to FY75. Research support for FY76 is currently estimated to be \$4.4 million. On the other hand, research support per faculty member increased 38.6 percent to \$122.7K, reflecting increased participation by our faculty in interdepartmental centers and laboratories. Approximately 20 percent of our faculty are now involved in research associated with the Energy Laboratory, for example.

Of great concern to the Department is the virtual disappearance of internal funds available as seed money to enter new fields of research, to support research initiation by junior faculty and shifts in field by senior faculty, and to support advanced research not currently popular with funding agencies. It is essential to the continued excellence of the Department that sources of support for these purposes be found. Equally important is educational research and development leading to the synthesis of new mechanical engineering disciplines and the generation of pioneering texts and other educational materials.

Research activities in the Department are concentrated in four principal programmatic areas: Energy and Environment; Manufacturing, Materials and Processing; Bioengineering; and Human Services including Transportation. The relative emphasis on these four areas, respectively, is approximately 30 percent, 20 percent, 30 percent, and 20 percent measured in terms of research support. The emphasis on Manufacturing and Processing is considered too small compared with the other program areas in light of its importance to the national economy, and steps are being taken to expand this area through staff changes and stimulation of industry oriented research.

Each of the Department's current research programs is summarized in the full "Annual Report of the Department of Mechanical Engineering," to be published in September 1976.

FACULTY

The size of the faculty remained constant at 48 in spite of a larger student body and research load. With 26 Professors, 13 Associate Professors (six tenured), and nine Assistant Professors, the present faculty is two-thirds tenured. The figure of nine Assistant Professors stands in stark contrast to 1962, when there were 24 Assistant Professors out of a faculty of 60.

The Planning Committee addressed the problem of faculty and staff development and stressed the need for more organized career guidance for junior staff and faculty, to come principally from senior members of the faculty. It also recommended that higher priority be given to increasing opportunities for junior personnel to develop to their full potential. The Committee also formally cited the success, and endorsed the system of postdoctoral research now in operation.

Three young members of the faculty were honored with Assistant and Associate Professorships this year. D. Graham Holmes was named the Esther and Harold E. Edgerton Assistant Professor of Mechanical Engineering, while Professor Quinlan now carries the title of Arthur D. Little Assistant Professor of Environmental Science and Engineering. She also received a Rockefeller Foundation Fellowship in Environmental Affairs and was named a Fellow of the Radcliffe Institute on the Gordon McKay Endowment and Research Fellow, and later Lecturer, in Environmental Engineering at Harvard.

An exciting first for the Department was the naming of Professor Woodie C. Flowers as the Class of 1922 Career Development Associate Professor of Mechanical Engineering. He also received the Everett Moore Baker Award for "extraordinary interest and ability in inspiring undergraduate interest in, and understanding of, academic work."

In the senior faculty, Professor Argon won the ASME/Pi Tau Sigma Charles Russ Richards Memorial Award as the outstanding mechanical engineer within 20 years of graduation, and Professor Backer was named the first Kenneth L. Hertel Lecturer by the University of

Tennessee, a lectureship awarded to a scientist or engineer "who has made outstanding contributions in the area of fiber and textile characterization and mechanics." Professor Backer also presented invited lectures at the Symposium on Texturing held at Manchester University in England and at the Symposium on Fiber Science held at Arad, Israel, February 1976.

Professor Stephen H. Crandall was named Ford Professor of Engineering. Professor Emeritus Jacob P. Den Hartog was presented with an honorary Doctor of Science degree from the University of Newcastle-on-Tyne and was given the Trent-Crede Medal by the Acoustical Society of America for outstanding contributions in the field of vibration and shock.

Professor James A. Fay continued as Chairman of the Massachusetts Port Authority and served on local and national boards concerned with the technology and policy of energy and the environment. Professor Griffith was given the Heat Transfer Memorial Award by the American Society of Mechanical Engineers for contributions to the art of heat transfer in two phase flow, boiling and condensation. He also served as associate editor of the ASME Journal of Heat Transfer.

Professor Emeritus Joseph H. Keenan was elected to the National Academy of Engineers and cited for his "contributions to engineering thermodynamics and engineering education."

The University of Evansville awarded an honorary Doctor of Engineering to Professor Richard H. Lyon for outstanding contributions to the field of sound generation, noise pollution, and random vibration.

The Carl Richard Soderberg Professorship in Power Engineering was established in honor of Institute Professor Emeritus Soderberg, a former Head of this Department and Dean of the School of Engineering, who is recognized internationally for pioneering work in the design and development of turbine engines.

Three new faculty members joined the Systems and Design Division during the past academic year. Dr. J. Karl Hedrick, a Visiting Associate Professor in the Department in 1974-75 on leave from Arizona State University, was appointed an Associate Professor. His areas of interest are systems dynamics, automatic control, and transportation. Professor Quinlan who received her Ph.D. in 1975 from M.I.T.'s Department of Civil Engineering, held appointments as Research Associate in the fall term and as Assistant Professor in January.

Dr. Carl R. Peterson became an Associate Professor in January. After serving as Assistant Professor in M.I.T.'s Department of Aeronautics and Astronautics from 1961 to 1963, Dr. Peterson spent 13 years in industry before joining our faculty. His field is mining and mineral resource recovery by mechanical means.

Dr. Cleary joined the Mechanics and Materials Division as a full-time Lecturer in January, after completing his doctorate in Civil Engineering at Brown University, and became an Assistant Professor in July. His field is continuum mechanics.

The resignations of Professors Roger E. Kaufman (Systems and Design), Philip Thullen (Fluid and Thermal Sciences), and Stephen P. Loutrel (Mechanics and Materials) were accepted with regret. Professor Brandon G. Rightmire retired on June 30 after 34 years on the faculty of the Department. Since 1952 he has been Head of the Lubrication Laboratory, now called the Surface Laboratory.

Department of Nuclear Engineering

Professor Emeritus Douglas P. Adams, who retired in June 1974 after 36 years of service, died on October 25, 1975. Professor Adams joined M.I.T. in 1938 as an Assistant in the Graphics Section, which was combined with the Design Division of the Department in 1956. He rose through the ranks, becoming Professor of Mechanical Engineering in 1969. During most of his career, he lived in Cambridge where he was active in civil defense, the Boy Scouts, and the Cambridge schools. A few years before his retirement he moved to Charlestown, his birthplace, where he put his love of American history to use in helping with that town's historical restoration. Professor Adams, by his personal example and dedication, inspired in generations of students and colleagues a spirit of intellectual honesty and precision as well as deep concern for people and their historical heritage.

Gordon Ball Wilkes, Professor Emeritus of Heat Engineering, died on February 16, 1976. A graduate of M.I.T. in 1911, he served on the faculty of the Department of Physics from 1911 to 1934, when he came to the Department of Mechanical Engineering. He has been retired since 1954.

Margaret M. Gazan, an Administrative Assistant who had been in the Department since 1963, died on May 6, 1976. She came to M.I.T. in 1954, and was promoted to Administrative Assistant in 1970.

HERBERT H. RICHARDSON

Department of Nuclear Engineering

This year the Department introduced an undergraduate program for the first time, and in addition undertook a special program of graduate education for the Iranian Government. The normal graduate program continued to grow, reflecting the increasing demand for nuclear power throughout the world. Despite well-publicized attacks on some aspects of the nuclear power program, interest in nuclear engineering careers remains high and demand for professionally trained nuclear engineers is strong.

In addition to Department activities relating to fission power (which involve about 60 percent of the Department effort), the area of controlled fusion grew to about 30 percent of the total Department activity. Other areas of effort include biomedical applications of radiation and applied radiation physics.

This year the Department had a total enrollment of 190 students, including 150 regular graduate students, 20 special Iranian students, and 20 sophomores entering the new undergraduate program. There were 22 faculty members. The Department granted 71 advanced degrees including 39 Masters of Science, 8 Nuclear Engineers, and 24 Doctorates. Qualified applicants continue to exceed the present capacity. In order to stabilize the enrollment to be consistent with the present size of the faculty, next year's graduate admissions will be limited to about 30 new regular students, plus 15 new Iranian students. In addition, about 20 more students are expected to enter the undergraduate program. The total graduate enrollment next year is expected to be about 185, and the undergraduate enrollment about 40. Because three faculty members will be on leave, the student-to-faculty ratio will exceed 10, and the graduate student-to-faculty ratio will be about 9.

Requirements for the new undergraduate program consist largely of subjects already offered by other Institute departments, while a limited number of new undergraduate nuclear engineering subjects were added. By using these available Institute resources, the program was introduced with little increase in the size of the Department of Nuclear Engineering faculty,

enabling the new program to be cost effective. Projections indicate that when the undergraduate class reaches full enrollment in two more years, the program will involve about 60 to 70 students.

Support for graduate students and their research continues to be a problem, though it has been relieved somewhat by the high level of sponsored research that faculty members have obtained. From a low of slightly more than \$0.5 million in 1972-73, the volume increased to \$1.4 million in 1974-75, and this year reached nearly \$1.6 million. These funds helped support the research of about 50 graduate students. The Department continues to benefit from more than a dozen traineeships from the Energy Research and Development Administration (ERDA) and fellowship support from the General Electric Foundation, the Babcock and Wilcox Company, the Northeast Utilities Company, and proceeds from the Theos J. Thompson Memorial Fund.

Because of the major changes in Department subject offerings during the last two years, the changes this year have been mostly in updating the content of present subjects, with only a few changes in subject offerings. The growth of the fusion technology area, with strong support from ERDA, brought the fusion and fission options closer together. The Department expertise in nuclear materials, and in heat transfer and fluid flow gained in fission-oriented programs, has been of great benefit in attacking these practical fusion problems. The curriculum development and instruction in this plasma physics area is carried out by Professors Thomas H. Dupree, Lawrence M. Lidsky, Peter A. Politzer, David J. Rose, Louis S. Scaturro, Dieter J. Sigmar, and James T. Woo.

This year the subjects in reactor engineering were integrated by updating and revising the subject content to better prepare students with the engineering background needed to cope with safety and other engineering problems in large modern nuclear power plants. Professor John E. Meyer further developed instruction in the area of structures, and coordinated this program closely with other engineering departments, particularly the Department of Civil Engineering. Professors responsible for the overall development of the engineering program are Michael J. Driscoll, Michael W. Golay, Neil E. Todreas, and Lothar Wolf.

Professor Gordon L. Brownell revised the content of the subjects relating to nuclear medicine to integrate these subjects with the M.I.T. Program in Health Sciences and Technology (H.S.T.). The Department continues its work toward cooperative research programs with the H.S.T. program.

The Department offered a number of special summer programs attended by a wide spectrum of professional people involved in nuclear engineering. The 490 registrants in Nuclear Engineering Special Summer Programs exceeded that of any other Institute department and accounted for 30 percent of the 1,635 registrants in all M.I.T. Special Summer Programs. In addition to providing added income, these programs are a valuable method of establishing contacts between the Department and the various parts of the nuclear industry. Programs included 22.83s Physical Aspects of Nuclear Medicine directed by Professor Brownell and Drs. Brian W. Murray and Donald J. Hnatowich, 22.92s Energy for Energy Decision Makers directed by Professors Rose and Golay, 22.94/95/96 Nuclear Power Reactor Safety directed by Professors Arden Bement and Norman Rasmussen, and 22.98/99 Nuclear Fuel and Power Management - Principles and Methods directed by Professors Kent F. Hansen and Edward A. Mason.

A number of Department faculty members work closely with the M.I.T. Energy Laboratory. Although the support of the Energy Laboratory, especially in the preparation of proposals, has required considerable extra work for some faculty members, the Department feels that the potential benefits are large. This year Dr. William D. Hinkle of the Energy Laboratory

staff helped teach 22.312 Engineering of Nuclear Reactors, and participated in Department research programs. Such ties with the Energy Laboratory broaden the Department's professional staff and are beneficial to both organizations.

During this year the M. I. T. Research Reactor went critical again after a shutdown for modification, directed by Professor David D. Lanning. Professor Otto K. Harling was appointed to the new position of Director of the M. I. T. Nuclear Reactor Laboratory. He will be responsible for developing a broader research program for the reactor. Lincoln Clark, Jr. holds the new position of Director of Reactor Operations. This marks the last year that the reactor will be the responsibility of the Department of Nuclear Engineering. After a careful review, it was decided to designate the reactor as an Institute laboratory and place it under the Vice President for Research so as to make the reactor a more broadly-based Institute facility with the aim of increasing its research program. The Department strongly supported this move, and looks forward to many more years of productive use of this important research facility.

RESEARCH

Research activities included: a reactor kinetics project with the Electric Power Research Institute by Professors Hansen and Allan Henry; a rod-drop analysis with Commonwealth Edison and development of few-group parameters with Electric Power Research Institute by Professor Henry; thermal neutron and light scattering studies with ERDA; neutron molecular spectroscopy with the National Science Foundation (NSF) and static and dynamic structure of dense gases with the NSF by Professors Chen and Yip; computer simulation studies of molecular solids with the Army Research Office by Professors O. Deutsch and Yip; frequency- and wavelength-dependent fluctuations in fluids with the NSF by Professor Yip; coolant mixing in rod bundles, fuel-coolant interaction, and fusion blanket design with ERDA by Professor Todreas; thermal hydraulic analysis of PWR with the New England Electric System and Northeast Utilities (through Energy Laboratory) by Professor Todreas; small high temperature gas-cooled reactor with the Defense Advanced Research Projects Agency by Professors Driscoll, Lanning, and Golay; gas-cooled fast reactor studies with the General Atomic Company by Professors Lanning and Rasmussen; light-water reactor core design with the Yankee Atomic Electric Company and light-water reactor thorium utilization with the Energy Research and Development Administration (through the Energy Laboratory) by Professors Driscoll and Lanning.

Other research included: reactor transient code analysis with the Electric Power Research Institute by Professors Lanning, Wolf, Henry, Todreas, Hansen; fast reactor blanket test facility program with ERDA by Professors Driscoll and Lanning; fuel performance analysis during normal and transient conditions with the New England Electric System and Northeast Utilities (through the Energy Laboratory) by Professor Meyer; plume dispersal with ERDA; cooling tower drift elimination with the New England Electric System and Northeast Utilities Service (through the Energy Laboratory); plenum mixing project with ERDA, and waste heat disposal with the Electric Power Research Institute and Battelle Northwest Institute by Professor Golay; reactor accident risk analysis with the U.S. Nuclear Regulatory Commission by Professor Rasmussen; boiling-water reactor heat transfer code with the New England Electric System and Northeast Utilities Service (through the Energy Laboratory); thermal hydraulic sensitivity study with the Electric Power Research Institute, and temperature fields in liquid metal fast breeder reactors with ERDA by Professor Wolf; fusion technology with ERDA by Professors Lidsky, P. Politzer, Woo, Scaturro, Bement, and Rose; creep behavior of zircaloy with the Electric Power Research Institute by Professor Bement; Tokamak Theory

with ERDA by Professor Sigmar; nuclear techniques in bone disease with the National Institutes of Health by Professor Brownell and Drs. Murray and Hnatowich; fibrinogen detection with the Health Sciences Fund by Professor Brownell and Dr. Murray; Os-Ir Generator with the National Institutes of Health by Dr. Hnatowich, and Boron Capture Therapy with the National Institutes of Health by Dr. Murray and Professor Brownell.

FACULTY

Professor Rose is a member of the steering committee of the National Academy of Sciences Committee on Nuclear Alternative Energy Sources, and serves as an advisor to the Office of Science and Technology Assessment on matters concerning Federal energy budgets. He was a member of the Organizing Committee for the AAAS Workshop on Adapting Science to Social Needs, and the World Council of Churches uses him in their study on energy. This year he completed service on the Massachusetts Governor's Advisory Committee on Nuclear Energy. In addition, he made two appearances before Congressional committees. Professor Hansen was chosen by the Dean of Engineering to chair the newly formed Committee on Engineering Education of the School of Engineering. This important committee is studying ways of improving the efficiency and effectiveness of engineering education at M. I. T. Professor Chen, while on a one-term sabbatical leave, was invited to give lectures at a number of leading laboratories of Western Europe on his work on neutron and light scattering. He also spent part of this time as a Visiting Scientist at the Argonne National Laboratory. Professor Henry continues as a member of the Advisory Committee on Reactor Physics for ERDA, and as a member of the editorial advisory board of Nuclear Science and Engineering. Though on sabbatical, Professor Driscoll remained on campus to pursue ongoing research interests and to promote a new research project under the M. I. T. Energy Laboratory's ERDA funded block grant. He was elected Vice Chairman of the Reactor Physics Division of the American Nuclear Society.

Professor Todreas remains Chairman of the American Society of Mechanical Engineers Heat Transfer Division's Committee on Nucleonics. Professor Meyer was elected Secretary of the Mathematics and Computation Division of the American Nuclear Society. Professor Elias Gyftopoulos directed a study for the NSF on government incentives for energy-conserving technologies in the paper and steel industries, and participated as a member of an M. I. T. team helping Spain establish an Institute of Industry. He accepted the invitation of his homeland to help formulate their national energy program, in the role of Chairman of the National Energy Council of Greece. He also served as a member of the Energy Task Force of the Commission of Socio-Technical Systems of the National Academy of Sciences. Professor Golay was elected Vice Chairman of the Northeastern Section of the American Nuclear Society and a member of the ANS Standards Committee, and Secretary of the Environmental Science Division. Professor Irving Kaplan serves as Secretary to the M. I. T. faculty. Professor Rasmussen continued service on the Defense Science Board, and his work on the Reactor Safety Study (RSS) for the US Nuclear Regulatory Commission, which concluded with the issuance of the final report in October.

President Ford asked two Department members to serve on the Presidential Advisory Committee charged with helping to develop areas of work for the new Office of Science and Technology Policy. Professor Manson Benedict was appointed to the Advisory Group on Anticipated Advances in Science and Technology, and Professor Rasmussen was appointed to the Advisory Group on Contributions of Technology to Economic Strength.

Department of Nuclear Engineering

Professor Lidsky was promoted to Professor this year. Dr. John Meyer was appointed a Professor to lead the Department activities in structures. Dr. Wolf was appointed Associate Professor, and Drs. Deutsch and Scaturro joined the faculty as Assistant Professors. Dr. Woo spent the year as Visiting Associate Professor. Dr. Harling joined the staff as Senior Research Scientist and Visiting Professor to take on his responsibilities as Director of the M.I.T. Reactor Laboratory. Dr. William E. Vesely was appointed a Research Affiliate. Professor Mason continued his leave of absence as a Commissioner of the U.S. Nuclear Regulatory Commission. Professor Bement started a two-year leave of absence to take on the job of Director of the Materials Research Program of the Defense Advanced Research Projects Agency. In his absence, Professor Lidsky assumes responsibility for the ERDA-sponsored Fusion Technology Program.

Honors and Awards

Professor Benedict received the National Medal of Science and the Founders Award of the National Academy of Engineering. Professor Chen was elected a Fellow of the American Physical Society. Professor Driscoll received the Outstanding Teacher Award of the Nuclear Engineering Division of the American Society for Engineering Education. Professor Todreas received the Outstanding Teacher Award of the M.I.T. Student Chapter of the American Nuclear Society. Professor Rasmussen received the American Nuclear Society Special Award and the Distinguished Achievement Award of the Health Physics Society. As the result of a national competition, one of our outstanding graduate students, Glenn E. Lucas, won the Joseph Warren Barker Fellowship in Engineering of the Research Corporation.

NORMAN C. RASMUSSEN

Department of Ocean Engineering

The oceans are increasingly appreciated as a significant source of energy, minerals, and food, and as a major medium for transport of the world's commodities. Through its teaching and research programs, the Department of Ocean Engineering contributes to this growing awareness. A hallmark of its programs is the span from engineering science to societal concern, since successful engineering for the oceans must include legal and political factors as well as physical ones.

Academic Highlights

The total enrollment of regular students in the Department stands at 199, an all-time high. Undergraduate enrollment is lower, but graduate enrollment is higher. It is expected that total enrollment will continue around the present level for several years.

Enrollment in Course XIII-C, the Cooperative Work/Study Program, has stabilized, largely due to economic uncertainties of the cooperating industries. A priority for next year will be to broaden the base beyond the industries already involved so as to lessen dependence on economic cycles. The Department is confident that it can attract additional industries into the program, and hopes that they will include an offshore oil company.

The Engineer's Council for Professional Development accredited the S. B. degree in Naval Architecture and Marine Engineering and the S. B. degree in Ocean Engineering for students both in the regular program and in the Cooperative Work/Study Program.

The curriculum consists of about 90 subjects, about 10 percent of which are revised or substituted for each year in response to developments in ocean engineering and to students' needs. Next year the undergraduate program will have one new subject, 13.96J Technology and Law II, and one revised subject, 13.10J Introduction to Structural Mechanics. The graduate program will have seven new ones (13.05 Boundary Layers; 13.48 Offshore Engineering Design; 13.76 Introduction to Random Processes in Ocean Engineering; 13.86 Ocean and Seabed Accustics; 13.992 Marine Navigation, Positioning, and Data Telemetry; 13.997 Principles of Oceanographic Instrument Systems I - Measurement Platforms; and 13.998 Principles of Oceanographic Instrument Systems II - Sensors and Measurements) and one revised one (13.80 Mechanical Vibration and Noise for Ocean Engineers).

The Joint Program with the Woods Hole Oceanographic Institution (W. H. O. I.) has been revised to accommodate several departments in M. I. T. 's School of Engineering as well as the Department of Ocean Engineering. Its name was changed to the Joint Program in Oceanographic Engineering to avoid confusion with the Department's name. This past April, the first class was admitted under the new arrangement and has promise of boosting overall enrollment in the Joint Program, probably without decreasing the number opting for the Department of Ocean Engineering. This arrangement increases flexibility to the students in the Joint Program, and so is more educationally sound. The Department looks forward to the possibility of a comparable broadening of programs at the Woods Hole Oceanographic Institution, to include departments other than W. H. O. I. 's Department of Ocean Engineering.

Based on the current programs of the Department, student interests and job opportunities, the jobs of naval architect, naval constructor, offshore engineer, and ocean resources engineer are the most popular, accounting for approximately 80 percent of student career interests.

RESEARCH

In spite of difficult times for academic institutions in obtaining support, the Department maintained its level of research as measured in absolute dollars in a range spanning the relatively broad interests of the Department. Studies included: methodology of planning for ship trials; impact of oil spills from sinkings of World War II tankers; methodology for individual, regional, and national port planning; advances in seismic profiling systems for offshore oil exploration; feasibility of obtaining useful energy from surface wave action, and analysis of the regulatory context of the deep-sea mining industry.

To support basic research relevant to oil spill clean-up at sea, construction of a precision flume was completed this year, and all aspects of the flume are operational. A major goal in the design of this device was the achievement of low turbulence level. Measurements of the turbulence level in the new flume show it to be only 0.3 percent which, to the Department's knowledge, is the best level ever achieved in a water flow facility of this type.

FACULTY

Professor J. Kim Vandiver joined the faculty, and Professor Arthur B. Baggeroer shifted his home department from Electrical Engineering and Computer Science to Ocean Engineering. Promotions include: Professor Chryssostomos Chryssostomidis (from Assistant to Associate Professor during the current academic year), Professors Judith T. Kildow and Henry S.

Marcus (from Assistant to Associate Professor effective next academic year), and Professor John W. Devanney (from Associate Professor to Associate Professor with tenure effective next year).

Professor Devanney was granted a leave of absence to accept a commission from the Secretariat of the Organization of the Petroleum Exporting Countries to develop a model of the world petroleum transportation and refining network. Professor Chryssostomidis took a leave of absence for the fall term to accept an Alexander von Humbolt Fellowship at Ruhr University.

Visiting Professor Michael R. Davis worked with Professor Patrick Leehey on a project sponsored jointly by the National Science Foundation and the Office of Naval Research on measuring the influence of sound upon boundary layer transition. Visiting Professor Owen F. Hughes worked with the structures group in the Department during the spring term, led the teaching of 13.12, and carried out research work. Professors Davis and Hughes are from the University of New South Wales, Australia.

The Department suffered a serious setback with the illness of Professor John Evans in early fall and the resignation of Dr. Alaa Mansour from our Structures faculty. Fortunately, in addition to Professor Hughes, two visiting staff members assisted in the structures curriculum, specifically 13.12. They were Dr. Torgeir Moan of the Norwegian Institute of Technology, Trondheim, Norway, and Vedran Zanic of the University of Zagreb, Yugoslavia.

Dr. Kouyu Itoga of the Kawasaki Heavy Industries, Ltd., Japan, visited the Department this year and assisted Professor Masubuchi in his research on welding techniques. He assisted Mr. Keays in teaching the latter half of Professor Evans's subject.

Ferdinando Laudiero of the University of Naples, Italy, assisted Professor Norman Jones in his research in structures.

The United States has been designated host country for the 1976 International Ships Structures Congress with Professor J. Harvey Evans as Chairman. The Congress is scheduled to be held at M. I. T. in August, with additional support provided by the American Bureau of Shipping, Maritime Administration, the Ships Structures Committee, and the Shipbuilders Council of America.

M. I. T. is also one of the four universities sponsoring the International Conference on Behavior of Offshore Structures (BOSS '76) to be held at the University of Trondheim, Norway, in August.

Department faculty authored or coauthored the following new texts: Ship Structural Design Concepts, Cornell Maritime Press, by Professor Evans, and The Challenge of Deepwater Terminals, D. C. Heath (Lexington Books), and Federal Port Policy in the United States, M. I. T. Press, both by Professor H. S. Marcus. Professor J. N. Newman's Marine Hydrodynamics will be published by the M. I. T. Press in late 1976.

Awards and Honors

Professor Chryssostomidis was awarded the von Humboldt Scholarship to the Ruhr University, Department of Civil Engineering, Bochum, West Germany, in fall, 1975. Professor Ira Dyer was elected to the National Academy of Engineering. Professor Jones was awarded a Senior Visiting Fellowship by the Science Research Council. Professor Newman was awarded a Bronze Medal by RINA. Professor Vandiver was named Henry L. Doherty Professor in Ocean Utilization, an appointment which supports research in the area of the dynamic response

of offshore structures to random ocean waves with applications to offshore platforms and mooring systems).

HART NAUTICAL MUSEUM

The Bicentennial exhibits of the Hart Nautical Museum were completed in February with the delivery of a 1/8"-scale model of the schooner Gaspee built from plans developed by the curator. The Gaspee, employed by H. M. Customs Service at Newport, Rhode Island, was burned by irate colonists in June 1772. Although large rewards were offered, none of those involved was ever taken by Crown officers. The major Bicentennial exhibit includes Hart Museum models of the schooner Royal Savage and the gondola Philadelphia that were active on Lake Champlain during 1776, and the frigate Raleigh, along with a plan of a Durham boat and other items pertaining to the type of boat used for Washington's crossing of the Delaware on Christmas Day 1776.

Other models added to the Museum's collections during the past year were: 1/8"-scale models of a Sharpshooter fishing schooner of the 1850s, the Merchant's and Miner's coastal steamship Gloucester, and the Canadian fishing schooner Bluenose. Other acquisitions included about 600 yacht plans, additions to the Davis-Hand collection; five books, and a large photograph of the yacht Gosling II designed by Gordon Munro.

As usual, a number of students and visitors with a variety of projects received assistance. Interest in boat building continues to grow, and many sessions with students and visitors are mini-courses in naval architecture. Material supplied for use outside the Museum included three models for a special minority group lecture; old maps and charts photographed by the Conservation Foundation, Washington, D. C., for a travelling exhibit concerning the exploration for petroleum; plans drawn by the curator and paintings for a Bicentennial exhibit, "New Bedford & Old Dartmouth: A Portrait of a Region's Past," in the Whaling Museum, New Bedford; 17th century Dutch harbor scenes for a student produced experimental TV movie; and a photograph of a Hog Island freighter (seemingly unobtainable elsewhere) for a lecture at Woods Hole.

In addition to photographs and prints of plans supplied to boat owners, model builders, and collectors, the following were furnished for publication: a picture of a sea serpent for the German edition of Killers of the Sea; a sail plan of yacht Aspenet in "The Woodenboat" No. 7; a photograph of a catboat for Racing of the Time-Life Boating Series; a photograph of the Atlantic Works assembly shop for Boston 200's booklet Labor History; and lines, sail plans, and photographs of the first "knockabout" yachts, in "The Woodenboat" No. 8.

Among the special events for the year were an exhibit of deep sea mining material furnished by the Sea Grant Office; a Sunday tour of the Museum for U.S. Naval Reserve Units; and a filmed interview for TV that created considerable public interest in the museum.

During the spring the curator visited maritime museums in San Francisco and Vancouver. In September, he attended the Second International Congress of Maritime Museums held at the Norsk Sjøfartsmuseum, Oslo. The curator contributed two papers to these seminars, one on ship preservation and the other on museum archives, outlining the unusual plan holdings of the Hart Nautical Museum.

Well known to sailing yachtsmen, the Herreshoff plans in the Museum are relatively unknown to those with naval and mechanical interests. An involved correspondence with a naval

researcher in England turned up the fact that a Herreshoff torpedo boat was the only foreign-built vessel ever purchased for the Royal Navy.

IRA DYER

Center for Advanced Engineering Study

During the 1975-76 academic year, the Center for Advanced Engineering Study (C.A.E.S.) continued to provide: on-campus study for mid-career professionals from industry, government, and academic institutions of the USA and foreign countries; off-campus study through distribution of videotaped subjects; video services to the Institute through television production, video equipment rentals, film activities, and a new cable TV service; support for various research and service projects in the Institute. The Center continues under the direction of Myron Tribus, Professor of Engineering; Jack Newcomb joined the staff in October 1975, as Assistant Director. Linda Ward is the Business Manager.

ON - CAMPUS PROGRAMS

Advanced Study Program

The on-campus education programs of the Center provided experienced men and women the opportunity to pursue studies tailored to their needs and the objectives of their employers or sponsors. On-campus programs consisted of the Advanced Study Program, the Advanced Study Program in Air Transportation, the Advanced Study Program in International Nutrition Planning, and the Education for Public Management Program.

In addition to making available regular graduate and undergraduate subjects and seminars, opportunities to participate in on-going research, and opportunities to do special studies guided by one or more members of the faculty, C.A.E.S. offered 10 special subjects specifically for the Fellows, a weekly seminar for the Fellows, and orientation programs on computer programming. During the summer the Center also offered a six-week intensive review of mathematics for incoming Fellows.

This year the number of Fellows rose by two to 56. They came from 18 countries in addition to the United States. Two-thirds of this year's Fellows came from foreign organizations, down from three-fourths last year. Thirty percent from US organizations were from industry.

Forty-three of the Fellows were in the Advanced Study Program, three more than last year.

C.A.E.S. offered the Education for Public Management Program jointly with the Department of Political Science. An academic year long program for mid-career Federal employees, it attracted nine Fellows, two more than last year.

The Center offered the newly established Advanced Study Program in Air Transportation jointly with the Flight Transportation Laboratory of the Department of Aeronautics and Astronautics but enrolled only one Fellow. This Program is still in the process of being established.

The Advanced Study Program in International Nutrition Planning, offered jointly with the Department of Nutrition and Food Science and the Center for International Studies, enrolled three Fellows, compared to five the year before.

The programs were educationally successful in that they enabled Fellows to meet their needs and objectives and were financially successful in that they broke even. The income for the year was over \$300,000. Of this, more than \$100,000 was a transfer to Institute General Funds for tuition for regular subjects attended by Fellows. The programs also supported three teaching assistants and one research assistant during the fall term and two teaching assistants and two research assistants during the spring term. Support of teaching assistants included tuition stipends.

An advantage of the very flexible format of the Advanced Study Program is that other more specialized programs can be started under its auspices. For instance, the Air Transportation Program and the International Nutrition Program do not need to stand on their own with just a few Fellows. These Fellows mix with and attend many of the same C.A.E.S. seminars and special subjects as Fellows in other Advanced Study Programs.

Technology Training Program

In conjunction with the Department of Aeronautics and Astronautics, C.A.E.S. continued the Technology Training Program for 15 citizens from the Republic of China. This two year program began in January 1975. Trainees attended academic subjects and worked on their project in the Measurement Systems Laboratory. The project of designing, fabricating, and testing an inertial measurement instrument ended June 30, 1976.

OFF - CAMPUS PROGRAMS

Self-Study Program

With an eye to the dwindling financial resources available for new program development, the emphasis in the self-study program has shifted toward obtaining wider distribution and utilization of existing materials. This has entailed a number of changes in our "marketing" approach. The somewhat cumbersome per-student tuition and lease-for-life plans were replaced with a simple rental or purchase plan. The full length subjects were "unbundled" into individually available lectures. The prices charged for both lectures and study guides were substantially reduced.

These changes have been incorporated in a new 104 page catalogue of films, videotapes, study guides, and texts, published in early 1976 and mailed to more than 8,000 industrial firms, colleges, and universities. There have been several rather dramatic consequences of this new approach, such as the number of orders per unit time has increased several fold over any previous time period; as a consequence, the number of different clients also has risen from a rather select few larger firms to companies of every size; orders from colleges and universities (virtually restricted from participating by the previous format and price structure) have become a significant part of the total, and, despite the decrease in unit prices, the dollar volume appears to be exceeding previous figures.

C.A.E.S. also has begun to develop a network of dealers and representatives to enhance distribution possibilities, both domestically and abroad. These representatives are primarily commercial firms specializing in audiovisual products. These firms operate either

on a commission basis, forwarding their orders to the Center, or as wholesalers, purchasing materials from the Center and selling them on their own account. In a few cases, e. g., with members of the Association for Media-based Continuing Education for Engineers, publishing arrangements have been established in which other universities offer M.I.T. materials in their own regions and pay M.I.T. a royalty on revenue.

C. A. E. S. and I. L. O.

This year has seen the development of a much closer relationship between C. A. E. S. and the Industrial Liaison Office. This has been manifested in two developments: in December 1975, C. A. E. S. videotaped an I. L. P. symposium, the Management of Technological Innovation. These videotapes were made available to I. L. P. members at a reduced price and in advance of a general offering via the C. A. E. S. catalogue. C. A. E. S. also has offered I. L. P. members a 20 percent discount on all of the self-study materials. The I. L. O. has taken on the responsibility of sending out C. A. E. S. catalogues marked with this discount information. This same arrangement also has been accepted by the M. I. T. Associates Office.

AMCEE

M. I. T. through C. A. E. S. has become a founding member of the Association for Media-based Continuing Education for Engineers (AMCEE). This consortium of 12 universities represents a large fraction of all the off-campus users of television and videotape in continuing education for engineers. The Association already has been assured of a \$250,000 grant from the Sloan Foundation to serve as a revolving fund for the development of innovative educational materials by the member institutions. And the Association has submitted a preliminary proposal to the National Science Foundation for operating expenses for an initial three years.

As indicated earlier, the Center has used the contacts afforded by AMCEE to develop several mutually beneficial distribution relationships. Four of the member institutions have purchased copies of videotapes and study guides produced by the Center to use on their own television or videotape systems. In the case of Colorado State University, the Center has agreed to market nationally two subjects that the University could otherwise not afford to produce solely for its regional clientele.

Television Broadcasting to the Boston Area

The Center has been investigating the desirability and feasibility of offering graduate level subjects to the local industrial community via "live" television. This proposed project would take advantage of the microwave channels set aside by the FCC for Instructional Television Fixed Service (ITFS). Preliminary discussions were held with the Department of Electrical Engineering and Computer Science, and an exploratory meeting was held with representatives of some of the high technology companies in this area. It is still too early to gauge the level of interest in industry. There is genuine interest among a number of the Department of Electrical Engineering and Computer Science faculty. This program will be developed further during the coming academic year.

VIDEO SERVICES

The video facilities at C.A.E.S. provide services for: the C.A.E.S. self-study program; Institute activities which received funding under the Sloan Foundation grant of February 1975; special events which the Institute administration wishes to record; special projects or research programs as requested by the departments, and users of the new cable system.

During this year an intensive review began to determine whether the expenses of the color studio could be supported by the Institute. With the end of production of self-study materials (because sales have not been sufficient to sustain the program in its previous mode of operation), the load on the color studio dropped. This decline was offset somewhat by work done for other organizations. Significant contributions were:

M.I.T. /Boston Public Schools	Video recording of public announcements regarding magnet school program
Department of Humanities	Technology and culture seminar -- "Humanitas Lecture Series"
A.T. & T. Convocation	Two-day program commemorating birth of the telephone
Department of Architecture	Louise Nevelson presentation
Department of Humanities	"The Problem," a play by Professor Albert R. Gurney, Jr.
Burmese National Theatre Dancers	Music and Dance Program in Kresge Auditorium

In addition to taping these special events, the facility was used to record interviews with visiting scholars, to present several programs by MITV (the student news reporting team) and for a few self-study tapes. The black and white experimental studio was changed so that M.I.T. faculty, with the help of a teaching assistant, could broadcast instructional information over the cable television system. The design of the studio permits the faculty member and teaching assistant to produce a live program of broadcast quality with minimal video instruction and preparation.

Under the auspices of the Sloan Foundation grant, C.A.E.S. provides instruction in the use of the television facilities and lends equipment (portable television cameras and recorders, lights, sound equipment, etc.) to different departments, student groups, and research projects. These activities are described in the next section.

THE SLOAN FOUNDATION GRANT

Under a grant received from the Sloan Foundation in February 1975, C.A.E.S. installed a television cable which forms a spine with a few branches, and reaches almost every center of activity on the campus. Work on the installation is continuing and by September 1976, it is anticipated that there will be 1,000 receiving stations in the dormitories plus about 20

stations in classrooms, departmental lounges, offices, and corridors. The studios and control rooms are in Building 9, the C.A.E.S. headquarters building. The cable system is capable of sending signals in both directions. Programs can be originated anywhere along the cable, transmitted to the control room and from there, converted to user frequencies and sent everywhere on the cable.

The cable was tried in January 1976, during the Independent Activities Period. Two channels were used two hours per day to transmit news, public service announcements, videotaped courses, administrative information, and cultural events. Materials were prepared by student groups, faculty, visitors to the Institute, and by the staff of C.A.E.S. After this first burst of activity, the cable was shut down except for occasional (weekly) MITV news-casts and some demonstrations for visitors. A few instructors tried the system as a means of holding evening question and answer sessions, with questions called in by telephone, but there were too few receiving stations on the system to make the experience more than a test of such a program.

The purpose of the Sloan Foundation grant was to encourage a diversity of uses of television on the M.I.T. campus. C.A.E.S. attempted to help the experiment by providing training and encouragement for students. The result is that now there are many students trained and interested in the use of television, and many faculty members pursuing a variety of projects.

Some of the more interesting uses of the system this past year include the following: Edwin Diamond of the Department of Political Science used the system to collect videotaped records of the political campaign messages, and arranged for M.I.T. student video crews to gain access to candidates during the New Hampshire primary. His students are invited to participate, with TV equipment, to record the Democratic Convention in 1976. Professor Charles E. Holt III of the Department of Biology produced a black and white tape to demonstrate some difficult procedures in biology (measurement of potentials in nerve system of a frog's eye). Daniel L. de Hainaut of the Department of Humanities used television to develop students' abilities at self-expression.

In April 1976, the Sloan Foundation notified the Institute that it has approved a follow-on grant of \$490,000 for 30 months to continue support of the experiments with television. Under the new grant it is anticipated that: the cable will be extended, perhaps across the Charles River to reach the fraternities; more users will be instructed; routine cablecasting of instruction, news, cultural events will begin; more equipment will be purchased. Seed money will be provided for staff to use in developing more sources of support for the cable system, and C.A.E.S. will operate, maintain, and manage the cable.

The objective, established by a committee under Professor Ithiel de Sola Pool of the Department of Political Science, is to integrate the cable into the life of the Institute.

THE FILM UNIT

During the past year the film, "Women's Work: Management," was completed and released for use in encouraging high school women to prepare for careers in management. This film was the second in the Women's Work series; the first, "Women's Work: Engineering," was released the year before. Both films are now in use in US high schools.

Efforts to raise additional funds for the series have not been successful as yet. The two women who produced these films, Christine Dall and Niti Salloway, continue to seek funding

for additional films. Proposals have been submitted to various sponsors in the Federal government as well as private foundations.

With the support of the Cambridge Bicentennial Committee, the Cambridge Public Library, and the US Army, a record of the participation of the City of Cambridge in the Bicentennial celebration, July 4, 1975, was made and edited for the Cambridge Public Library archives.

OTHER RESEARCH AND DEVELOPMENT ACTIVITIES

Dr. Tribus, Director of the Center, collaborated with Dr. Larry Evans of the Department of Chemical Engineering in developing a system of modular instructional materials for practicing chemical engineers. It is hoped that these modules will be prototypes for continuing education. The objective is to substitute the module as the unit of instruction, instead of the 16-week subjects typically listed in the catalogue. People practicing chemical engineering often do not want to take a 16 week series of lectures just to learn one thing they need to know. The NSF sponsored project is expected to last for 30 months.

C.A.E.S. provides administrative support to Professor Merton Flemings of the Department of Materials Science and Engineering in a project to develop a technical institute for the training of high level technicians in Shiraz, Iran. Wentworth Institute and M.I.T. collaborate under a project sponsored by the Imperial Organization of Social Services of the Government of Iran. C.A.E.S. has prepared sample videotapes for technical instruction. Dr. Tribus serves on the steering committee of the project.

OTHER STUDENT ACTIVITIES

C.A.E.S. does not enroll undergraduates in accredited subjects. There are, however, several activities involving undergraduates. The use of the experimental studio by faculty for undergraduate instruction is an example.

C.A.E.S. continues to provide office space, video facilities, and professional advice to MITV, the student group which produces and displays a weekly news program for the M.I.T. community, and for another student group called Student Cable Vision. SCV was formed this past academic year and is an umbrella organization for all student video projects.

MYRON TRIBUS

Center for Policy Alternatives

The Center's fourth year was one of increasing interaction with the educational programs of the School of Engineering and its departments, of increasing contact with decision processes on technology policy at the national level, and of continuing service to the Institute as a whole.

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 on-going 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.

In the past two and a half years, the Alfred P. Sloan Foundation support permitted a solid beginning to be made in the Center's overall development -- seven research programs were established, selected sociotechnical issues were examined, a resident research staff was assembled, and a number of relationships were developed with organizations around the world involved in research on similar policy issues. Less visible is the impetus that Sloan support has provided for the future growth and development of the Center. The Center's formative period will continue for the next few years as research programs broaden and grow, participant programs are expanded, additional sociotechnical issues are identified and studied, and new educational programs are planned and implemented. The foundations and momentum for the development of the Center were established with the initial two-year Sloan grant. This year the continued development of the Center was assured with the award of a final three-year Alfred P. Sloan Foundation grant to the Center.

In March the Center moved into newly renovated space in the Webster Building at the east end of the campus. The move from Buildings 35, 37, 39 and 20-B to the Center's new Building E-40 space marks the first time in almost three years that the Center's personnel and programs are in a single contiguous area. With conference and document facilities, and modest expansion space, the new quarters will contribute to interaction of staff and students and to the Center's educational and research programs.

RESEARCH

The Center's sponsored research volume in fiscal year 1976 was \$1.1 million. The leveling of sponsored activities from \$1.2 million in fiscal 1975 reflects the completion in January 1975, of the \$1 million, 18 month Sahel-Sudano project, an Institute-wide research effort administered by the Center. If this program is excluded, the Center's sponsored activities have grown steadily from \$300 thousand in fiscal 1973, to \$525 thousand in fiscal 1974, to \$750 thousand in fiscal 1975, to the present \$1.1 million. The Center's sponsored and developmental research activities during the fiscal year fell in seven broad program areas: technology policy and innovation; manpower policy; consumer related studies; industrial productivity policy; environmental and workplace regulation; natural resources and energy; and communications and the public interest.

Technology Policy and Innovation

The Technology Policy and Innovation Program includes five sponsored projects as well as continuing research. One component seeks to examine national policies influencing innovation and technical change within various nations, to formulate alternative policies specific to each national environment, and to translate foreign experience to US policy. A second 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.

In the fall the Center completed a five-country technology policy project after more than two years of research. Supported by a National Science Foundation grant, with start-up funds from the Alfred P. Sloan Foundation, this project examined and evaluated consequences of various government policy instruments on technological change in France, the Netherlands, Japan, the United Kingdom, and West Germany. The final report, which included a monograph on each studied country, was completed under the direction of Dr. Nicholas A. Ashford, Senior Research Associate. The report's findings and assessments suggest new direction for US policy and provide a solid basis for the continuing examination of government policies in developing as well as developed countries. The project and its findings were summarized at a number of national and international briefings by Dr. Ashford, Dr. J. Herbert Hollomon, Director of the Center, and Dr. James M. Utterback, Research Associate. Presentations were made to the President's Advisory Group on Contributions of Technology to Economic Strength, the Vice-President of the United States, the Secretary of Commerce, the National Science Foundation, the Organization for Economic Development and Cooperation, the West German National Ministry for Science and Technology, the Organization for Applied Industrial Research in the Netherlands, and other government agencies in several countries.

A collaborative research project with the State Council on Technology (CET) of São Paulo, Brazil, under the direction of Dr. K. Nagaraja Rao, Senior Research Associate, was completed in May. Funded by CET, the two year project examined government programs promoting existing and new technologies for economic development and suggested alternative programs for the unique São Paulo environment. Tasks included sector analyses of the food processing, electronic, metallurgical, and machine-tool industries; analytical studies of innovations based on a sample of São Paulo firms; and an examination of the role of multinational firms in technological development in Brazil. Byron F. Battle, Research Associate, directed the São Paulo team.

In June the Center began research sponsored by the Delegation à l'Amenagement du Territoire et à l'Action Regionale (DATAR), a French government agency responsible for national programs of regional development. The project will focus on identifying and examining conditions under which successful, self-sustaining implementation of technology oriented complexes in a region take place. This effort is an outgrowth of the Center's five-country study and of an earlier Center research program sponsored by the French government.

In May the Center undertook a project for the National Academy of Engineering (NAE) to assemble a fact book on the relationship between technology and international trade. The fact book, which will summarize the legal arrangements affecting international trade as well as trade statistics, was presented at a national workshop sponsored by NAE in August.

A project examining the economic impact of the National Sea Grant Program on US industry and foreign trade continued under the direction of Dr. Hollomon and Dr. Utterback. This study represents the Center's first evaluation of a US instrument to stimulate innovation and the diffusion of technology in the US environment. Funded by the National Oceanic and Atmospheric Administration (NOAA), it includes examining the possible economic consequences of

selected Sea Grant projects and analyzing four economic sectors potentially affected by Sea Grant activities. The transfer of this project's findings and evaluative techniques to the Office of Sea Grant will be carried out with additional NOAA support during fiscal 1977.

Manpower Policy

The Center's continuing research on the supply and demand for professional and technical manpower is motivated by two factors. First, recent economic analyses indicate that labor market conditions and government support for education significantly influence the supply of young people opting for certain professions. Second, few officials in either State and Federal government or higher education realize how much their policies affect the supply and mix of educated professionals, especially in technical disciplines.

As a part of the School of Engineering, the Center's first concern has been the engineering profession and the factors affecting the supply and demand for trained engineers. During the year, Research Associate Dr. Marvin A. Sirbu and Robert Treitel, Research Staff, continued to update the Center's model for the engineering profession as a whole, and extended their examination and development of models relating demographic, enrollment, salary, and market demand factors for various engineering disciplines. A second aspect of the Center's manpower activities focused on the more general problem of the impact of declining college enrollments on institutions of higher education during the 1980s. This work resulted in several proposed programs to examine the dynamic nature of present higher education configurations and of alternative delivery systems. An article in the fall, 1975 Change, "The Declining Value of College Going," by Dr. Hollomon and Professor Richard B. Freeman of Harvard University, projected enrollment shifts and outlined the potential impacts on the higher education system.

The first phase of the two and a half year Venezuela manpower project was completed in June; the final phase of research is scheduled for completion in summer, 1977. The program is funded by the Fundacion Gran Mariscal Ayacucho (FGMA) scholarship program, that nation's largest scholarship agency. Directed by Dr. Rao, the research effort analyzed supply and demand phenomena for professional and technical workers in the public and private sectors of Venezuela in order to provide policy alternatives for the FGMA scholarship program.

Clementina Gomez de Petit coordinated the research team of Venezuelan students in Caracas, Venezuela. Similar programs examining anticipated labor market, training, and education problems at the national level were developed and proposed to several foreign governments.

In fiscal 1975, Robert T. Lund, Senior Research Associate, developed the inverse seniority concept as an alternative personnel policy for the conflict between Equal Employment Opportunity programs and worker seniority experienced during economic downturns. Results and findings of this work were published in Harvard Business Review, presented at the Industrial Relations Research Association annual meeting, and later reviewed and discussed in Monthly Labor Review.

Consumer Related Studies

Mr. Lund continued to direct the warranties, service contracts, and alternative project which examines various instruments for protecting the consumer from economic consequences of product failure. With second phase funding from NSF, the two and a half year program is scheduled for completion next spring.

Industrial Productivity Policy

The Center's Industrial Productivity Policy Program is concerned not only with identifying opportunities for new technologies in industry, but also with the social and economic aspects of manufacturing. Mr. Lund continued to participate in the joint M.I.T. -Industry Polymer Processing Program directed by Professor Nam Suh of the Department of Mechanical Engineering. Mr. Lund's evaluation of the advantages and disadvantages of this unique and innovative program was completed in June as a part of the NSF "seed-grant" that helped establish the overall program. Throughout the year he and Professor Nathan B. Cook of the Department of Mechanical Engineering followed developments in the application of integrated computer/machine systems to manufacturing processes. In August, Dr. Nake M. Kamrany, Research Associate, completed a preliminary investigation of the social and economic aspects of the discrete parts manufacturing industry in the United States. This study was part of a larger Draper Laboratory project funded by NSF to explore the role of the Federal government in, and to delineate the research areas for, improving the productivity of discrete parts manufacturing firms.

In the second half of the year, the Center and the Interdisciplinary Center for Technological Analysis and Forecasting at Tel Aviv University carried out a joint examination of opportunities for improving the cost and delivery of housing in Israel. This modest effort was funded by Tel Aviv University and involved Dr. Hollomon, Professor Robert D. Logcher of the Department of Civil Engineering, Professor Emeritus Albert G. H. Dietz of the Department of Architecture, and a number of faculty and staff. As a result of this work, the Center will jointly carry out with Tel Aviv University and the Israeli Institute of Technology at Haifa (Technion) for the Israeli Ministry of Housing a four year research program on innovation in housing production in Israel. Scheduled to begin in September, it will lead to a demonstration housing program in Israel and market tests of alternative housing forms and production processes. Faculty from the Departments of Civil Engineering and Architecture and the Sloan School will take part in this important research program.

Environmental and Workplace Regulation

The Center's Environmental and Workplace Regulation activities expanded during the year and are in part outgrowths of Dr. Ashford's early research at the Center on occupational health and safety sponsored by the Ford Foundation. Findings of this research were published this fall by the M.I.T. Press in Crisis in the Workplace: Occupational Disease and Injury, the first systematic analysis of the complex technical, economic, political, and legal issues involved in this important area.

An examination of the multiple impacts arising from Federal regulation of the production, use, and distribution of chemicals was completed under the direction of Dr. Ashford for the US Council on Environmental Quality and the Environmental Protection Agency. To understand the diversity of regulatory impacts, eight case studies of specific regulations were carried out for food additives, pesticides, pharmaceuticals, and industrial chemicals. These case studies are a first step toward understanding the efficacy of different approaches towards chemical regulation.

A preliminary analysis of the legal and technical issues involved in arriving at appropriate regulations for occupational noise was completed during the summer. Project findings were summarized in testimony before the Occupational Safety and Health Administration in the Department of Labor and were published in February as an EPA report. Throughout the year, the research team developed alternative strategies for OSHA use in reducing occupational disease. This on-going work is carried out for the Department of Labor in collaboration with ICF, Inc. of Washington, D. C.

Late in the year, two development efforts resulted in sponsored programs for 1976-77. Professor Joel P. Clark of the Department of Materials Science and Engineering, Dr. Hollomon, Dr. Ashford, and several Center staff developed a program to analyze the multiple impacts of Federal, State, and local regulations on the copper wire industry, and will be funded by NSF. In June, Dr. Ashford began an examination of the relationship between environmental/safety regulation and technological innovation under an NSF grant. Professor Lawrence B. Evans of the Department of Chemical Engineering and several Center staff will be involved in the program which will examine selected product segments in the chemical industry.

Natural Resources and Energy

Center activities focusing on natural resources and energy continued at a modest level. Dr. Jean-Claude Derian, formerly Research Associate at the Center and now at DATAR in Paris, and Dr. Irwin C. Bupp of the Harvard Business School completed a two-year assessment of how political and social factors have affected the commercialization of nuclear power. Study findings, based on the US, French, British, West German, and Swedish experiences, are scheduled for publication this fall.

Mr. Lund and Professor William F. Flanagan, an NSF Faculty Fellow on leave from Vanderbilt University, studied opportunities for improved life-cycle costs and conservation of resources through increased product life. An outgrowth of the Center's earlier consumer durables program, this work is based on the tentative view that one major answer to the "resource problem" is longer use of products. Mr. Lund summarized findings on incentives for longer product life before the Environmental Directorate of the OECD. At an Office of Technology Assessment workshop Professor Flanagan presented a paper jointly prepared with Mr. Lund reviewing findings on factors controlling longer product life in consumer durables.

Dr. Ashford and Research Associates Dale Hattis and Albert E. Murray studied potential industrial applications of chitin and chitin derivatives under the sponsorship of the M. I. T. Sea Grant program. Unlike many previous studies of this promising material, this work focused on identifying business as well as technical uncertainties whose resolution will be important if chitin is to be developed as a viable commercial production. Active involvement of business and industry representatives was an important part of the project which is now nearing completion.

In February the Center began a seven-month program studying proposed government actions and alternative institutional arrangements for ameliorating present and future shortages, disruptions and over-supplies of resources and commodities in the US.

Communications and the Public Interest

The multisponsored Datanet project, begun during fall, 1974, is funded by the US Department of State and Commerce, AID, and the National Aeronautic and Space Administration. Directed by Professor Ithiel de Sola Pool of the Department of Political Science, its overall effort is examining specific issues in the design, organization, and use of international data communication and information retrieval systems, particularly the political and social impacts of these low cost, distance-insensitive communication systems. As the fiscal year ended, Dr. Sirbu was beginning design of a research program to examine and analyze future options and opportunities for development of electronic mail systems.

Educational Activities

As part of the School of Engineering, the Center has a continuing interest and concern in public and private policies influencing education and career development of engineers in the United States and throughout the world. This commitment is reflected not only by the Center's on-going research activities on professional and technical manpower already noted, but also by the direct participation of Center staff in the development of new degree programs, the design and teaching of new subjects, and on-going appraisals of the School's present activities and future alternatives.

Supported by an Alfred P. Sloan Foundation grant to the School of Engineering, Dr. Hollomon and Dr. Sirbu participated with a large number of faculty from throughout the Institute in developing a new Master's degree program for engineers. The program, leading to a Master's degree in Technology and Policy, is an intensive graduate program for students who wish to study economics, social science, and systems analysis simultaneously with a concentration of subjects in one of the engineering disciplines. Dr. Sirbu worked with Professor Thomas B. Sheridan of the Department of Mechanical Engineering and Dr. David Noble, Postdoctoral Fellow in the School of Social Science and Humanities and the School of Engineering, in the development of case study materials for the proseminar in the new curriculum. In the fall, several graduate students received academic credit for developing case study materials through a special subject offering presented by Dr. Sirbu and Professor Sheridan. In fall, 1976, Dr. Sirbu, Professor Sheridan, and Dr. Noble will present the proseminar to the first class of students in the new Technology and Policy Program.

During the second term Mr. Lund (who is also Lecturer in the Department of Mechanical Engineering) and Professor David P. Hoult of that department again taught 2.96J Management in Engineering, a joint offering of the Department of Mechanical Engineering and the Department of Electrical Engineering and Computer Science. Mr. Lund taught 2.863 Elements of Manufacturing during the first term, and continued to head a faculty study group considering educational and research opportunities related to manufacturing within the School of Engineering.

During the second term, Dr. Ashford, Research Staff member Judith Katz, and Professor Joseph F. Vittek of the Department of Aeronautics and Astronautics developed 16.793 The Law/Technology Interface as part of the Institute's Law-Related Studies Program. Taught as a special reading subject in the spring, it is scheduled to be offered as a regular subject during the second term of 1976-77. As Adjunct Professor of Law at the Franklin Pierce College Law Center, Dr. Ashford conducted an elective seminar entitled Law, Technology and the Work Environment, and will develop a similarly titled subject for undergraduate engineering students as part of the M.I.T. Law-Related Studies Program this fall. Dr. Utterback, as Visiting Associate Professor of Production and Operations Management at the Harvard Business School, and Professor Edward B. Roberts of the Sloan School presented the joint Harvard-M.I.T. Seminar on the Management of Technology during the second term. In the coming year, Dr. Utterback will develop and offer an experimental undergraduate seminar on technology and industrial development through the Department of Mechanical Engineering.

Throughout the year, Dr. Rao served on the advisory committee of the joint M.I.T. - Wentworth Institute-Imperial Organization of Social Services (Iran) program aimed at developing technician training centers in Iran. In addition, Dr. Rao is carrying out a preliminary analysis of the development of and demand for technicians in the changing economy of Iran.

J. HERBERT HOLLOWON

Center for Transportation Studies

The growth and development of the Center for Transportation Studies (C.T.S.) has continued during the years 1975-76. The two major interdisciplinary research projects sponsored by the US Department of Transportation's University Research Program have been continued; the number of students admitted to the Center for the 1976-77 academic year has increased; the Center's communication and coordination programs continue to make progress, and the Center's influence on the U S transportation community continues to advance.

Professor Paul O. Roberts of the Department of Civil Engineering has continued as Director of the Center for one more year. The Steering Committee consists of Professor Roberts and Professor Alan Altshuler (Department of Political Science and the Department of Urban Studies and Planning), Professor Ernst G. Frankel (Department of Ocean Engineering), Professor Ralph G. Gakenheimer (Department of Urban Studies and Planning, representing the School of Architecture and Planning), Professor Peter Lorange (Sloan School of Management), Professor Herbert H. Richardson (Department of Mechanical Engineering), Professor Robert W. Simpson (Department of Aeronautics and Astronautics and Director of the Flight Transportation Laboratory), Professor Joseph M. Sussman (Department of Civil Engineering and Head of the Transportation Systems Division), and Professor William C. Wheaton (Department of Economics and Department of Urban Studies and Planning, representing the School of Humanities and Social Sciences).

In addition to Research Associate Elizabeth Bennett, the Center now employs five full-time research staff, and is conducting an Affirmative Action search for a Research Engineer to become involved in one of the Center's projects. Dr. Frank C. Colcord, Jr. of Tufts University and Dr. Daryl Wyckoff of the Harvard Business School have appointments as Research Affiliates. The Center employs undergraduates through the UROP Office and graduate students as Research Assistants.

Besides offices in Rooms 5-204 and 5-206, the Center is assigned additional allocated research space in Rooms 5-008 and 5-014. The space in 5-008 is a temporary facility for the Transportation Information Center until rehabilitation of these rooms can be accomplished.

Newsletter

The newsletter, published in summer and fall, 1975 and spring, 1976, reports recent contracts, seminars and workshops, and other transportation related news at the Institute. Newsletter editor Rebecca Muller also handles graphic art layout and coordination of all C.T.S. publications.

Transportation Information Center

The Center has inaugurated a Transportation Information Center coordinated by Rebecca Lacy, who has a Master's Degree in Library Science. The Information Center contains copies of all available M.I.T. transportation related publications, as well as copies of frequently referenced texts and current publications and magazines. Rehabilitation of the space occupied by the Transportation Information Center should be completed by fall, 1976.

Transportation Research Reports

Published reports in the C. T. S. Report Series for 1975 number 21. Already, there are seven in 1976. They are:

- 1) C. T. S. Report 76-1 - Forecasting Freight Flows Using a Disaggregate Freight Demand Model, Paul O. Roberts, January 1976;
- 2) C. T. S. Report 76-2 - Transferability and Updating of Disaggregate Travel Demand Models, Moshe Ben-Akiva, January 1976;
- 3) C. T. S. Report 76-3 - Developing Freight Origin-Destination Data for Use in Freight Planning, Paul O. Roberts, February 1976;
- 4) C. T. S. Report 76-4 - Incremental Per Diem, Carl Martland, April 1976;
- 5) C. T. S. Report 76-5 - Railroad Abandonment and the Small Community: Five Case Studies, Joseph F. Vittek, Jr., Elizabeth Lambert, Michell Polito, March 1976;
- 6) C. T. S. Report 76-6 - Models of Freight Loss and Damage, Laurence B. Wilson, Paul O. Roberts, James T. Kneafsey, April 1976; and
- 7) C. T. S. Report 76-7 - Freight Tariff Estimation Models, Ralph D. Samuelson, Steven R. Lerman, Paul O. Roberts, James T. Kneafsey, April 1976.

Other transportation related research reports are published by the various laboratories and departments associated with the Center.

A publications list has been prepared for distribution. It contains all significant transportation related reports developed by the faculty and staff at M. I. T. since 1960. Copies of the list and the publications therein can be ordered from Rebecca Lacy in the Transportation Information Center.

Luncheon/Seminar Series

Throughout the year, the Luncheon Seminar Series featured an informal buffet followed by a talk on policy by an invited speaker. The 20 speakers included: Dr. Morton Ehrlich, Vice President, Planning for Eastern Airlines; Dr. Daniel Brand, Undersecretary of the Executive Office of Transportation and Construction for the Commonwealth of Massachusetts; Edward S. Olcott, Director of Planning and Development in the Port Authority of New York and New Jersey; David W. Davis, Executive Director of the Massachusetts Port Authority; and Charles D. Baker, President, Harbridge House, Inc.

RESEARCH

Eight of the 18 proposals submitted under the auspices of the C. T. S. were awarded. Their contract value for the next fiscal year totals approximately \$1.4 million.

<u>Title</u>	<u>Sponsor</u>	<u>Supervisor</u>
Analysis of the Incremental Cost and Trade-Offs between Energy Efficiency and Physical Distribution Effectiveness in Intercity Freight Markets	Federal Energy Administration	P. Roberts
Analysis of Freight Markets	US DOT/Univ. Res. Prog.	P. Roberts H. Marcus
Scenarios for Alternative Roles of the Federal Government in Transportation	US DOT/Univ. Res. Prog.	A. Friedlaender R. Simpson
New Perspectives in Urban Transportation: Strategies for Overcoming Barriers to Innovation	US DOT/Univ. Res. Prog.	A. Altshuler
Transportation Network Analysis and Decomposition Techniques	US DOT/TSC	R. Simpson
Evaluation Framework for Transportation Planning in Developing Countries	Dept. of State AID	F. Moavenzadeh
Improve the Integration of Air Quality Considerations into Transportation Decision Making	EPA	M. Manheim
Reaching Power Plant Siting Decisions with Environmental and Social Consequences	NSF	M. Manheim
Reliability and Car Utilization	Assoc. of American RR's	J. Sussman
Urban Travel Forecasting Research	US DOT	M. Manheim
Integrated Adaptable Metropolitan Service Program	Regional Transit Service, Inc.	D. Roos
Development of an Aggregate Model of Urbanized Area Travel Behavior	US DOT	P. Roberts
Intercity Data Analysis	US DOT/TSC	P. Roberts
Railroad Reliability and Freight Car Utilization	Federal Railroad Administration	J. Sussman

School of Engineering

Four proposals amounting to more than \$800,000 that are still pending include:

The Effects of Transportation Policies of Spatial Choices	US DOT Univ. Res. Prog.	M. Ben-Akiva
The Impact of Regulation Upon Technical Change in the Railroad Industry	NSF/Office of R & D Assessment	A. Friedlaender
Urban Transportation Policy Studies	UMTA	D. Roos R. Gakenheimer
A Study in Policy Sensitive Freight Model Development	DOT	P. Roberts

Summer Session

In summer, 1976, four major programs will be offered in transportation at the Institute. Air Transportation Systems Analysis, Part I, and Part II, will be presented by the faculty and staff of the Flight Transportation Laboratory, Department of Aeronautics and Astronautics. Analysis and Design of Transportation Systems, Part I, and Part II, will be directed by Professor Marvin L. Manheim of the Department of Civil Engineering. He will be assisted by M. I. T. faculty from the Departments of Civil Engineering, Ocean Engineering, and Aeronautics and Astronautics. Analysis of Urban Service Systems will be given under the direction of Professor Richard C. Larsen, Associate Professor of Urban Studies and Electrical Engineering. He will be assisted by staff from the Department of Aeronautics and Astronautics and other experts outside the Institute. Urban and Public Economics will be directed by Professor Ronald E. Grierson from Columbia University. He will be assisted by Professor William C. Wheaton from the Department of Economics and by experts from other universities.

Development Plan

The Development Plan of the Center has been approved by the administration and its funding renewed for this next year. Work to gain support for the plan has been initiated and specific proposals are now in preparation. Professors Roberts, Sussman, and Manheim have made development calls on a number of industry leaders and alumni to obtain advice and support. Copies of the Development Plan are available from the Center's offices.

PAUL O. ROBERTS

Innovation Center

The M.I.T. Innovation Center was initiated in June 1973, under a contractual agreement with the National Science Foundation (NSF) as an educational experiment aimed at developing technological entrepreneurs. NSF provided \$1.125 million to cover costs associated with the first five years of the Center's operation. It was anticipated that funding resulting from Center-developed innovations would provide the necessary resources for operation beyond the initial five-year period.

Operationally, the Innovation Center may be described in terms of two activities: the Innovation Education Program (IEP) which concentrates on classroom and laboratory teaching; and the Innovation Co-op which concentrates on developing "hands-on" experience in innovation and in bringing the results of the process to the market.

Innovation Education Program

Five subjects developed under sponsorship of the Innovation Education Program are now offered by the School. During 1975-76, 144 students registered for one or more of these subjects as compared to 129 in 1974-75 and 41 in 1973-74.

Introduction to Innovation: Principally for freshmen, this seminar introduces students to the general topics of invention, innovation, and entrepreneurship. The Innovation Center Program is presented with emphasis on its interaction with the various engineering departments. Specific topics such as patents, licenses, marketing, and business plans are presented. The students are given an opportunity to begin work on an invention or other project of their own choice.

Invention: This subject covers market needs, technology, and parameter analysis -- the identification and utilization of key parameters of a specific problem of invention. Faculty and students examine inventions and specific market needs associated with an invention to determine its feasibility and profitability. Case studies and group projects stimulate close student-faculty interaction.

Entrepreneurship: Material presented in this subject provides technical innovators interested in becoming entrepreneurs with an introduction to the various aspects of such activities as concept evaluation, marketing, financing, and small business management. Students participate in group projects to apply the concepts they have studied.

Invention Development Laboratory: This subject centers on the analysis and evaluation of inventions to identify the one or two critical issues associated with the invention and to perform studies and experiments necessary to determine its feasibility.

Internship in New Enterprise Development: The subject provides a "learn by doing" opportunity for students interested in entrepreneurship. Students may work on an individual project, such as a market survey for a particular product, or may engage in a group project in the Co-op or the Invention Development Laboratory. Again, critical analysis is stressed to determine the importance of each activity.

Other Activities: Through its Outside Invention Evaluation Program and Student Invention Contests, the Center helps aspiring inventors become more objective. Since the Center's inception, it has evaluated more than 200 outside inventions.

Center staff instructing the Invention class have developed a methodology for teaching the process of invention which is equally applicable to evaluating inventions and to inventing. Under contract with the National Bureau of Standards' Office of Energy-Related Inventions, this methodology, formally known as parameter analysis, will be developed further.

The Innovation Co-op

The Innovation Co-op is an experiment to determine whether a standard hands-on program in innovation and entrepreneurship can be developed which will become self-supporting in the sense that income from student generated inventions is sufficient to support the next generation of student projects.

The ultimate educational goal of the Innovation Co-op is to give self-motivated students an opportunity to develop their talents by following the entire product development loop from the conception of a product to its marketing. A major milestone for the students is the formation of their own companies. This exercise aims at developing experience in anticipating risk factors in the downstream operations so that risks can be minimized. While such an undertaking presents an alluring academic challenge to the Center, it is, perhaps, the most time consuming and expensive of our various programs. To date the Center has undertaken three such projects. They have resulted in the formation of the Computer Controls Corporation (application of microprocessor technology to control systems for heating, ventilating, and air conditioning), the HETRA Corporation (a quick and nondestructive method to check gold bullion), and the Klein Corporation (development of a bicycle frameset combining high rigidity and ultra-light weight).

A number of other projects concentrate on industrial development. This part of the Center's operation represents faster return on investment and also offers broad opportunities for the students. Through contacts established by the M. I. T. Industrial Liaison Office and the M. I. T. Associates Program as well as through the news media, services of the Center have become known to several industrial firms. One mutually beneficial activity involves matching the broad base of technology available at M. I. T. with the production and marketing expertise of industrial firms. The industrial sponsor assumes the responsibility and risk of financing, producing and marketing the product, while students are involved to the greatest extent possible in these activities. Because students have the opportunity to become inventors and to share in any royalties M. I. T. receives for the Innovation Co-op as a result of licensing the new product, they are involved in the risk-reward process characteristic of innovative ventures.

One successful project was the TV Tennis Game. Based on a new product developed by six students, the game was manufactured and marketed by Executive Games, Inc. at a substantially lower price than similar games offered by the competition. Production and marketing of this product included setting up new production facilities, creating 100 new jobs, and brought the project to the market within six months. Students benefitted educationally from the experience of conceiving and developing the product under a severe time constraint, and shared in the royalty income. Three other projects are now under way.

Another objective of the Innovation Co-op is to encourage students and faculty to be constantly on the lookout for market needs upon which to exercise their inventive intuition. Through stages of evaluation and funding, promising schemes proposed by students may be developed

into advanced prototypes to attract industrial firms under licensing agreements. While this program covers the shortest span of the entire product development process, it requires the highest degree of accomplishment in technical innovation in order to overcome the downstream obstacles before reaching the marketplace. Examples of products developed under this category are an electronic guitar with exceptionally low cross-talk between strings, thus permitting independent tone adjustment with an electronic system (four manufacturers have shown serious interest in marketing this product but no license agreement has been signed); and detectors, based on a biomedical engineering doctoral thesis to measure partial pressures of O_2 , CO , CO_2 , NO_2 , and other gases (an extensive patent application for these detectors has been filed and assigned to M. I. T. for the benefit of the Center).

Y. T. LI

Electric Power Systems Engineering Laboratory

The Electric Power Systems Engineering Laboratory (E. P. S. E. L.) of the School of Engineering recovered fully from the curtailing effects of the economy on industrial support. Its areas of activities grew to include several projects involving the application of high power semiconductor devices to energy processing systems. Laboratory personnel continued to offer undergraduate and graduate students theses and project laboratory opportunities encompassing a wide range of disciplines within the electric power engineering field.

The following brief description of activities in E. P. S. E. L. illustrates the diversity and scope of its research. The highly accurate scaled physical model of a power system consisting of generators, transformers, circuit breakers, and transmission lines was used to develop and evaluate a variety of power system protection schemes. A project to develop control strategies and techniques to optimize power system integrity under emergency conditions is under way. It will utilize digital computer technology and the scaled model power system to assess new control strategies. A three thousand kilovolt-ampere superconducting generator was completed, paralleled to the Cambridge Electric System, and tested to full MVA ratings. Several attractive ship propulsion drives, off-springs to the superconducting machine project, are being constructed and tested in the Laboratory. Work on acoustic noise generated from ultra high voltage overhead transmission lines has culminated in development of a new type of conductor which inhibits the transduction process. Work is in progress to study the mechanisms of contaminant formation and the resulting flashover process on the surfaces of insulators and direct current transmission lines.

Several projects concern the application of high power semiconductor and control technology to power systems. These involve integrating high power semiconductor circuit design with energy storage devices to provide highly efficient interfaces between conventional power systems and novel energy generation and storage systems. Finally, a major effort has begun to extend the present state-of-the-art technology of superconducting generators to yield machines with improved stability and terminal voltage ranges more nearly matching the needs for future electric power systems.

GERALD LOOMIS WILSON

School of Humanities and Social Science

This was the third successive year of significant changes in the School. The new Institute Requirement in the Humanities, Arts, and Social Sciences came into full operation after a transition year. There was a substantial reorganization in the areas of Cognitive Studies, Philosophy, Linguistics, and Foreign Languages. We negotiated with Wellesley College to increase cooperation between the two institutions. And further steps were taken to strengthen the offerings in the Humanities and related areas. The School was honored by the appointment of Professor Noam Chomsky as an Institute Professor and by the appointment of Professor Hans-Lukas Teuber as Killian Lecturer for 1976-77.

The new Institute Requirement has been functioning smoothly, thanks to the devoted attention of the Institute-wide committee on the Requirement. Professor Robert E. Jones, committee chairman for the second consecutive year, worked closely with Professor Donald Blackmer, who as Associate Dean had particular responsibility for the working of the Requirement. The committee has been concerned with three main tasks: the approval of distribution subjects, the recognition of concentrations, and the drawing of dividing lines between those elective subjects that may reasonably be regarded as belonging to the Humanities, Arts, and Social Sciences and those that may not. These tasks inevitably involved controversy, particularly in cases where the committee had to draw the difficult line between those subjects which it regarded as sufficiently "humanistic" to qualify under the faculty's guidelines as distribution subjects and those which were insufficiently "humanistic," and to draw a line between subjects which lie on the boundaries between the social and natural sciences or involve a combination of humanistic, social science, and natural science approaches (as in Psychology). Guided by the Committee on Educational Policy, the committee was sufficiently flexible in its deliberations to arrive at a satisfactory solution to most of the problems it encountered.

The new Requirement increased students' freedom to choose subjects. The pattern of enrollment has, however, tended to parallel that for elective subjects before the big shifts of student interest in the mid-sixties. Effects of the concentration requirement (normally three subjects in a given field - not changed in 1974) are monitored under the new Requirement to give us, for the first time, an indication of student choices (Table III). As was expected, the most attractive fields of concentration are Economics and Psychology, the two disciplines currently most popular at other major universities. This was probably also the case under the old Requirement.

The Humanities are allotted a special place within the Institute Requirement in the form of a three-subject distribution requirement. Students taking distribution subjects are much more evenly spread across disciplines (see Table I) than might have been expected from the experience of other universities, and probably reflects the existence of major gaps in the M.I.T. Humanities curriculum, which has for some years lacked such standard courses as an introduction to American history.

Reorganization in the Cognitive Studies area was a subject of intense but amicable discussion during much of the year. A proposal from the head of the Department of Philosophy, Professor Richard L. Cartwright, made to the School Council in December 1975, led to a unanimous agreement that the Linguistics and Philosophy programs should be combined in a renamed Department of Linguistics and Philosophy styled Course XXIV. At the same time a new

undergraduate degree program in Linguistics, Philosophy, and Psychology as an option in Course XXIV was agreed to, with the title of Language and Mind. It was also agreed to work (again in conjunction with Psychology) toward a new Ph.D. option in Cognitive Studies, within the Department of Linguistics and Philosophy. The reorganized department will come into being on July 1, 1976, with Professor Morris Halle as Acting Head of the department which will be located in Building 20.

On this occasion I should like to pay a special tribute to Professor Cartwright, who has been head of the Department of Philosophy throughout its period of independent existence from 1971 to 1976. Without his efforts, there would never have been a Department of Philosophy at M. I. T. As department head he has been widely respected and his speech to a meeting of his fellow department heads on the intellectual basis for the merger of Linguistics and Philosophy was a tour-de-force.

The proposal for a new relationship between Linguistics and Philosophy led to the ending of long-established, but uneasy connection between Linguistics and Modern Languages. The teachers of Foreign Languages and Literatures were thereby freed to follow the logic of their increasingly close connections with the Department of Humanities and to join that department. The new situation also gave us an opportunity for the thorough review of our Modern Language offerings which is now under way with the assistance of outside experts. The Department of Foreign Literatures and Linguistics came to an end on June 30, 1976, and Course XXIII was vacated.

These changes enjoyed the unanimous approval of the faculty members concerned and were discussed at a special joint session of the visiting committees of the Departments of Philosophy and Foreign Literatures and Linguistics in February 1976. Meeting both jointly and separately, the two committees conducted full discussions with faculty and students and unanimously endorsed the changes. The recommendation of the Dean and the visiting committees was reported to the faculty on February 18 and was endorsed by the Corporation on March 5, 1976.

The changed administrative arrangements for Linguistics and Philosophy offer considerable advantages in terms of intellectual coherence, and also give us a new base for moving into the more theoretical aspects of the Cognitive Sciences. However, as Professor Teuber points out in his report, we have moved only part of the way towards a completely new posture in the Cognitive Sciences. We need to develop a laboratory or center that is both experimentally and theoretically oriented and that will form a common base for development not only in Psychology, Linguistics and Philosophy, but for building on work in the communications area already under way in the Research Laboratory of Electronics and elsewhere.

The School has been anxious to develop closer relations with Wellesley College for some time, but apart from joint M. I. T. -Wellesley subjects in Political Science, there have been few imaginative new ventures. This year we began to discuss ways of using the strength of Wellesley in French and Chinese to the advantage of M. I. T. students. Language subjects are especially time-consuming so that conducting language classes at Wellesley does not appear to be a practical proposition for most students. We have therefore begun to discuss joint faculty appointments and have for 1975-76 made a first experimental joint appointment in French. The School also has encouraged the Institute committee on the Humanities, Arts, and Social Sciences Requirement to accord recognition to Wellesley subjects as M. I. T. distribution subjects. A number of Wellesley subjects which do not overlap with M. I. T. subjects were recognized for the purpose. We hope that, as we learn from cooperation, we can make further connections with Wellesley.

The need to strengthen the teaching of the Humanities at M. I. T. has long been recognized, but the process of institutional change is a slow one. This year preliminary steps were taken

to effect substantial changes in the offerings in Literature, History, and Writing. Recent vacancies in the Literature faculty made it possible to strengthen the leadership of the program by making two tenured appointments from outside the Institute, the first new tenured appointments since 1970. There also will be further junior appointments. In History, a committee was established to try to remedy the long-standing weakness of the programs in American History and the History of Modern Industrial Society. In Writing, a committee headed by Professor Nathan Sivin and composed largely of faculty members from outside the department and the Institute, recommended numerous changes in order to convert the so-called "Pilot Writing Program" into a broadly-based Writing Program designed to assist all students of the Institute in the development of writing skills.

Even more important for the future, we have moved nearer the development of a strong interdisciplinary program in the Humanities and Science/Engineering, designed to take up the task which Course XXI shouldered in the early sixties. In the coming academic year we shall have a new team in the School, headed by Professor Elting Morison, and consisting of Professors Kenneth Keniston, formerly of Yale, Leo Marx, formerly of Amherst, and Gerald Holton, who will be visiting us from Harvard. Professor Keniston will hold the Mellon Professorship in the School and Professor Marx the Kenan Professorship. Also working on related problems will be Professor Carl Kaysen, who joins us from Princeton, where he has been director of the Institute for Advanced Study, and Professor Robert Morison, who will be in his second year as visiting Class of 1949 Professor.

This new senior talent should help us make inroads in developing an integrated program of education in the Humanities, broadly construed, and the Sciences and Engineering.

A Retrospect

Dean John Ely Burchard headed the School in its early years and exercised a great personal influence in many aspects of American cultural life. His death on December 25, 1975, suggests that the time is ripe for an historical retrospect.

The School began life as an administrative unit as a consequence of President Karl Taylor Compton's reorganization of the structure of the Institute. He established a 'Division of Humanities' in 1932, though no dean was appointed until 1937. (The deans of the division were Edwin Sharp Burdell, 1937-38, Robert Granville Caldwell,¹ 1939-48, and John Ely Burchard, 1948-50.) The division became the School of Humanities and Social Studies in 1950. In 1959 it was renamed the School of Humanities and Social Science by Dean Burchard, who served as dean of the School until his retirement in 1964, when he was succeeded by Robert Lyle Bishop, who continued until 1973.

The School of Humanities and Social Science always has been more heterogeneous in character than the other Schools of the Institute, both because it embraces such a wide range of disciplines and styles of operation, and because the departments assigned to it have histories going back to the early days of the Institute. Appointed in 1865, the first band of 10 professors included a Professor of English Language and Literature who was also secretary of the Institute and a Professor of Modern Languages. In the 1870s Professors of Vocal Culture and Elocution and Philosophy were temporarily added. However, departmental organization developed slowly, though the professors of English and Modern Languages became in effect department heads responsible for the work of a growing band of instructors. What we should now recognize as full-fledged departments evolved in the 1890s. By the beginning of the twentieth century

¹Robert Caldwell outlived John Burchard by some months. He died on May 8, 1976, at the age of 94. Before coming to M. I. T., he had been a career diplomat for many years.

there were departments of English, Modern Languages, History and Political Science, and Economics and Statistics. The departments of English and History and Political Science merged in 1919 to form a joint department of English and History (renamed Humanities in 1953). The Division of Humanities of 1932 and the School of 1950 thus consisted of three departments (English and History, Modern Languages, Economics) that had been in existence for many years and had developed their own traditions.

John Burchard inherited in the Department of Economics and Social Science (its 1934-1965 title) a broad-based social science department that had branched out into Industrial Organization and Psychology and was about to become associated with the new Center for International Studies in the development of Political Science. From these developments emerged the present departments of Psychology (1964) and Political Science (1965). Burchard himself was primarily concerned with developments in the Humanities, the Arts, and the library system needed to back them up. It was he who was responsible for the introduction of a new Humanities Requirement in 1950, following the report of the Lewis Committee. Burchard also encouraged the growth of Philosophy and Music within the Humanities Department, though he was always rather disappointed with the quality of the English and History programs. Indeed, from his office in the new Hayden Library building he in effect acted as a sort of super department head for the Humanities Department.

John Burchard was a man of broad culture and great charm. He wrote on many subjects and talked vigorously and wittily about still more. The School needed a dean of his quality in the postwar period, and M. I. T. was extraordinarily lucky to find such a man already on its faculty.

HAROLD J. HANHAM

TABLE I

Enrollment in Distribution Subjects: 1975-76

Field	# of Subjects	Year	Year	Year	Year	Year 5 &	Total	Wellesley	Harvard	GRAND TOTAL	%
		1	2	3	4	Graduate	MIT				
Foreign Languages	12	107	106	59	56	8	336	0	0	336	7.9%
History of Art	5	57	107	71	62	5	302	2	1	305	7.2%
Humanities	34	991	652	331	222	7	2203	35	1	2239	53.0%
American Studies	1	11	6	5	1	0	23	1	0	24	0.6%
Anthropology/Archaeology	3	89	58	29	14	0	190	0	0	190	4.5%
Creative Writing	2	192	138	68	44	0	442	1	0	443	10.5%
Crossroads	8	74	61	26	25	0	186	6	0	192	4.5%
History	7	161	108	47	36	1	353	5	0	358	8.5%
Literature	7	128	94	55	32	0	309	4	0	313	7.4%
Music	3	301	163	82	55	5	606	16	0	622	14.7%
Technology Studies	3	35	24	19	15	1	94	2	1	97	2.3%
Philosophy	8	318	124	56	62	3	563	1	0	564	13.3%
Political Science	6	194	119	56	37	0	406	3	0	409	9.7%
Urban Studies	3	22	41	24	16	3	106	0	0	106	2.5%
Visual Arts & Design	2	71	96	45	27	12	251	17	2	270	6.4%
TOTAL	70	1760	1245	642	482	38	4167	58	4	4229	100.0%
%		41.6	29.4	15.2	11.4	0.9	(98.5)	1.4	0.1	100.0%	

Enrollment data are taken from the Registrar's fifth week report (Subject Distribution Report).

TABLE II

Enrollment in Humanities, Arts, and Social Sciences Elective Subjects: 1975-76

Field	# of Subjects	Year 1	Year 2	Year 3	Year 4	Year 5 & Graduate	Total MIT	Wellesley	Harvard	GRAND TOTAL	%
Economics	20	244	498	423	393	35	1593	17	2	1612	25.9%
Foreign Languages	21	176	134	99	101	43	553	2	4	559	9.0%
History of Art	3	1	8	13	7	19	48	3	0	51	0.8%
Humanities	133	238	511	501	531	37	1818	120	14	1952	31.4%
Anthropology/Archaeology	8	4	8	12	17	2	43	6	3	52	0.8%
History	22	38	45	63	67	2	215	10	1	226	3.6%
Interdisciplinary	22	17	61	68	66	5	217	54	7	278	4.5%
Literature	39	61	162	171	195	8	597	37	0	634	10.2%
Music	22	64	145	108	101	6	424	2	2	428	6.9%
Technology Studies	8	7	7	10	19	3	46	0	1	47	0.8%
Writing	12	47	83	69	66	11	276	11	0	287	4.6%
Philosophy	15	16	72	80	52	8	228	5	0	233	3.8%
Political Science	28	38	132	135	117	7	429	151	4	584	9.4%
Psychology	7	88	220	210	186	4	708	34	0	742	11.9%
Urban Studies	13	6	27	43	45	12	133	15	6	154	2.5%
Visual Arts	12	20	54	55	74	45	248	17	4	269	4.3%
Subjects in Other Schools	7	3	8	10	19	5	45	6	5	56	0.9%
TOTAL	259	830	1664	1569	1525	215	5803	370	39	6212	99.9%
%		13.4	26.8	25.2	24.5	3.5	93.4	6.0	.6	100%	

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

<u>Field</u>	Student Class of:				<u>Total</u>
	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	
Anthropology/Archaeology	2	2	4	0	8
Creative Writing	29	26	21	5	81
Crossroads	4	5	2	1	12
Economics	194	104	27	2	327
Foreign Languages	34	37	13	1	85
History	40	23	11	0	74
History of Art	10	2	1	0	13
Labor in Industrial Society	2	2	2	0	6
Linguistics	2	2	1	0	5
Literature	72	29	8	1	110
Music	37	20	26	0	83
Philosophy	45	38	9	1	93
Political Science	63	39	16	1	119
Psychology	240	66	13	2	321
Technology Studies	0	5	2	1	8
Urban Studies	14	6	1	0	21
Visual Arts & Design	31	13	3	1	48
Special Concentrations	22	4	2	0	28
Total	841	423	162	16	1442

TABLE IV

Undergraduate Majors in the School of Humanities and Social Science*

<u>Year</u>	<u>Economics</u>	<u>Humanities</u>	<u>Philosophy</u>	<u>Political Science</u>	<u>Total</u>
1965-66	50	114	--	60	224
1966-67	76	121	--	73	270
1967-68	81	148	--	76	305
1968-69	84	195	--	79	358
1969-70	68	200	--	85	353
1970-71	60	162	--	59	281
1971-72	63	124	13	38	238
1972-73	64	92	15	39	210
1973-74	55	67	10	30	162
1974-75	63	48	1	14	126
1975-76	67	41	3	24	135

TABLE V

Graduate Students in the School of Humanities and Social Science**

<u>Year</u>	<u>Economics</u>	<u>Linguistics</u>	<u>Philosophy</u>	<u>Political Science</u>	<u>Psychology</u>	<u>Total</u>
1965-66	111	34	24	63	23	255
1966-67	117	42	29	79	26	293
1967-68	114	31	27	80	27	279
1968-69	118	38	23	87	27	293
1969-70	117	41	31	82	41	312
1970-71	103	34	36	78	23	274
1971-72	104	40	29	70	29	272
1972-73	109	34	24	82	23	272
1973-74	114	33	21	96	25	289
1974-75	114	35	18	95	25	287
1975-76	120	33	16	89	27	285

*As registered in the second term of academic year 1965-66 to 1975-76 (omitting freshmen and undesignated sophomores).

**As registered in the second term of academic year 1965-66 to 1975-76 (including special graduate students).

Technology Studies Program

During the past year, Technology Studies became a fully functioning academic program offering varied and comprehensive undergraduate subjects, many for the first time. Individual faculty research efforts produced a diverse array of significant publications. The Program established new working relationships with faculty and students of all Schools at the Institute. Along with the excellent response to our expanded seminar series, these activities suggest that there is serious interest in the humanistic study of science and technology transcending the boundaries of separate disciplines.

FACULTY

The seven faculty who form the nucleus of the Technology Studies Program include: Irving Kaplan, Professor of Nuclear Engineering and Technology Studies; Nathan Sivin, Professor of the History of Science and of Chinese Culture; Charles Weiner, Professor of the History of Science and Technology; Louis L. Bucciarelli, Associate Professor of Engineering and Technology Studies and Program Director; Joel Yellin, Associate Professor of Social Sciences; Kenneth Manning, Assistant Professor of the History of Science; and Langdon Winner, Assistant Professor of Political Science. They carry the major responsibility for giving direction to the Program's activities, staffing its subject offerings, and sustaining an environment for productive scholarship in Technology Studies. Other faculty from a variety of departments participate, particularly in teaching Technology Studies subjects, which are jointly sponsored by the faculty member's home department. Over the past year new offerings were developed in concert with Sherry Turkle, Assistant Professor of Sociology; Merton Kahne, Professor of Social Psychiatry; Michael Modell, Associate Professor of Chemical Engineering; Harvey Sapolsky, Associate Professor of Political Science; Richard Douglas, Professor of History; and Leon Trilling, Professor of Aeronautics and Astronautics. David Kingery, Professor of Ceramics, and Judith Wechsler, Associate Professor of the History of Art, continue to contribute to the list of Program offerings.

Undergraduate Education

Descriptions of Technology Studies subjects appeared in the M. I. T. Bulletin for the first time this past academic year. Student response was encouraging, particularly to those subjects carrying humanities distribution credit -- 150 students enrolled in four such subjects. In February, the Program was granted full status as a Field of Concentration in the Humanities, Arts, and Social Sciences. Prior to that time, seven students had selected Technology Studies as a field on a provisional basis. We expect to see that number increase significantly this next academic year.

The addition of a new course in the history of nineteenth century science and a seminar in the history of contemporary science strengthened instruction in the history of science. A subject treating the legal, ethical, and scientific issues in industrial regulation has been added to a second subset of subjects concerned with the development of technology, its impacts over the past, and its relevance to contemporary social choice. Three new subjects -- Professions, Culture and Therapy, and Aspects of the Scientific Imagination -- enrich a third set which

addresses the ways professional work in science, engineering, and medicine are affected by social and political norms as well as individual aspirations. Finally a new listing, *Technology and History: China and the West*, joins a group of subjects oriented toward cross-cultural study.

Graduate Education

Although Technology Studies offers no formal graduate program of instruction or training, in the past year several graduate students sought out individual faculty and established working relationships based on shared interests.

RESEARCH

Faculty affiliated with Technology Studies conducted research spanning a variety of fields and disciplines. Professor Sivin uses the tools of history, philosophy, anthropology, and sociology to study science and its relations to culture and society in traditional China. His aim is not only to understand a system fundamentally different from ours, but also to build an independent comparative standpoint from which to study modern science and technology.

Professor Weiner studied the social context of contemporary science and technology. As Director of the M. I. T. Oral History Program, he was involved in several archival research projects including one concerned with documenting the development of recombinant DNA research guidelines. This unique effort in contemporary history is supported by research grants from the National Science Foundation and the National Endowment for the Humanities.

Professor Yellin is researching the social, environmental, and economic implications of the international spread of nuclear power with Professor Paul Joskow of the Department of Economics and Professor Henry Jacoby of the Alfred P. Sloan School of Management. A Ford Foundation grant supports their work. Supported by a grant from the National Institute for Health, Professor Yellin and Professor Paul A. Sameulson of the Department of Economics continued their collaboration in research on population biology.

Professor Bucciarelli, together with Professor Michael Folsom of the Department of Humanities, obtained a grant from the National Endowment for the Humanities to develop resource materials and ways of teaching the history of industrialization. With Nancy Dworsky, Professor Bucciarelli also has completed a book length manuscript on Sophie Germain and her contributions to early nineteenth century developments in the theory of elasticity.

Publications

Professor Sivin published several articles and continued work on a book, Science and Civilization, with Joseph Needham and Gwei-djen Lu. He also has worked on a translation and evaluation of a text for training traditional Chinese doctors, a source book of Chinese science, and has sent to press a volume of selected essays (from ISIS), Science and Technology in East Asia, for which he carried editorial responsibility.

Professor Manning's study "The Emergence of the Weierstrassian Approach to Complex Analysis" appeared as Volume 14, Number 14 of the Archive for History of Exact Sciences. He is presently writing a book on the Concept of Rigor in the History of Mathematics.

M. I. T. Press will soon publish Professor Winner's Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought. Professor Yellin's evaluation of the Nuclear Regulatory Commission's Reactor Safety Study (WASH-1400) was published in a spring issue of The Bell Journal of Economics.

LOUIS L. BUCCIARELLI, JR.

Oral History Program

The Oral History Program devoted its first full year of operation to several projects designed to create and use unique resources for teaching and research on the historical development and social impact of twentieth century technology and science. More than 200 hours of tape-recorded interviews were conducted, transcribed, and catalogued thus far. These interviews provide first-person testimony and recollections documenting the human interactions and social processes involved in scientific research, education, and applications. Along with relevant archival materials, the interviews offer otherwise unavailable information on the life histories of scientists and engineers, the emergence and growth of new research fields, the development of institutional environments for research, and the interaction of science, technology, and society.

Autobiographical projects completed during the year include extensive interviews with Professor Harold E. Edgerton, Professor C. Richard Soderberg, and Dr. Charles Stark Draper, which document their lives and work with special attention to their roles in research and education at M. I. T. Research was initiated in preparation for future interviews with other M. I. T. faculty.

A major ongoing contemporary history project is documentation of the emergence and implementation of safety guidelines for research on recombinant DNA. Thus far the Program has conducted more than 100 hours of interviews with 40 individuals who have been involved at the international, national, and local levels, and 1,000 archival documents have been collected. The work continues as events unfold. The goal of the project is to produce a fully catalogued archival/oral history collection and to publish a documentary history for use in teaching and research on the ethical and social dimensions of science.

The life histories and the educational and professional experiences of women in science and engineering are being documented in another project of the Oral History Program. So far interviews have been conducted with Professor Vera Kistiakowsky, Professor Mildred Dresselhaus, and Dr. Christine Jones. Additional interviews are planned for the coming year.

Other projects completed during the year include documentation of the history of the Physical Sciences Study Committee, the first large postwar experiment in curriculum reform; the Center for Transportation Studies' five year program with the California Division of Highways on "Community and Environmental Values in Transportation Planning;" and the emergence of Ocean Engineering as a distinct research field.

A continuing project explores the use of oral history in connection with personal correspondence to provide source materials on the life, work, and public role of Robert Oppenheimer. The result will be a book combining interview excerpts and selected correspondence.

The tapes, transcripts, and archival materials generated by the Oral History Program's staff and consultants are being catalogued and prepared for deposit in the new Oral History Collection in the M. I. T. Libraries. Some of these materials will be available for use in research and teaching during the 1976 fall semester.

Exploration of the use of oral history in undergraduate education supplemented the Program's documentation activities. Oral history materials were used in the teaching of some Technology Studies subjects, and the technique was used by students to gather first hand information for term projects in these classes and an Experimental Studies Group seminar. In addition, the Oral History Program worked with several UROP students and writers of senior theses who conducted oral history interviews as an essential part of their research.

A four-session "Workshop in Oral History" was offered during IAP in January 1976, and because of its success it will be repeated in 1977.

CHARLES WEINER

Department of Economics

Undergraduate Program

The long run impact of the past year's changes in the Institute Requirement in the Humanities, Arts, and Social Sciences is not yet clear. Unquestionably they have increased the Department's enrollment, but the precise amount is uncertain, because simultaneously a major revision was made in the two introductory economics subjects. In the past year, enrollments were larger than previously, but smaller than in the transition of the previous year. Nearly 200 of the Class of 1976 concentrated in economics for their Humanities, Arts, and Social Sciences Requirement. Of all students presently enrolled, 327 (primarily juniors and seniors) have elected to concentrate in economics.

Undergraduate majors remain steady in numbers. As in 1974-75, 20 degrees were awarded. In the spring term the Undergraduate Economics Association was reactivated. Its weekly meetings with faculty led to several proposals for revision of the undergraduate program, and several student-faculty socials were organized.

Graduate Program

Enrollment has been remarkably steady in the graduate program. The number of applications for admission was virtually identical to the average of the previous six years. Next year's entering class of 32 will be slightly larger than average, and will have fewer foreign students and more women, reflecting a shift in the percentage of applications from these groups. Four students from minority groups are expected to be in this class.

Financial support for the graduate student has changed very little over the last several years. We are still fortunate in having from one-third to one-half of the entering students on National Science Foundation Fellowships. For the whole student body, there has been an increase in the support by US foundations (other than NSF) and a decrease in support provided by M. I. T.

The number receiving the Doctor of Philosophy increased somewhat in the past year to 21. For the first time, two American blacks received degrees. The class fared well in placement, their median salary offer totaling 24 percent above that of 1971. Like the past average, 86 percent went into teaching and 14 percent into non-teaching positions.

The Graduate Economics Association awarded the outstanding teacher in the Department prize to Professor Stanley Fischer.

PUBLIC SERVICE ACTIVITIES

The faculty has always been involved in public service activities tying research to the public interest. In connection with M.I.T.'s participation in the Bicentennial Celebration, Professor Jagdish N. Bhagwati set up a recent conference on the New International Economic Order; Professor Ann F. Friedlaender is planning one for this fall on Air Pollution and Administrative Control. Through the German Marshall Fund, Professor Richard S. Eckaus is organizing a fall conference on economic problems of Portugal. Professor Franco Modigliani arranged a conference through the Bank of Finland on International Monetary Mechanisms.

Various Congressional committees and government agencies have been advised. Professor Peter A. Diamond served on the Consultant Panel on Social Security for the Congressional Research Service. Professors Rudiger Dornbusch and Fischer and Institute Professor Paul A. Samuelson prepared a report for the US Department of Commerce on international financial arrangements. Professor Robert E. Hall was a member of the Advisory Committee on Population Statistics, Bureau of the Census. Professor Jerry A. Hausman served on the Econometrics Advisory Committee to the Federal Energy Administration. Institute Professor Modigliani was a consultant and member of the Committee on Monetary Statistics, Board of Governors of the Federal Reserve System. Institute Professor Samuelson consulted with the Board of Governors of the Federal Reserve System, the US Treasury, and the Congressional Budget Office. Professor Charles A. Myers was a member of the National Manpower Policy Task Force. Institute Professor Robert M. Solow served as Deputy Chairman, Federal Reserve Bank of Boston.

Several faculty members have been involved with the National Academy of Sciences and its related organizations. Professor Eckaus prepared a report, Appropriate Technology for Developing Countries, for the Board on Science and Technology for Developing Countries of the National Academies of Science and Engineering. Professor Franklin M. Fisher served on a National Academy panel on the Effects of Deterrence and Incapacitation; Professor Friedlaender was on the Executive Committee, Assembly of Behavioral and Social Sciences, National Research Council; Institute Professor Modigliani was on the Finance Committee, Institute Professor Samuelson served on the Editorial Board of the Proceedings; and Institute Professor Solow chaired the Steering Committee on Environmental Studies.

Professor Eckaus led an OECD Mission to Portugal that included Professors Lance Taylor and Dornbusch. Professor Paul L. Joskow was a consultant to OECD in energy. Professor Evsey D. Domar was a member of a delegation of economists sent by the American Economic Association to the Soviet Union. Institute Professor Modigliani, who gave much time to the problems of stabilization in Italy, was a member of the Board of Directors of the Italian Council for Social Sciences.

The Brookings Institution Panel for Economic Activity included Professors Dornbusch and Hall, with Institute Professors Modigliani, Samuelson, and Solow as senior advisors to it. Professor Friedlaender served on the examining committee, Graduate Records Examination,

Educational Testing Service. Institute Professor Modigliani served on the Committee on Economic Stabilization, Social Science Research Council. Professor Fisher is a member of the Board of Governors of Tel Aviv University. Institute Professor Solow continues as Trustee for the Institute of Advanced Study.

RESEARCH

International topics seem to dominate the research interests of the faculty. Professor Bhagwati, in addition to his work in developing countries and international trade theory, has given attention to a proposal for applying taxation to the brain drain. Professor Eckaus studied the role of financial markets and their regulation and the behavior of income distribution in economic development. Professor Taylor had three major areas of research: the development of nutrition planning models in Pakistan, international food aid and reserve policies, and growth and income distribution in Brazil.

Professor Morris A. Adelman's continuing research on the world oil market, Professor Joskow's analysis of the international nuclear energy industry, and Professor Martin L. Weitzman's examination of OPEC and oil pricing involve applied microeconomics with international implications.

Research in various applied microeconomics areas was responsible for the second largest fraction of faculty effort. Institute Professor Solow continued to research the economics of exhaustible resources, and Professor Weitzman completed his analysis of the optimal development of resource pools. Professor Joskow has explored the future of the electric utility industry and its financing, the future of the US atomic energy industry, and the pattern of energy consumption in the US. He is developing a simulation model of the energy industry, and is reviewing the regulatory activities of government agencies in general and the health care sector in particular. Professor Hausman examined the Project Independence Report and is analyzing the choice of new technologies in energy research.

In the transportation field, Professor Friedlaender surveyed the issues in regulatory policy for railroads and alternative scenarios in federal transportation policy. Professor Jerome Rothenberg examined such problems in urban transportation as pricing policies, demand sensitivity to price, and modeling locational effects. Professor William C. Wheaton considered an optimal pricing and investment policy in highways under a gasoline tax.

Inextricably intertwined with urban transportation are questions of urban location and housing. Professor Rothenberg carried out research in such aspects of this problem as microeconomics of internal migration, supply-demand for housing in multizoned areas, the impact of energy costs on urban location, and the development of a model of housing markets and of metropolitan development and location that can be applied to general policy questions. Professor Wheaton developed an equilibrium model of housing and locational choice based on Boston experience.

Institute Professor Modigliani also conducted research on the housing market, but his interest comes primarily from the side of stabilization policies and similar macroeconomic problems. He also participated in a review after 20 years of his life cycle hypothesis of saving, made monetary policy prescriptions for both the US and Italy, reflected on the description of financial sectors in econometric models, and explored more deeply the application of optimal control to the design of optimal stabilization policies in economic models. Institute Professor Samuelson reviewed the art and science of macromodels over the 50 years of their development. Professor Friedlaender completed a quarterly macromodel of the Massachusetts economy. Professor Hall developed a model to deal with income tax changes and consumption.

Public economics has both macro and micro aspects, both of which are represented in the Department's research. With visiting Professor James A. Mirrlees, Professor Diamond theorized about public shadow prices with constant returns to scale, and about the assignment of liability. He also has generalized the Ramsey tax rule and continued his research into an optimal Social Security system. Professor Hausman is reexamining the cost of a negative income tax; Professor Rothenberg analyzed the distributional impact of public service provision; and Professor Wheaton explored intertemporal effects of land taxes, fiscal federalism in practice, and the financial plight of American cities.

Besides such theoretical research, there was significant research of an entirely pure nature. Professor Robert L. Bishop reexamined the measurement of consumer surplus. Professor Fisher extended his exploration of the stability of general equilibrium and of aggregate production functions. Professor Weitzman investigated the welfare significance of national product in a dynamic economy. Professor Hal R. Varian further explored the theory of fairness, non-Walrasian equilibria, and macromodels of unemployment and disequilibrium. Professor Hausman examined the econometric implications of truncated distributions and samples, of probit models, and of simultaneous equation models. In historical research, Professor Domar was concerned with serfdom, while Professor Charles Kindleberger investigated the role of the merchant in nineteenth century technologic transfer.

Publications

Professor Bhagwati edited Taxing the Brain Drain: A Proposal and Brain Drain and Taxation: Theory and Empirical Analysis, and coauthored Foreign Trade Regimes and Economic Development: India. Professors Dornbusch and Kindleberger published numerous papers on implications of the new international monetary exchange structure for exchange rates, price stability, international trade, and international capital movements. Professor Weitzman continued his study of the Russian economy with a paper on the new Soviet incentive model.

With Visiting Professor of Management Ezio Tarantelli, Institute Professor Modigliani published Labor Market, Income Distribution and Private Consumption (in Italian) and various papers on stabilization policy in Italy. He also wrote papers on inflation and the housing market and edited New Mortgage Designs for Stable Housing in an Inflationary Environment. Professor Hall's labor market research resulted in papers on persistence of unemployment, occupational mobility, and taxation of earnings under public assistance. Professor Michael Piore wrote on labor market stratification and the effect on industrial growth of immigration from Puerto Rico to Boston. Professor Fisher had several publications on indexation and adjustment of mortgages to inflationary episodes. In the realm of economic history, Professor Temin published Reckoning with Slavery and Did Monetary Force Cause the Great Depression?

Institute Professor Samuelson published theoretical papers on factor price equalization and trade pattern reversal. In the realm of pure research, he put out papers on non-linear and stochastic population analysis, optimal population growth, and the optimal Social Security system implied in a lifecycle growth model. He also brought out the tenth edition of his famous text, Economics: An Introduction Analysis.

FACULTY

Visiting Professor John R. Moroney was here from Tulane University; Visiting Professor James A. Mirrlees came in the spring term from Nuffield College, Oxford University.

Regular faculty on leave were Professors Fisher and Joskow in the fall and Professor Weitzman in the spring.

It is a pleasure to report the promotion to Associate Professor of Jerry A. Hausman. A new appointee, Professor Jeffrey E. Harris, with the unusual background of an M.D. and a Ph.D. in economics, will provide long-sought coverage in health economics.

Professor Kindleberger will retire as Ford Professor and become a Senior Lecturer on a half-time basis. Since 1948, when he came as an Associate Professor, Professor Kindleberger has been an effective teacher, scholar, participant in faculty governance, and counselor to governments and the public. He has trained the leading international economists of the next generation; he has produced a dozen books and more than a hundred articles in international trade and finance and in economic history. He epitomizes the highest kind of academician.

Several honors were bestowed on members of the Department. Institute Professor Modigliani will complete his year as President of the American Economic Association. Professor Myers received a Distinguished Alumni award from Pennsylvania State University. Professor Fisher was F.W. Paish Lecturer to the Association of (English) University Teachers of Economics. Institute Professor Solow received a D. Litt. from Warwick University, and Institute Professor Samuelson, a D.Sc. from the University of Rochester.

EDGAR CARY BROWN

Department of Foreign Literatures and Linguistics

The major event to be noted in this report is the liquidation of the Department of Foreign Literatures and Linguistics (Course XXIII) as an independent administrative entity as of June 30, 1976. On that date, the foreign language/literature faculty will transfer to the Department of Humanities, and the linguistics faculty will join the faculty of the Department of Philosophy to form the new Department of Linguistics and Philosophy (Course XXIV). There were several reasons for this administrative reorganization. On the one hand, in the course of the last 15 years -- i. e. , since the establishment of the graduate program in linguistics -- there has developed a noticeable separation between the teaching staffs in the linguistics program and in the language and literature program. Persons teaching in one program were seldom involved in the other programs, nor did they share common research interests.

On the other hand, such common research interests did develop quite naturally among the linguistics faculty and various members of the philosophy faculty, and these interests led to serious discussions concerning the possibility of developing a more formal institutional framework for this collaboration. Ever since the appointment of James W. Harris as Head of the Department of Foreign Literatures and Linguistics in 1973, there had been a gradual integration of foreign language courses into the Institute's humanities offerings. The ties between the programs were strengthened further by the restructuring of the undergraduate requirement in the Humanities, Arts, and Social Sciences last year, with increased joint participation of language and literature faculty with humanities faculty in committees concerned with undergraduate education and various aspects of curriculum planning. The administrative reorganization, thus, is primarily an attempt to give institutional form to changes that had taken place in the course of time.

Among other events of importance was the Department's participation in the celebration of the Centennial of the Invention of the Telephone. During 1975 and early 1976, Professor G. A. Miller of Rockefeller University and Professor Morris Halle of this Department organized a series of meetings bringing together scholars from various groups working in the area of language and cognition. The results of these discussions were formally presented in one of three concurrent symposia held at M.I.T. on March 9-10, 1976, as part of the Convocation on Communications, co-sponsored by the Institute and AT&T. The symposium, titled *New Approaches to a Realistic Model of Language*, comprised the following papers: J.W. Bresnan, M.I.T., "Towards a Realistic Model of Transformational Grammar;" K. Forster, Monash University and M.I.T., "The Autonomy of Syntactic Processing;" R.M. Kaplan, Xerox Corporation, "Models of Comprehension Based on Augmented Transition Networks;" E.H. Wanner, Harvard University, "Garden Paths in Relative Clauses;" M.F. Garrett, M.I.T., "The Organization of Sentence Processors;" S. Blumstein, Brown University and Aphasia Unit, VA Hospital, Boston, and E. Zurif, Aphasia Unit, VA Hospital, Boston, "Language and the Brain: Evidence from Aphasia;" G.A. Miller, Rockefeller University, and R.S. Jackendoff, Brandeis University, "Semantic Relations Among Words;" S. Carey, M.I.T., and M. Maratsos, University of Minnesota, "Language Acquisition: The Role of the Lexicon." The symposium was attended by about 300 scholars from various universities and research groups both in the USA and abroad. The reception of the papers indicated that the issues under discussion were at the forefront of current concern and that the symposium was likely to exercise a significant influence on the future development of the field.

RESEARCH IN LINGUISTICS

Research in linguistics continued at the usual pace and, as in past years, dealt with all areas of language.

In his researches, Professor Noam Chomsky has developed further the so-called "trace theory of movement rules," which stipulates that, when an element (specifically an NP) is moved by a transformation, it leaves behind a phonetically unactualized element (which may, however, have indirect phonetic consequences) that can be interpreted as a bound variable. Professor Chomsky and others have shown that such bound variables are strikingly similar to variables introduced in the interpretation of quantifiers and the analysis of focus. These investigations suggest that the logical form of a sentence can be captured only with the help of a logic -- such as the predicate calculus -- which makes use of variables. This result is of great importance for it opens up the possibility that empirical data can be brought to bear on the question of what is the appropriate logic for representing the information about the scope of logical elements (quantifiers, connectives, modal operators) and properties of anaphora.

An important result of Professor Kenneth Hale's recent work has been his discovery that number agreement may be quite distinct from person agreement. In languages where number agreement is morphologically distinct from person agreement, there is a corresponding syntactic distinction. Typically, number agreement applies early in the derivation of a sentence, while person agreement applies late. In fact, in the languages Hale has been studying, no transformational rule has been shown to precede number agreement, which may, therefore, be a nontransformational process. If this should indeed be the case, then a whole series of syntactic arguments will have been reviewed because they were based on the putative transformational character of number agreement rules. Professor Hale also has actively investigated the educational potential of linguistics in communities seeking to define the role that their native language should play in elementary and secondary education. Professor Hale has participated in the development of a number of educational games,

puzzles, and other teaching devices that can be used in the classroom to introduce children to the scientific study of language.

Professor Rene Kiparsky's work has centered on phonological questions. In the spring, 1976 he carried out an extensive phonological study of English versification. Its object was to test different theories of the linguistic nature and representation of stress currently being debated in the field. The results favor quite conclusively a version of the theory advanced in Liberman's (1975) dissertation, which explains a large number of already known facts as well as pointing the way to some quite significant previously unobserved regularities. This work is now completed and will be reported in *Linguistic Inquiry*.

In collaboration with W. O'Neil, Professor Kiparsky undertook an analysis of Old English phonology. This was stimulated by an earlier article by J. Keyser, whose conclusions were in some ways incompatible with those of Kiparsky's earlier theory. Kiparsky and O'Neil found a solution which is in many respects more elegant than Keyser's, but which still fits perfectly in the more restrictive framework indicated by recent research.

With L. Menn, Kiparsky wrote a review of the literature on acquisition of phonology. The scholars took issue with some aspects of the predominant, Jakobsonian view as well as the more recent proposals by Stampe, concluding that the diversity and what might be called the inventiveness of the earliest steps in the acquisition of phonology had been greatly underestimated. They argued that even these early stages have exactly the same "problem-solving" character as was established for the later stages by Berko and others, suggesting a more unified view of language acquisition than has been generally entertained, and requiring less rigidly determined innate schematisms.

Professor David Perlmutter's work on the theory of Relational Grammar has been carried out in collaboration with P. M. Postal of IBM. It has progressed to a point where Professor Perlmutter felt it wise to obtain separate support from the National Science Foundation. An intriguing proposal emanating from this work is the possibility of replacing the well known tree-like base structures of transformation grammar and the set of transformations with the help of which surface structures are generated in a step-like procedure, by a single object which has the formal properties of a network in graph theory and from which the surface structure can be read off directly with the help of a set of language-specific rules.

Professor John R. Ross has continued to develop his ideas on non-discrete grammars. His guiding thought is that most, if not all, metalinguistic predicates are quantifiable -- e. g., he has argued that there is a feature [α verby], with α being a real number between 0 and 1, which expresses the differences among words belonging to the categories below:

Noun	Present	Perfect	Adjective	Adjectival	Noun
	Participle	Participle		Noun	

Similarly, Professor Ross believes that grammatical processes are differentiated with regard to the degree of their sensitivity to the presence of a given property. These two hierarchies interact to form what he has called squishes.

In collaboration with William Cooper, Professor Ross has been exploring applications of notions of non-discrete grammar to the study of such set expressions as "here and there" (but not "there and here"), "bits and pieces" (but not "pieces and bits").

The reconstruction of the Indo-European accentual system has been a classical problem in linguistics for well over a century, but in spite of efforts on the part of some of the best minds, the problem has resisted solution. Professors Kiparsky and Halle have proposed a new approach to this old problem, and judging from the critical comments of specialists to whom they have presented their proposal, real headway has been made. A preliminary report of the most important results has been submitted for publication.

RESEARCH IN FOREIGN LANGUAGES AND LITERATURES

The foreign languages and literatures faculty and staff have been engaged in evaluation and planning for the future of their programs in a new administrative and intellectual context. In connection with this, a series of in-house seminars was initiated in spring term by Professor Catherine Chvany, as part of her activity as a Lilly Post-Doctoral Fellow, for the purpose of sharing research and teaching interests across the separate language groups. Ilona Ricardo-Kinzer spoke on "English Reactions to Voltaire's Criticism of Shakespeare," a part of her ongoing work on Voltaire's biography. Renate Briggs led a discussion of methodology for the first-year language course. Claire Kramersch, who gave an IAP course on folklore, spoke on "The Folktale as a Model for the Study of Language as Expression." Magda Tisza reported on surveys of language requirements for scientists, including a panel discussion at the Annual Meeting of AAAS. Outside participants included Joyce Toomre of Brown University, who spoke on "The Art of the Seminar" as practiced at M.I.T. by Professor Krystyna Pomorska, and at Brown University and the California Institute of Technology; the ensuing discussion focused on American and European approaches to the seminar. Ms. Toomre's paper has been submitted for publication. These seminars attracted colleagues from neighboring institutions and will be continued next year.

Further publicity for M.I.T.'s language programs was provided by an article on computer aided instruction in Foreign Language Annals by G.E. Nelson, Roy Kaplow, et al. Claire Kramersch's paper "Reliving Schiller at M.I.T.: A Workshop Approach to German Literature" will appear in Die Unterrichtspraxis for September 1976. The second edition of a textbook coauthored by J.W. Harris and G. Segreda, Spanish: Listening, Speaking, Reading, Writing appeared this year. Selected papers from the Soviet-American Conference on the Russian Language published in The Slavic and East European Journal in fall, 1975 included Professor Halle's work on Russian accentuation, Professor Robert Channon's work on the single stem verb system, and Professor Chvany's work on applications of linguistics to language teaching.

The increase in pedagogical and community activities has not reduced the research productivity of the language and literature faculty. Professor Martin Dyck continues his work on a theory of comedy and has completed an article, "Der Gedichtschluss: entwurf einer Theorie der Lyrik," presenting a new theory of poetry based on the closure of poems. Among his other publications and talks, the article "Lessing and Mathematics" reflects his continuing interest in the interrelations between German literary figures and the History of Mathematics.

Professor Robert Jones is completing his book Lenormand for Twayne Publishers, as well as a critical bibliography of Lenormand, to be published in 1976-77. He has completed an article "L'Esthetique de la Tragedie: L'Electre de Giraudoux," to appear in France next year, and a paper on "Sexual Roles in the Works of Tennessee Williams." In addition to serving as chairman of the committee on the Institute Requirement in the Humanities, Arts, and Social Sciences, he offered an IAP course in The New French Cooking, which was so popular as to require three sections.

Marcia Josephson has been awarded a National Endowment for the Humanities Fellowship to take part in a Seminar on George Sand at Princeton University in summer, 1976.

Professor Pomorska's book Themes and Variations in Pasternak's Poetics was published by The Peter DeRidder Press, Lisse, Holland. In addition to participating in a conference on "Semiotics in the East and West" at Brown University, she completed two articles, "Roman Jakobson and the New Poetics," which will appear in To Honor Roman Jakobson in 1976, and "Peculiarities of Pushkin's Journey to Erzerum," which will appear in Pushkin Symposium, 1976. Her continuing work on the structure of modern artistic prose includes public lectures and an article on the prose of Chekhov and Solzhenitsyn, on Pasternak's Dr. Zhivago, and an ongoing study of Gogol's parodistic parallelism. A revised version of her anthology Fifty Years of Russian Prose was reissued by M. I. T. Press in 1976.

Professor Channon is testing and applying Professor Perlmutter's theory of Relational Grammar to problems of Russian syntax. He presented a paper "Dative Advancements in Russian" before the Western Slavic Association in San Diego, in February 1976.

Professor Chvany explored consequences of recent theoretical proposals, particularly Chomsky's lexicalist hypothesis. Her article "Syntactic Word Derivation in a Lexicalist Theory (Toward a Restudy of Russian Morphology)" is in press. She also has found evidence from second language acquisition supporting a general principle and forcing a reexamination of certain established assumptions about second language learning. Her paper "On the Naturalness of the A Over A Principle" has been accepted for publication. Her current work applies concepts of the Prague School and generative linguistics to literary and linguistic analysis of Slavic texts.

FACULTY

The Departmental restructuring has been accompanied by changes in appointments. Professor Harris, on leave in spring, 1976, ended his term as Head of the Department of Foreign Literatures and Linguistics in January. His leadership led to a strengthening of the foreign language programs, with increased participation of the foreign language and literature faculty in the M. I. T. community. He will hold a joint appointment as Professor in both departments, continuing to teach and supervise the Spanish offerings in the Department of Humanities, and researching problems of Romance phonology and morphology in the Linguistics section of the Department of Linguistics and Philosophy. In addition to his Spanish textbook, his publications this year include Fonologia generativa del espanol, Madrid, a much expanded translation of his Spanish Phonology. A pioneer in the application of phonological theory to the study of historical change, he published three articles on Spanish phonology and historical morphology and completed three others this year.

During Professor Harris's leave, Professor Halle was Acting Head of the Department. Professor Halle also has been appointed Acting Head of the new Department of Linguistics and Philosophy.

Joan Bresnan, appointed Associate Professor of Linguistics in 1975, held a Guggenheim Fellowship in 1975-76. She will begin her duties at M. I. T. on July 1, 1976. Noam Chomsky was promoted to Institute Professor in recognition of his outstanding contributions to the science of language. Morris Halle was appointed Ferrari P. Ward Professor of Modern Languages and Linguistics. G. E. Nelson, Assistant Professor of German, is leaving M. I. T.

for a position in industry. His contributions to the German program included the launching of German House in the new West Campus complex.

MORRIS HALLE

Department of Humanities

In the academic year 1975-76, more than 4,700 students enrolled in over 220 subjects offered under the Humanities designation (XXI), a significant increase over the 3,448 taking Humanities subjects in 1974-75, thereby reversing a downward trend since 1971-72. The increase may be attributable in part to strong efforts on the part of faculty to attract students and in part to the widening of the Department's interests, ranging from audiovisual subjects to beginning Greek. The latest expansion of the Department will take place on July 1, when Foreign Languages and Literatures, formerly in a separate department, will join the Department of Humanities, adding 12 full-time and six part-time teaching members to its roster.

Before 1953, the Department of Humanities was known as the Department of English and History, two disciplines which have always been basic to its definition and to its efforts. It is therefore a pleasure to report initial achievements and long-range plans to strengthen the teaching and intellectual vitality of both Literature and History. In English and American Literature, a distinguished ad hoc committee was formed to recommend new appointments and we are sanguine that these appointments (Professors Irene Tayler and David Thorburn, who are described at length in the Literature Section report) will add strength to a Section that has already demonstrated its ability to attract students. Under the auspices of the English Literature Section, there was a Bicentennial celebration taking the form of a fall and spring symposia on the state of American literature. In the fall, the Department sponsored Geoffrey Bush's play on Calvin Coolidge and a seminar led by playwright Arthur Kopit on the historical element in American literature. The spring symposium featured E. L. Doctorow, author of the prize-winning novel Ragtime; Justin Kaplan, who wrote a prize-winning work on Mark Twain and is currently engaged in a study of Thomas Wolfe; and Linda Wagner, of the Wellesley College faculty. The theme was the role of the historical experience in fictionalized form. Plans are under way for a Literature Workshop next year, with the intent of establishing M. I. T. as the Boston area center for exciting literary conversations. A model of this goal was a seminar with Professor and critic Harold Bloom of Yale University, who spoke to a room filled with students and faculty from other universities as well as M. I. T.

In Writing and Literature, the Writing Program has continued to attract students. During the academic year of 1975-76, 763 students were enrolled in 49 sections of 13 subjects. In addition, the Program offered nine projects during I. A. P. Eighty-one students chose writing as their Humanities concentration, and five graduating seniors majored in writing. The success of the Program calls renewed attention to the problems of staffing, evaluation of teachers, the correct mix of creative and technical or expository writing, etc. A Committee to evaluate the Program, formed by the Dean of the School and headed by Professor Nathan Sivin, spent the year talking to staff, observing classes, and interviewing, testing, and surveying students inside and outside the Program.

In History, a Workshop was established, to focus on the family in industrial society, with specific attention on the American family. Each month, a distinguished speaker was brought in to give a paper, and a continuing group of scholars from M. I. T. and other New England universities then discussed the papers. Requests have been made for the Workshop's continuation next year. Building on this Workshop experience, plans are now under way to establish a group or center for the study of industrial society in historical perspective. Alexander Keyssar, whose field is American Social History, has been appointed Assistant Professor in the History of Industrial Society. He is just completing his doctoral thesis on "Unemployment and the American Worker: Massachusetts, 1875-1916" (Harvard). Professor Keyssar already has published a small volume, Melville's Israel Potter: Reflections on the American Dream (Harvard University Press); an article on "Widowhood in 18th-Century Massachusetts" in Perspectives in American History; and a major review in The Times Literary Supplement.

It is clear that history and the historical perspective need to play a more vital and central role at M. I. T., as the Institute continues to emphasize its activist and policy oriented functions. What is more natural than the study of industrial society in historical perspective at M. I. T.? An ad hoc committee, chaired first by Professor Elting Morison and then by Professor E. Neal Hartley, is seeking, therefore, to recruit a group of four people who will work as a team. To secure released time for their research, they will be expected to seek outside funding as a group, a new style in a discipline where most work is carried out by a single individual. Members of the group will be expected not only to teach regular history offerings, so badly needed in the Department but to pioneer in the offering of workshops where students will work, as in other parts of the Institute, in direct conjunction with their teachers on a common research problem. Such firsthand research experience at the undergraduate level is unknown in history courses at most universities, and it is entirely fitting that M. I. T. innovate in this area.

In the fall the Department was fortunate in having two distinguished Visiting Professors, in history, Henry Steele Commager, whose course on Foundations of American Nationalism, 1774-1815 attracted almost 60 students; and, in writing and literature, John Hersey, whose The Writer's Craft set a standard of grace and distinction for the Department.

Numerous initiatives, many of which are described in the sectional reports, are afoot in the Department. In addition, mention should be made of: efforts in drama and audiovisual work by Professor Albert R. Gurney, who is supported by a Sloan Grant; planning for a new concentration in ancient and medieval studies under the direction of Professor Harald Reiche; and a reexamination of Crossroads and of the Cambridge Humanities Seminar. Outside the Department, the Shakespeare Ensemble continues vigorously under the direction of Professor Murray Biggs.

As for the faculty, efforts are being made to establish clear and concise guidelines for the hiring and evaluation of instructors, lecturers, and senior lecturers. Such guidelines are needed to introduce greater rationality in the handling of these ranks, as well as greater equity among the constituent parts of the Department.

In the senior ranks, Professor John Buttrick, after four years of innovative and expansionary effort as Director of Music and Chairman of the Music Section, asked to be relieved of his posts and will be succeeded by Professor Stephen Erdely. Professor E. Neal Hartley, to our great though selfish pleasure, will return full time to the Department after resigning his position as Institute Archivist. To our great sadness, Administrative Officer Ruth DuBois retired on June 30, 1976. The new Administrative Officer of the Humanities Department is Marjorie Lucker, assisted by Margot Pelkey, both of whom have served in those respective capacities in the Foreign Languages and Linguistics Department. To handle the

transition, as the Foreign Languages group enters the Humanities Department as a Section, the Acting Chairman will be Professor Donald Blackmer, the Associate Dean of the School of Humanities and Social Sciences. Heather Lechtman is the new Chairman in the Anthropology/Archaeology Program.

The Department has again been the grateful recipient of moral and financial support by the Friends of Humanities, headed by I. Austin Kelly III. This support has allowed us to invite a number of distinguished lecturers, as well as to hold seminars and workshops. It also has allowed us to bring the faculty together, once for cocktails in the fall, and once at a Renaissance Banquet in the spring. The latter involved an adaptation of the banquet given in Mantua in 1532, for the Duke of Ferrara and other illustrious guests. Entertainment of the period was provided by members of the Music Section. The menu, the music, and the whole production was under the direction of Timothy Aarset. In a multidisciplinary Department such as ours, such support for scholarly, communal, and social efforts is especially needed; and we are especially grateful.

BRUCE MAZLISH

ANTHROPOLOGY / ARCHAEOLOGY PROGRAM

This was a productive year for the Anthropology/Archaeology Program. In addition to our teaching and the individual professional activities described below, the Program sponsored a series of three talks by prominent anthropologists on "Human Nature: Environmental and Biological Determinism."

Professor Lechtman completed a busy year with a flourish when she received tenure in May. She acted as coordinator of the new Education Program of the Inter-institutional Center for Materials Research in Archaeology and Ethnology, a program being planned to be established during the next three years through the cooperation of eight Boston area universities and museums. In that capacity, she helped design and teach a graduate seminar, "Metallurgy in Ancient Societies," offered in fall, 1975 to graduate students in anthropology, archaeology, art history, and materials science from these eight institutions. She also taught a graduate "Laboratory in Archaeological Metallurgy" to those same students during the spring semester. Professor Lechtman received research grants from the Tinker Foundation for laboratory research in pre-Columbian metallurgy, and from the American Philosophical Society and the Wenner-Gren Foundation for field research in the Andes during summer, 1976.

Professor Arthur Steinberg devoted time and energy to the Center for Materials Research in Archaeology and Ethnology, writing proposals, lobbying with funding agencies, and working on plans for the Center in its steering committee. Professor Steinberg continued his studies of the ancient Cypriot copper industry and its relations to the political and economic decline of the Roman Empire, and he is now extending this investigation to the mining and smelting industry of Spain. He was a member of the review panel for archaeology of the National Endowment for the Humanities, and he is President of the Boston Society of the Archaeological Institute of America.

Professor Wilma Wetterstrom has set up a lab for the analysis of archaeological plant remains. She analyzed remains excavated at the Arroyo Hondo site, supported by a grant from the School of American Research, and in summer, 1975 she was assisted by two students paid by the UROP Program. She also analyzed plant remains from a fourteenth century Indian site in southeastern Missouri, and will write her analysis of this work during the summer, 1976. Professor Wetterstrom organized and chaired a symposium entitled

"Nutrition and Prehistoric Populations" at the 1975 American Anthropological Association meetings, and at the meetings of the Society for Economic Botany in June 1976 she gave a paper on the use of wild plants at Arroyo Hondo. She is also working on a paper on food processing techniques and the adaptation of early humans. In the summer, 1975 she acted as consultant to the I-88 Archaeological Project at Oneonta, New York.

Professor Martin Diskin, on leave during 1975-76, is carrying out fieldwork on nutrition and the market system in the Valley of Oaxaca, Mexico. He will extend his leave through 1976-77 to finish the research and to begin writing.

Professor James Howe spent summer, 1975 in further fieldwork among the Cuna Indians of Panama, supported by a grant from the National Endowment for the Humanities. At the December meetings of the American Anthropological Association, he organized and chaired a session on ritual and symbolism in Central America, in which he also delivered a paper on Cuna exorcisms. In April he gave a talk on the sociology and symbolism of fox hunting for the Anthropology Department at Brandeis.

Professor Jean Jackson has been preparing for field research on the "Regional Social Structure in the Central Northwest Amazon," to be supported by the National Science Foundation and an Old Dominion Fellowship. If she overcomes a set of bureaucratic hurdles and complies with the Colombian government's strict new regulations for foreign anthropologists, she will spend 1976-77 in the field; if not, she will spend the year writing a book based on her previous research.

In 1976-77 three Program members (Professors Diskin, Jackson, and Steinberg) will be away on leave. A part-time social anthropologist and a full-time industrial or historical archaeologist will take their places for the year.

Publications

Professor Lechtman published "A Metallurgical Site Survey in the Peruvian Andes" in the May 1976 Journal of Field Archaeology. Professor Steinberg wrote book reviews for Technology and Culture.

Professor Howe coedited a volume on ritual and symbolism in Central America for the University of Oregon series of Occasional Papers in Anthropology. The volume is based on the symposium he chaired at the December 1975 American Anthropological Association meeting. Encyclopedia of Anthropology contains several short articles by him. He is presently working on several articles based on his fieldwork in Panama. The University of Panama Press will publish his volume of sacred Cuna chants.

Professor Jackson's paper "Vaupés Marriage: A Network System in the Northwest Amazon" was published by Academic Press in a volume on regional analysis. She also wrote a field review for the American Anthropologist and presented papers at American Anthropological Association meetings and a colloquium series at Brandeis.

JAMES HOWE

HISTORY SECTION

The History Section enjoyed a significant increase in student enrollment this past academic year. Enrollment in fall, 1975 totaled 347, and spring, 1976 brought a yield of 296, making a total of 643 for the year, compared to 417 for 1974-75.

The most popular courses were 21.300 (118 students), 21.301 (105), 21.413 (52), and 21.303 (45). The number of students concentrating in history to satisfy their Humanities requirement rose encouragingly to 70. Advance expressions of interest suggest that this number will be exceeded in the approaching year.

A new appointment was made to augment our ranks, somewhat depleted by retirements in recent years. Professor Monroe Little, whose field is Black Studies, will join the Section in the fall. Professor Alexander Keyssar, as reported in the general introduction, has been appointed a member of the Group for the Study of Industrial Society in Historical Perspective, and will also teach courses in American Social History.

Furthermore, Professor Reiche, a longtime member of the Department, has accepted our invitation to become a member of the Section. He will concentrate in the area of Ancient History, with special emphasis on Greece and Rome. Professor Arthur Kaledin will be on leave of absence for the entire year, and Professor Robert Rotberg for the fall term. Professor Robert I. Rotberg chaired sessions of the Caribbean Studies Association Annual Meeting, the African Studies Association Annual Meeting, and special meetings of the Council on Foreign Relations and the Brookings Institution.

Publications

Professor Robert M. Fogelson served as consulting editor for Arno Press and finished a manuscript on the transformation of big city police from 1890 to the present. Professor Robert E. MacMaster finished the manuscript of "Tolstoy at the Time of the Emancipation." Basic Books published Professor Mazlish's The Revolutionary Ascetic. Professor David B. Ralston published articles in the U.S. Naval War College Review and War and Society: A Yearbook of Military History. Professor Rotberg edited East Africa and the Orient: Cultural Synthesis in Precolonial Times; The Mixing of Peoples: The Problems of Identity and Ethnicity; and The Journal of Interdisciplinary History. Professor Thomas Mahoney gave a paper at the American Academy for the Advancement of Science's February convention in Boston.

THOMAS H. D. MAHONEY

LITERATURE SECTION

The Literature Section appointed a search committee consisting of two senior Section members and two distinguished external members of the profession, Helen Vendler of Boston University and Geoffrey Hartman of Yale. Through their efforts we secured the services at the Associate Professor level of Irene Taylor, formerly of the Graduate Center of the City University of New York, and David Thorburn, formerly of the Yale University Department of English. Professor Taylor is the author of Blake's Illustrations to the Poems

of Gray, a ground-breaking effort in studies of the relationship between visual and verbal materials. She works in the area of historical and biographical criticism, and the climates of opinion known as the Enlightenment and Romanticism. Professor Thorburn has authored Conrad's Romanticism and edited anthologies of short stories and theories of Romanticism. His research extends from modernism and theories of narrative to contemporary fiction and the relation between high and popular cultures. He is a frequent contributor to Partisan Review, Commentary, and other notable journals.

Activities of the Section's members include the production of Professor Albert Gurney's play Who Killed Richard Corey? at the Circle Repertory in New York City; and the commissioning of Professor Barry Spacks by the National Endowment for the Humanities to furnish a libretto for a lyric theatre piece, "The Quarry," based on the Unicorn Tapestries in the Cloisters Museum of New York.

Honors included the award to Godine Publishers of the Carey Thomas Special Citation Awards for excellence in publishing by Publisher's Weekly for a series of poetry volumes, of which Professor Spacks' Teaching Penguins to Fly was the last, and the receipt by Professor Murray Biggs of the annual Baker Teaching Award at M. I. T.

Our various programs and mini programs continue to be active. An inter-university workshop and seminar on "Literary Criticism Since Northrop Frye," will be based in the Section next year, as a preliminary for which Professor Harold Bloom of Yale University lectured on his work this last semester.

Publications

Cambridge Press published Professor Peter Donaldson's A Machiavellian Treatise. Doubleday and Company have accepted Professor Gurney's Human Events, a novel of academic life. Professor Ruth Perry wrote the introduction to a reprint of Fabulous Histories by Sarah Trimmer. Professor Spacks published poems in Ploughshares, Salmagundi, The Sewanee Review, and The Massachusetts Review. Five essays by Professor Wayne O'Neil are either in print or in press. One by Professor Louis Kampf is in print and two by Professor Alvin Kibel are in press.

ALVIN C. KIBEL

MUSIC SECTION

The 1975-76 year witnessed an all-time high enrollment of 1,200 in the Music Section's courses, plus an increase in the activities of seminars and performing groups. Highlights of the year included the opening of the Electronic Studio, a performance by the Symphony in Washington's Kennedy Center, and a new series of concerts by the M. I. T. Chamber Players.

Course offerings were similar to those of the past year, but student interest in Sight-Singing and Piano Laboratory, Theory courses, and Distribution offerings increased. Consequently, the faculty was hard pressed to offer the same kind of attention to individual problems, particularly of the aural perception, that had marked our intentions for these courses. The breaking point in terms of facilities and current faculty has been reached,

however, unless there is a more efficient way in terms of faculty time to teach the introductory course, which is under study and debate among the faculty.

The performing groups changed only in the vocal area: the Choral Society merged with the Glee Club and gave three performances. The Symphony recorded six works including two with Professor Marcus Thompson as soloist. The Jazz Band was invited to the Notre Dame Jazz Festival as one of the competition finalists. The Concert Band gave four concerts on campus including a children's matinee. Students, faculty, and occasional guest artists joined in the four concert series by the M.I.T. Chamber Players. The Chapel Thursday Noon Hour Concerts flourished with mostly Baroque music played for large audiences.

Violinist Sandor Vegh visited in November. A concert by the Alban Berg String Quartet was perhaps the outstanding concert of the year by a visiting group, but the Abramowitz Memorial Concert with the Amadeus Quartet had its supporters as did the Tel Aviv Quartet.

The faculty likewise enjoyed individually productive years. Professor David Epstein's book Beyond Orpheus on musical structure was accepted for publication by the M.I.T. Press while he continued his conducting and music Directorship at Lancaster, Pennsylvania. His performances with the M.I.T. Symphony will be released by Vox Records in the fall. Professor John Harbison completed the Koussevitsky Foundation commissioned orchestral work Diotina, and began two other commissioned works, one choral and one orchestral. Professors John Buttrick and Marcus Thompson continued their concertizing here and abroad. Professor Barry Vercoe saw the public opening of the Electronic Studio on which he has been working steadily for the past four years and wrote a new piece for viola and computer-generated sound which Professor Thompson helped him premier at the concert. This coincided with the annual meeting of the American Society of University Composers, cosponsored by M.I.T. and the New England Conservatory. Professor Hallmark was elected chairman of the New England chapter of the American Musicological Society, and continued as tenor soloist for the Boston Camerata. He and Professor Vercoe were awarded Old Dominion grants for 1976-77. Professor Martin Farren had a number of his works played by the Blackearth Percussion Ensemble, and has a book on theoretical practices in progress. Finally, Professor Stephen Erdely was selected to take over the chairmanship of the Music Section on July 1. A native of Hungary, and a recipient of Law and Music degrees in that country, Professor Erdely was a member of the Cleveland Orchestra violin section for 16 years while completing a Doctorate in Ethnomusicology. He has continued to concertize with his wife, Beatrice, a pianist who teaches at the New England Conservatory, and to pursue his work in musical folklore in the Boston area.

In this, my last report as Chairman of the Music Section, I should like to express my appreciation to the President, Chancellor, and Provost for their encouragement and help during what have been four years of vigorous expansion for this Section, in respect to both curriculum development and student demand for contact with music and musicians. And a special thanks, too, to Dean Hanham and Professor Mazlish, who have had the job of finding funds and space for these burgeoning activities. Much remains to be done outside of the Institute to put this program in a proper building, to realize the potentialities of the musical vitality of the M.I.T. community, the students, and the faculty. The pursuit of a new facility with a good hall and proper rehearsal spaces is at the top of our priority list as well as that of M.I.T.'s Arts Advisory Facility Study.

Nevertheless, until this can be realized, we expect the musical impulse to flourish at M.I.T., and it is with confidence that I turn over the direction of this Section to Professor Erdely.

JOHN BUTTRICK

COURSE XXI

The year 1975-76 was a relatively quiet one for Course XXI, which continued under the joint direction of Professors Travis R. Merritt and Louis L. Bucciarelli. Following the untimely death of Susan Beyor in the fall semester, Anne Hunter took over as Course XXI Secretary.

Course XXI enrollment for spring, 1976 showed a slight falling off from the 58 of a year ago to 52 this year, with losses in Literature and Music partially offset by modest gains in Writing and Literature, Anthropology/Archaeology, and History. Embracing as many different disciplines and options as it does, Course XXI suffers in important ways from sparse population in some fields of study. Efforts to increase the number of majors have had to run against the strong current of established M.I.T. admissions policy and widely recognized educational conservatism among today's undergraduates. Nevertheless, there are many able and interested students at the Institute who do not seriously consider the possibility of a Humanities major either because they are only vaguely aware that such programs exist or because they do not receive timely encouragement from members of the teaching faculty. Some effort has been made to identify likely prospects, particularly among the Concentrators in the several fields, but, on the whole, the Humanities faculty has been too passive in this regard.

In at least one case -- that of the full (XXI-B, 2) major in Literature, which underwent a drop from 16 students to 10 -- there may be an inverse relation of quantity to quality. Tightening of specified program requirements (most notably the introduction of chronological distribution guidelines, two special advanced seminars, and a senior thesis) have certainly made it a more formidable undertaking than before, and one less likely to attract late or casual converts. In fact there has been a discernible improvement in the quality and seriousness of academic performance by Course XXI majors, as indicated by testimony from faculty members and by the extraordinarily small number of warnings issued to our students by the Committee on Academic Performance this term.

The most significant trend was the continued decline in popularity of joint programs XXI-A and XXI-B, 1, whose combined enrollment went from 22 to 15 in a year's time. This trend reflects increased competition from other special degree programs now being offered around the Institute, but it also underscores certain weaknesses in XXI-A and XXI-B, 1 themselves. Plans for revising and strengthening these programs, described in an addendum to last year's annual report, were further refined during 1975-76 by Professors Bucciarelli and Merritt, assisted by an advisory committee of interested M.I.T. faculty members from various departments and sections. In view of the organizational and curricular changes taking place within the School of Humanities and Social Science, it was thought best to proceed very deliberately with revisions of the joint programs. Data gathering and educational policy are now at an advanced stage, and it is expected that by early November a firm and detailed proposal will be ready for consideration by the Department and the School.

Organization flux and staffing uncertainties also made it difficult to assess and solidify the relatively new programs in Writing and Literature, American Studies, and Russian Studies. After Professor Sivin's ad hoc committee makes its recommendations on the future status of the Writing Program, and after appropriate administrative actions have been taken, the future of work in this area will be clearer. There have been exploratory discussions toward sharper definition of the American Studies program's core educational experience, but concerted work in this direction must wait until faculty strength is more securely identified, and the degree of commitment to the program convincingly established. Russian Studies remains little more than a paper program, but Professor Krystyna Pomorska has indicated that, with the incorporating of Foreign Languages and Literature into the Department of

Humanities, and with initiatives toward closer working arrangements with Harvard, it should be possible to strengthen the program as a major offering in the near future.

The Humanities Senior Seminar, 21.901, was conducted jointly by Michael Folsom, Assistant Professor of Literature and American Studies, and Louis Bucciarelli, Associate Professor of Engineering and Technology Studies. Focusing on the growth and decay of the New England textile industry, they pursued a multi-perspective inquiry into the history of industrial America. They insisted on an understanding of the engineering that was part of this history, as well as addressing questions about human experience in a manufacturing society. Field trips to the cities of Lowell and Lawrence, to the Merrimack Valley Textile Museum, and to Old Sturbridge Village were an integral part of the seminar, providing an occasion to deal with that part of the historical record of industrial technology (factories, canals, looms) which is not literary.

For the second year, Course XXI administered the I. Austin Kelly III Prize competition to promote serious and sustained scholarly work in the humane disciplines. A panel of four Humanities faculty members judged entries and made awards to three undergraduates.

The Course XXI Society, recently renamed the Humanities Student Association, organized lecture series and a new literary magazine, Mithras. A group of students sent out a brochure describing the Department's offerings to all entering freshmen. In addition, a late spring Open House exhibited the many talents and interests of the Department. This year, in addition to the sherry hours, there was a lecture series funded by the Council for the Arts and arranged by various students from the Department. Among the speakers were poets John Peck and Ned O'Gorman, composers Nichola LeFanu and Tona Scherchen, Homer translator Robert Fitzgerald, and critic Harold Bloom. Buckminster Fuller accepted an invitation to speak, but had to postpone until the fall. Money was given to Elizabeth Sholl to help with her poetry/fiction reading this spring. In spite of all this activity, the leaders of the Association expressed disappointment at the level of student participation and faculty support.

TRAVIS R. MERRITT
LOUIS L. BUCCIARELLI

CAMBRIDGE HUMANITIES SEMINAR

The Cambridge Humanities Seminar is 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, Brandeis University, and Wellesley College, and represents a variety of disciplines. Its central feature is a faculty colloquium that meets on a bi-weekly basis for three hours, with additional meetings scheduled for curricular planning and discussion. The colloquium has two distinct but related tasks: to identify and explore the most fruitful areas for interdisciplinary scholarship, and to design courses which will be taught by members of the Seminar to classes of cross-registered students. The hope has been that courses developed in this way -- i. e., out of the ongoing concerns of an active professional colloquium -- will speak to each other more closely than is usual with interdisciplinary programs.

During 1975-76, the faculty colloquium, through regular presentation of essays and bibliographies, continued the investigation of its general subject: the ways in which art, science, and literature reinterpret works from their past in light of the difference that modern works have made in the conception of each subject. Last year's Progress Report listed five topics that conveyed our lines of inquiry. These concerned modernism in the arts, ideas of progress

in the arts and the sciences, the relation of "internal" to external histories of an intellectual discipline, the effects of secularization on the practise of various intellectual enterprises, and the claim of modern proponents of each discipline to establish universal contexts for considering the history of their subjects.

During the first semester, our subject was the problematic status of the term "modernism" as it applies to various disciplines and activities. In our treatment of modernism in the previous year, we had tended to take various definitions of it for granted as a basis for discussion. Our examination of various texts as well as of the papers submitted by the members of the Seminar elicited problems in the assumptions that underlay the descriptions of modernism. The question about the historical uniqueness of the modern turned into an even more radical questioning of: 1) historical generalizations that embrace more than one national tradition, and 2) the value of historical periodization generally. Structuralism, with its archaeological sense of experience, its belief in irreducible discontinuities separating "historical" periods, was at once a source of fascination and irritation to members of the Seminar. Nietzsche's Use and Abuse of History was a powerful mediating text, critical at once of various modes of historical discourse and yet offering a vitalistic standard for a healthy relation to the past.

This past year, the Seminar was approved in substance and intention by appropriate faculty committees at Boston University, Brandeis, and Wellesley, so that in future years subjects offered by the Seminar will appear in their catalogues of offerings on a regular basis, thus extending the situation that already exists at M.I.T. This past year the Seminar offered three subjects each semester. Two, Ideas of Progress and Problems in Twentieth Century Architecture and Philosophy, were each taught jointly by M.I.T. and Wellesley faculty members. Courses also were offered by Seminar participants at M.I.T. and Boston University, and one member of the Seminar based at Brandeis offered a subject at M.I.T.

As an experiment next year, the Seminar will launch a series of public lectures whose structure is governed by the syllabus of one of its subjects, "Darwinism and Culture."

ALVIN C. KIBEL

Department of Philosophy

In March, the Corporation approved the formation of a Department of Linguistics and Philosophy, effective July 1, 1976. The new department will include the present Department of Philosophy and the Linguistics Group of the present Department of Foreign Literatures and Linguistics. The Corporation's action followed several months of discussion among faculty members and graduate students affected by the change, consideration by the Visiting Committees of the two departments, and presentation of the contemplated change to the faculty of the Institute at its February meeting.

It is understood that existing degree programs will continue in substantially their present forms and that the new department will maintain a heavy commitment to undergraduate teaching over a wide spectrum of subject matters in philosophy. Nevertheless, formation of the new department should not be viewed as merely an organizational change. Over the past decade, student and faculty linguists and philosophers at the Institute have come to recognize areas of common intellectual concern. This is to be attributed in part to the emphasis given in research and teaching to the philosophy of language and the more theoretical aspects of linguistics. But trends within the disciplines are at work also. Philosophers have come to appreciate the relevance of linguistics to issues in philosophy of

language, philosophy of mind, and philosophy of logic; linguists in turn have come to realize the relevance of work in logic and philosophy of language to problems concerning the syntax and semantics of natural languages.

The common concerns of linguists and philosophers overlap at crucial points with those of psychologists. In recognition of this, and in response to considerable student interest, the Department of Linguistics and Philosophy will offer a new undergraduate degree program, Language and Mind, concerning the intersection of philosophy, linguistics, and psychology. The focus of the program will be the nature of language and the mental representation of knowledge. Subjects will cover such topics as the nature and existence of innate knowledge, the nature of meaning, the relation between logical and linguistic form, the psychological reality of linguistic structures, the relation of mind to brain and behavior, interaction between grammatical structure and verbal performance, relations between language and culture, explanatory models in linguistics, and the mechanisms of speech production, acquisition, and comprehension.

There are no firm plans for a new graduate degree program. It is assumed that students wishing to pursue programs involving both philosophy and linguistics can be accommodated within existing provisions of the Graduate School for interdisciplinary degrees. Discussions have begun concerning the possibility of instituting a doctoral program in the cognitive sciences, but it is too early to report on the content of such a program or on the details of its administration.

PUBLICATIONS

The IQ Controversy, an anthology coedited by Professor Ned Block with Professor Gerald Dworkin (formerly of this Department and now of the University of Illinois at Chicago Circle), was published by Random House. It includes Professors Block and Dworkin's essay "IQ, Heritability, and Inequality." Publication of the book was the occasion for an appearance by Professor Block on NBC's "Today" program. Professor George Boolos wrote on the philosophical understanding of second-order logic. He is currently at work on the application of modal logic to proof theory and plans eventually to publish a monograph on the subject. Professor Paul Horwich published two essays on philosophical problems concerning space and time, and has recently undertaken a major research project in confirmation theory. Professor Judith Thomson's book on action has been accepted for publication by Cornell University Press. The book is a prolegomenon to future work she plans to undertake on the nature of human rights.

FACULTY

Professor James Thomson was on leave of absence during the spring term in order to hold a Mills Distinguished Visiting Professorship at the University of California at Berkeley. In order to pursue research, Professors Block and Horwich took one-term leaves of absence without salary. Professor James Kostman will be on leave of absence for the whole of next year. He has been granted an Old Dominion Fellowship for the fall term and will be Visiting Assistant Professor at the University of California at Berkeley during the spring term. Professor Horwich has been granted an Old Dominion Fellowship for the fall term of next year. Professor Judith Thomson will be a Visiting Professor at the University of Pittsburgh during

the fall term next year. Johan Kamp, Lecturer at Bedford College of the University of London, was Visiting Professor during the spring term. He taught subjects in philosophy of language and philosophy of science.

RICHARD L. CARTWRIGHT

Department of Political Science

At both the graduate and undergraduate levels there has been a marked increase this past year in the study of public policies and in academic programs that provide students with opportunities for public service experiences and careers. This trend appears most clearly at the undergraduate level in the expansion of the internship program which provides students in various departments throughout the Institute with opportunities to combine work experience in Federal, state, and local government with academic training; and at the graduate level with the development of new variants of the Master's degree program and research activities with a public policy focus. While this report describes the full range of Departmental activities during the year, special attention has been given to reporting these and other related public policy/public service activities.

Undergraduate Program

During the 1975-76 academic year the Departments of Political Science and Urban Studies and Planning offered a year-long internship in state and local government in which students worked at least eight hours a week during the semester in a public sector job and participated in a bimonthly evening seminar with assigned readings and papers. Forty M.I.T. and Wellesley College students took part in the internship program, which was directed by Professor Alan Altshuler and Professor Martha Weinberg, with participation from Tim Bird of the M.I.T. Chancellor's office, and State Representatives Barney Frank and Mel King. Guest speakers included former Governor Francis Sargent, former Mayor John Collins, the Governor's Chief Secretary David Liederman, and other public officials.

One measure of the success of the program is that 19 students accepted paid positions for the summer with their agencies, four found salaried positions in other state and local agencies, and four others continued in their jobs with the help of UROP funding. By the final session of the course, most students indicated that they were considering spending part of their careers in the public sector.

Another field-oriented undergraduate program was the News Study Group under the direction of Lecturer Edwin Diamond, which examined the primary process, the political conventions, and the role of the media. In January 1976, two student crews videotaped the New Hampshire primary, paying special attention to the interaction between the candidates and the media. Some of their materials were incorporated into two public affairs programs on national public television, the Robert MacNeil Report and Bill Moyers' USA. Their video materials also were used on the M.I.T. cable system and in Political Science classes. Since this work-study experience, three students have taken jobs with television stations. Several students continued their video work this summer covering the political conventions as part of the News Study Group.

A retrospective look at politics in Boston from 1915 to 1940, "The Age of Machine Politics," attracted attention during the Independent Activities Period in January. Directed by Professor Martha Weinberg, the series focused on the Boston of Mayor James Michael Curley and included a lecture by the Honorable Kevin H. White entitled "Where are the James Michael Curleys of Today?" The six programs of lectures and films, sponsored jointly by the Department of Political Science and Urban Studies and Planning, attracted standing room only audiences in a large campus lecture hall, and were features in Time Magazine.

Mention should be made of the joint program launched this year with the Department of Political Science at Wellesley College. In an effort to strengthen the M. I. T. -Wellesley exchange program and to expand the offerings of both departments, each offered two subjects on a rotating basis each week on the two campuses. Wellesley dealt with constitutional law, and American interest group politics, and M. I. T. discussed black politics in urban America, and South Asian politics.

Undergraduate enrollment increased by 60 percent over the previous year to 120. The Undergraduate Program Committee, led by Professor Jeffrey Pressman, has been at work to develop plans for a new undergraduate variant of the political science major focusing on the study of public policy. The Department tentatively plans to initiate the new program in the 1977-78 academic year.

Graduate Program

The Department has decided to expand its offerings for the Master's degree in the fields of arms control and defense analysis and in science and public policy. A number of students have been admitted in these fields for the 1976-77 academic year. A central objective of this program will be to apply research and training on public policies leading toward public service careers.

The Department is gratified by the continued success of its graduate students in soliciting financial support from outside the Institute. Among the awards received by graduate students in 1975-76 were grants from the Consortium for World Order Studies, the Ford Foundation, Fulbright, Canada Council, the American Political Science Association, the National Science Foundation, the Foreign Area Fellowship Program, the National Institute of Mental Health, the Marshall Fund, the Rockefeller Foundation, and from the governments of Malaysia, Saudi Arabia, Mexico, and Canada.

Departmental funding for students remains a problem, but with a small increase in the number of teaching assistants as a result of the expansion of the undergraduate program, and with an increase in research assistantships, there was a slight relief for the graduate students this past year. Nonetheless, the need continues to be substantially greater than the resources available. The Department faces the difficult problem of equitable allocation of its own funds between entering students who are not ordinarily eligible for teaching assistantships and most research assistantships, and students who have completed a year of graduate studies but are not yet in a position to seek outside support for doctoral thesis research.

Under the direction of Professor Ted Greenwood, the Department undertook a self-evaluation of its efforts to increase opportunities for minority students in the graduate program. Although two minority students completed the Doctorate this past year, the completion rate among minorities remains substantially below that of other students in the Department. The Department agreed to take a closer look at its admission criteria for minorities, to provide research assistantships rather than fellowship aid whenever possible, to strengthen the

faculty guidance program, and to encourage all students, not only minorities, who have completed their general examinations to acquire Master's degrees in the event that they are unable to complete the Doctoral thesis.

In spite of the stringent job market, students completing the Doctoral degree continue to find academic and non-academic positions and postdoctoral awards.

Publications

In honor of Professor Harold Isaacs, who retired from M.I.T. this year, several members of the Department prepared a Festschrift entitled The Mixing of Peoples: Identity and Ethnicity. The volume, edited by Professor Robert Rotberg, contains contributions from Professors Rotberg, Ithiel Pool, Lucian Pye, and Myron Weiner, as well as from several long-time friends outside of M.I.T.

Comparative analyses and studies of politics in the developing countries and within Europe were the thrust of Professor Pye's psychological study, Mao Tse-tung: The Man in the Leader; a volume of essays coedited by Professor Pye in honor of Professor Gabriel Almond of Stanford University, The Citizen and Politics: A Comparative Perspective (which contains papers by Professors Pye and Weiner); two volumes coauthored and edited by Professor Rotberg, The Black Homelands of South Africa, and The African Diaspora; Professor Weiner's Electoral Politics in the Indian States: Party Systems and Cleavages; two monographs by Professor Willard Johnson in the Business Management for Economic Development Project series published by the Center for International Studies; and a monograph by Professor Wayne Cornelius for the Social Development Division of the United Nations, The Role of Citizens in Improving the Quality of Life in Low-Income Urban Settlements. In press is a volume edited and coauthored by Professor Cornelius, Metropolitan Problems and Governmental Response in Latin America.

The Migration and Development Study Group, which includes Professors Nazli Choucri, Cornelius, and Weiner, initiated a monograph and working paper series under the general editorship of Professor Weiner. Four papers by him and two by Professor Cornelius have already appeared, and one by Professor Choucri is in press. The series also includes four monographs by present and former students of the Department.

Studies prepared by three faculty members for the Rockefeller Commission on Critical Choices for Americans are now in press. Professor Suzanne Berger's "France: the Dilemmas of Alliance" and "Italy: On the Brink or on the Verge," will appear in The United States and Western Europe, edited by David Landes. Professor Weiner's study of South Asia is to appear in Southern Asia: The Politics of Poverty and Peace. Professor William Griffith edited another volume for the Commission, The Soviet Empire: Expansion and Detente. Professor Donald Blackmer is coeditor and contributor to Communism in Italy and France.

In the field of American politics and policies, Professor Jeffrey Pressman authored Federal Programs and City Politics and coauthored Exploration in Convention Decision Making: The Democratic Party in the 1970s. Edwin Diamond's widely-reviewed The Tin Kazoo: Television, Politics and the News appeared this year. The first books of three junior faculty members have been accepted for publication: Professor Weinberg's study of Massachusetts government, Managing the State; Professor Lorenzo Morris's The Invisible Politics: Culture and Political Participation in Black and White America; and Professor Langdon Winner's Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought.

Professor Altshuler has in press a second edition of his edited volume, The Politics of the Federal Bureaucracy, and he helped complete a book-length report for the US Department of Transportation which he plans to revise and expand for publication.

Also in press are two volumes coauthored and coedited by Professor Michael Lipsky, Theoretical Perspectives on Urban Politics and Riot Commission Politics: the Processing of Racial Crisis in America. Professor Lloyd Etheredge's The Case of the Unreturned Cafeteria Trays: Psychological Theory and Public Policy, is to be published shortly by the American Political Science Association in a new series of monographs for undergraduate instruction. Professor Walter Dean Burnham published a number of articles on parties and elections in America, Professor Ithiel Pool on communications policies, Professor Eugene Skolnikoff on US science policy, and Professor Harvey Sapolsky on health policy.

In the field of energy policy, Professor Choucri coauthored International Politics of Energy Interdependence: The Case of Petroleum, and Professor Greenwood wrote two papers, "International Issues in Energy R & D Policy" and "Canada's Quest for Energy Autarky." Other studies on international politics and American foreign policy included Professor Greenwood's Making the MIRV: A Study of Defense Decision Making; Professor George Rathjens' Arms, Defense Policy and Arms Control, which he coedited; and Professor Lincoln Bloomfield's The US, Interdependence and World Order.

RESEARCH AND TEACHING

One consequence of a number of research activities has been the establishment of several year-long faculty-graduate student seminars and workshops. Part of Professor Pool's Research Program on Communications Policy, was a faculty-student seminar. Similarly, Professor Weiner, as director of the Migration and Development Study Group, organized a fortnightly seminar with a dozen guest speakers from American and European universities. Professors Winner and Miles Morgan set up a colloquium on research ethics in the social sciences.

Interdepartmental and interdisciplinary research and teaching involved many members of the Department. Professors Weinberg and Greenwood worked with the new Master's degree program in the School of Engineering on Technology and Policy. Professors Skolnikoff and Weiner served on the advisory board of the International Nutrition Planning Program. Professor Weiner is director of a new research program on Migration and Development, which was inaugurated this year with a grant from the National Institute of Child Health and Human Development, and involved members of the Department of Economics and the Boston University African Studies Program. Professor Sapolsky was involved in several interdisciplinary health policy activities including the Health Systems Study Group organized by the Harvard-M.I.T. Program in Health Sciences and Technology and the Health Management Program in the Sloan School. Professors Choucri and Rathjens participated in the Technology Adaptation Program at M.I.T. Professor Pool chaired the M.I.T. Cable Policy Board, of which Edwin Diamond was a member. Professor Altshuler chaired the M.I.T. Advisory Committee on the Secondary Technical Education Project involved in the development of a magnet school in East Boston. Professor Douglas Hibbs, under a grant from the National Science Foundation, engaged in a comparative study of the political economy of macroeconomic policy. Professor William Kaufmann participated in the work of the Center for Advanced Engineering Study where he taught a course on the Federal budget. Professor Weiner headed an Institute Task Force to review Institute procedures and policies concerning the use of human subjects in social science research, a task force whose members included Professor Pool

and Dr. Menand. Professor Altshuler was the principal investigator in a multidepartmental, multidisciplinary research project entitled "New Perspectives in Urban Transportation," funded by the US Department of Transportation; and Professor Pye, in his capacity as President of the M.I.T. Faculty Club, participated in the most interdepartmental program at M.I.T.!

Much research was conducted with the cooperation and often under the aegis of the Center for International Studies which assisted in raising research funds and in the administration of many projects.

The Department also maintained close links with the new program in Technology Studies, with Professor Winner serving in his dual capacity as assistant professor in both departments. This year Professor Joel Yellin in Technology Studies was a Lecturer in the Department of Political Science and he joined with Professor Skolnikoff to teach the new undergraduate subject Value, Choice and Risk in Modern Technology, which explored social effects of 20th century technology. A similar arrangement was established with the International Nutrition Program. Dr. John Field from the I.N.P. staff taught a Political Science subject focusing on nutrition problems and planning in India.

Other new or substantially revised subjects included an undergraduate subject on the Social Impact of New Communications Technologies taught by Professor Pool, Comparative Politics of Latin America: Public Policy and Rural Underdevelopment (a graduate subject taught by Professor Cornelius), an undergraduate subject on Arms Control and a graduate seminar on the domestic and international politics of energy taught by Professor Greenwood, and a combined undergraduate and graduate subject on the evolution of American politics by Professor Burnham.

FACULTY

Public Service and Professional Activities

Members of the Department continued to be called upon for a wide variety of public service activities involving both foreign and domestic affairs.

Professor Kaufmann served as a consultant to the Department of Defense, Professor Weiner as a consultant to the World Bank and to the Department of State, Professor Pye as Vice President of the National Committee on US/China Relations and chairman of the Study Group on China for the Council on Foreign Relations, Professor Willard Johnson as an advisor to the African Development Bank, and Professor Greenwood as a member of the Working Group on Nuclear Weapons and other Weapons of Mass Destruction of the Council on Foreign Relations. Professor Pool worked with the National Academy of Sciences on the World Food and Nutrition Study project, Professor Harvey Sapolsky served as a consultant to the National Academy of Sciences and to the Office of Naval Research, and Professor Rotberg consulted with the Department of State.

In the area of domestic affairs, Professor Altshuler served as chairman of the US Federal Energy Administration Transportation Advisory Committee, Professor Weinberg as a member of the Governor's Management Task Force and the Massachusetts Rate Setting Commission Advisory Board. Professor Rathjens was chairman of the controversial

Governor's Commission on Nuclear Safety and was a member of the Ford Foundation's Nuclear Energy Policy Study, and Professor Greenwood was a consultant to the US Congress Office of Technology Assessment. Professor Pool, under a grant from the Sloan and Markle Foundations, prepared a study of the internal educational needs of the Federal Communications Commission, and Professor Rotberg continued as an elected member of the Lexington School Committee.

The involvement by members of the Department in professional activities included the following:

Professor Cornelius was appointed Program Chairman of the 1977 joint national meeting of the Latin American and African Studies Associations; Professor Blackmer was elected to the Steering Committee of the Council for European Studies; Professor Berger was elected Chairman of the Social Science Research Council-American Council of Learned Societies Committee on Western Europe; Professor Rathjens was chairman of the fund for the Federation of American Scientists; Professor Pye was a member of the Social Science Award Selection Committee of the American Academy of Arts and Sciences; Professor Rotberg was elected a member of the Nominating Committee of the American Historical Association; and Professor Bloomfield was Chairman of the political subpanel on US-Soviet Collective Security for the United Nations Association of the USA.

Honors, Promotions

The Department honored Professor Harold Isaacs at a dinner in May on the occasion of his retirement from M.I.T. Professor Isaacs came to M.I.T. in 1953 as a senior research associate in the Center for International Studies, then subsequently became a Lecturer and Professor (in 1965) in the Department of Political Science. As a journalist and scholar, Professor Isaacs has written widely on world politics and on racial and ethnic identities.

Professor Cornelius received an award from the Graduate School Council for excellence in graduate teaching. Professor Kaufmann was awarded the Department of Defense Distinguished Public Service Medal, and received a letter of commendation from President Gerald R. Ford. Professor Altshuler was elected to the National Academy of Public Administration, and Professor Pye to the American Philosophical Society.

Professor Burnham was asked to spend a year at the Institute for Advanced Study in Princeton; Professor Hibbs was invited to spend a year at the Center for Advanced Study in the Behavioral Sciences at Stanford.

Members of the Department have received a variety of awards and grants this year from the Ford Foundation, the Markle Foundation, the Sloan Foundation, the Hazen Foundation, the Rockefeller Foundation, and the National Science Foundation.

The new faculty members joined the Department this past year as Assistant Professors. Professor Etheredge, a specialist in political psychology and behavior with a doctorate from Yale University, came from the University of Manitoba. Professor Weinberg, a specialist in urban and state politics, joined the Department after completing her doctorate at Harvard University. Professor Charles Langford Jones, a specialist in political analysis, concepts and methods, joined the Department for a year as a replacement for Professor Hayward Alker who has been on leave as a Visiting Professor at the University of Geneva, and for Professor Hibbs who has been on research leave. Professor Jones came to M.I.T. from Edinburgh University in Scotland. Professors Michael Lipsky, Willard Johnson, and Harvey Sapolsky also have been on research leave this past year.

Professors Cornelius and Pressman were granted tenure, Professors Cornelius and Hibbs were promoted to the rank of associate professor, and Edwin Diamond was promoted to senior lecturer. Professor Berger began her term as associate chairman of the faculty.

MYRON WEINER

Department of Psychology

With the summer of 1976, the Department of Psychology will reach early or middle adolescence. The Department is 12 years old, if one counts from the official founding date in 1964, or 15, if one goes back to the reorganization of what was then a Section on Psychology in the Department of Economics. Whatever the precise age, adolescence should be a time for self-scrutiny and for trying out new roles; it is a time of potential strains and of nearly limitless possibilities.

As one looks back upon the beginnings, it is clear that the Department has defined itself from the outset by a number of crucial choices: not to be too large, to concentrate on postdoctoral and graduate training, and to define its field in a deliberately unorthodox manner, by working in only three increasingly overlapping areas: 1) the study of relationships between brain and behavior; 2) the study of perception and perceptual-motor learning; and 3) the inquiry into human language and logic and into the early development of the child's intellect. These topics were chosen in order to focus on those regions of behavioral and neural science where one could confidently expect discoveries.

Concern with the three pivotal areas has meant that the Department had to assemble, under a single roof, a thoroughly unconventional combination of specialists: representatives of brain anatomy and nerve-cell physiology joined with those studying the behavior that the nervous system sustains, from the capacities involved in adult pattern vision or complex motor control to the riddles of human memory, and to the infant's perception of lines and of faces, and his earliest reactions to the sounds of speech.

But regardless of its successes, the Department pays its price for being different. Though it is fiercely selective in its choice of topics, the areas actually chosen require such a wide range of specializations that faculty and graduate students have to be forever vigilant in order to encompass all of it. Fortunately, the membranes between adjacent laboratories have hardly stiffened with advancing age, and new combinations of efforts, such as the recently launched program of research on "plasticity" of the central nervous system in relation to behavior, have added to the integrative functions of the Department as a whole. During the past year, these activities across component laboratories found a further (and quite spontaneous) expression in a year-long series of departmental research meetings held on Monday noons, in which work of Department members from all three areas of the departmental program was informally discussed.

As the group enters upon its thirteenth year, its major hazards are certainly not to be found in questions about the continuity of aims: the group as a whole wants to find out, by its diverse methods, what goes on within ourselves when we perceive, move, feel or express emotion or learn and remember -- a tall order that should keep the departmental faculty and students employed throughout the second decade of the group's history and well beyond. Given such a mandate, the group must resist any temptation to sacrifice the uniqueness

derived from its own internal diversity. As opposed to the more standard format of psychology at many universities, the Department approaches neuroscience virtually without concern with behavior, and attempts analyzing behavior (as in much of current work, elsewhere, in cognitive studies), without recourse to experimental science. Neither of these approaches could be adopted without abandoning what has been gained.

The remaining strains (and opportunities) are equally apparent: they all relate in one form or other to the question of size of the group and of its available facilities. To be sure, the group is too small for its range of commitments, both in teaching and research. Should one decrease the commitments, or increase the group? Much of the following argument supports increasing the group sparingly, since its unity and productivity depend so much on the convergent use of dissimilar methods. A closely connected question is whether there should be a more formal undergraduate program. Should such a new "major" or "majors" become a vehicle for the ongoing doctoral training, which is in jeopardy as graduate training grants are phased out across the country, and across fields? These outstanding matters will be taken up after a review of last year's research and teaching programs.

RESEARCH

The Department of Psychology is known for its work on brain circuitry and for its recent discoveries of heretofore unsuspected capacities for plastic change in the living structure of the brain. The Department is equally known for powerful analyses of human visual perception and skilled movement, from their earliest development in the infant to their persistence in stressful environments in the adult, as when in flight or in outer space.

Such studies are now complemented by experimental disclosures about single nerve cell activity within the brain during acts of sight or of touch, and by corresponding findings about such single-unit activity in the course of deliberate coordinated movements of the body. Similar efforts are directed at discovering basic forms of change in the brain during learning, and some of these efforts use the uncanny ability of certain animals to acquire distinctions between odors, quite early in their lives.

Another group within the Department studies human performance after brain damage, in children and adults. The goals are to discover subtle aftereffects of brain injuries, to detect altered behavior early in brain disease, and also to look for clues as to how the affected regions of the brain function in the normal state. In this way, studies of breakdown of language and perception in the brain-injured adult or child are complementary to fundamental inquiries by other Department groups who concentrate on questions of how we acquire language, or manage to produce and understand sentences, or of how normal children structure their thoughts or learn how to know one face from among thousands of faces.

During the past academic year, Department members produced a total of 125 articles, chapters, and monographs.

TEACHING

The coherent if unconventional view of the field that emerges from the departmental research program continues to be reflected in the Department's teaching. On graduate and under-

graduate levels, the three subfields are taught with two sets of integrating subjects as preludes: the large introductory subject for undergraduates (9.00 or 9.61, which continues to attract more students than any other elective subject at the Institute), and the small but intensive first-year "Proseminar" for all graduate students (now renumbered as 9.901 and 9.902) which must be tackled by every doctoral candidate regardless of subsequent specialization.

The large introductory subject was cancelled for the fall term to permit resolution of uncertainties about its role as an elective, a question happily resolved in time to permit resumption of the subject in the spring. The increase in undergraduate enrollment from 253 in the fall term to 642 in the spring term shows the effect of the subject's reinstatement. During the year, 16 undergraduate subjects were taught to 895 students.

There were 81 and 156 graduate students enrolled, in fall and spring, respectively, for a total of 237 in all of the 20 graduate subjects for the academic year. Overall enrollment thus came to 1,132, a figure that is bound to return to its more typical level of 1,400 or 1,500 next year, when the undergraduate introductory subject will be taught under its original designation (9.00) in the fall term, and in a more advanced version (under a new number, 9.001) in the spring. The number of undergraduate concentrators in psychology (i. e., those students taking three psychology subjects as their social science concentration) among the graduating seniors this year reached 240.

As in previous years, the regular subject offerings and laboratory activities were supplemented by a colloquium series, which drew attendance from many institutions in the greater Boston area and beyond. Twenty-one of the 64 colloquium speakers came from outside the United States.

FACULTY

In spite of an unusually large number of visiting lecturers, the departmental staff again gave over twice as much in return, since they presented 151 lectures or invited papers at other universities, at national meetings, and at 17 international conferences. The small departmental staff was also involved in 28 different Institute committees, ad hoc groups, and interdepartmental liaison functions. As these figures indicate, many Department members assumed several such obligations during the year.

In January, Professor Richard Held organized two special all-day conferences: a meeting on early visual development attended by representatives of seven US and Canadian laboratories; and the fourth annual Conference on Vision, Art and Science, which was cosponsored by M. I. T.'s Council for the Arts. The Independent Activities Period, which included an intensive microscopy workshop, a week long session on a new computer approach (ALICE) to the rapid analysis of multidimensional data in behavioral research, and a three-week review course in electronics as applied to the biobehavioral sciences. Similarly, Professor Ann Graybiel arranged and hosted a poster exhibit on the neurosciences at M. I. T. in March 1976, within the framework of the Boston Area Neurobiology Group, and both she and Professor Hans-Lukas Teuber addressed the Institute's alumni in September 1975.

Honors and Awards

Special honors and awards can only be listed at the risk of seeming capriciously selective. Professor Emilio Bizzi was elected a member of the Barany Society, and Professor Susan Carey was given a special Radcliffe Institute Fellowship for young women faculty in the Boston area; Professor Stephan Chorover was chosen as one of the trustees of Franconia College in New Hampshire, and Professor Graybiel was elected a counselor of the Society for Neuroscience. Professor Held was appointed to the Publications Board of the National Academy of Sciences and elected to the Executive Committee of the International Neuropsychology Symposium, while continuing to serve on the Board of Directors of the Foundations Fund for Research in Psychiatry. Institute Professor Walle Nauta received the Merit Award from the Association for Research in Nervous and Mental Disease and served as the Messenger Lecturer at Cornell University. He gave the Salmon Lecture to the New York Academy of Medicine and was the Annual Rockefeller University Lecturer in New York City. He also participated in the deliberations of the Neurosciences Interdisciplinary Cluster of the President's Committee on Biomedical Research. Professor Mary Potter served as Distinguished Lecturer to the Psychology Department of the University of Richmond, and the Department Head, Professor Teuber, became the First Harpuder Memorial Lecturer of the New York Academy of Medicine. He also served as Distinguished Visiting Lecturer in Neurology at Johns Hopkins University, gave the keynote address at the Winter Conference on Brain Mechanisms in Colorado, and, in late spring, 1976, received the James R. Killian Award from M.I.T. He was elected to the National Institute of Medicine, and served on the Communicative Sciences Cluster of the President's Committee on Biomedical Research.

SPECIAL ISSUES

As was pointed out earlier in this report, the year 1975-76 saw continuing discussions of several overlapping questions, from the general issues of graduate student funding and a possible undergraduate major, to the clearly related issues of Department size and interactions with neighboring departments and research centers at the Institute. The main patterns of the doctoral program are clearly defined, and it progressed during the year under review without serious difficulties. It is the future funding of this part of the program that remains an area of recurrent concern. Although the overall funding of the Department's research laboratories has been gratifying, the pattern of support benefits the younger graduate student only to a rather limited and indirect extent. Some additional help has been received for major portions of the research program through the generosity of the Spencer Foundation, which made a continuation grant of \$200,000 for departmental inquiries into brain mechanisms underlying perception and learning and into the early development of such mechanisms. Yet this welcome award, like most of the other departmental resources, is primarily destined for support of research rather than training.

For the support of most doctoral students, the Department continues to rely on a departmental training grant, which enters into its last year in 1976-77. Thus, new resources for advanced training must soon be discovered to guarantee a smooth continuation of the small but effective and highly specialized graduate training that the Department provides. As part of a pending bid for support, the Department reviewed the present placement of the 50 Ph.D. s it has sent out into the world in the past 11 years. The picture is clear. With possibly two exceptions, all are active in research or teaching posts at other universities, or in government or industry, and a good number already have begun to repay society for the training

they received at M.I.T. with their own discoveries. There are no indications that recent graduates of this unorthodox Department are in any less demand than their predecessors.

At present, the problem of future graduate program funding is unsolved, and it is unclear whether the solution, which is not at all specific to this Department, will come from the outside, or will have to come from within. An external solution would be a nationwide reinstatement of Federal training programs for doctoral students. An internal solution might be to place increasing numbers of graduate students on teaching and research assistantships, a measure that had been neither necessary nor feasible for the Department in the past.

An Undergraduate Major?

A further and obviously related question for the Department concerns the possible expansion of its role in undergraduate education. To date, the Department has confined itself to post-doctoral and doctoral training, and has taught its many undergraduate students for all these years without offering a "major." Should the Department move toward such a major now? That would require, first, a decision about how the major should be approached. It could be built up from within the departmental faculty, which would require at least three additional members, as well as expansion and equipping of laboratory space. Alternatively, an undergraduate major could evolve out of collaborative arrangements with other departmental faculties and centers, but problems of space and additional staff would still be sizable. Pressures for such an undergraduate major have grown. As we have noted, 240 graduating seniors this year chose psychology as their field of concentration to satisfy the Institute's humanities and social science requirement.

Developments in Linguistics and "Cognitive Science"

In this context, it may be well to reflect on a recent development within the School of Humanities and Social Sciences: by the end of the year under review, the Department of Philosophy has been merged with the Linguistics Section of the former Department of Foreign Literatures and Linguistics; those faculty members primarily concerned with foreign literatures have, in turn, entered the Department of Humanities. The Psychology Department welcomes the marriage of the Department of Philosophy and the linguistics section of the former Department of Foreign Literatures and Linguistics, for it brings together two units obviously compatible with one another. However, the Psychology Department is puzzled as to how it should receive the anticipated offspring of that union, for the newly formed Department of Linguistics and Philosophy proposes to offer an undergraduate major entitled "Language and Mind" and a new graduate (doctoral) program in "Cognitive Science." Both topics are obviously continuous, if not almost identical, with the work of the Psychology Department's third section, which deals with psycholinguistics, cognition, and cognitive development. Either of two outcomes are foreseen: first, an increasing symbiosis of the relevant portions of the Psychology Department with the proposed teaching and research programs, on both undergraduate and graduate levels, in the newly created Department of Linguistics and Philosophy, or, less happily, an increasing pull upon the third section of the Psychology Department away from the experimental core of the field.

Should such a loss of empirical content and method occur, it would weaken the new programs and would raise the specter of a development akin to that at Harvard, where Psychology split, over two decades ago into two different departments, one experimental in orientation, the other concerned with personality and social issues. Most observers (including most members of the two resulting Harvard groups) now agreed that this split occurred to the detriment of both fragments, which have now recombined, with some anguish to both areas.

Certainly, from the standpoint of a unitary and sufficiently rich set of offerings in Psychology at M.I.T., the time has come to make a concerted effort toward a genuine undergraduate curriculum that is firmly based on empirical and experimental methods, but does not slight the theoretical resources to be found in M.I.T. Linguistics and other communications sciences Much depends for all of the fields concerned, upon how these issues are resolved over the next few years.

Departmental Size

Regardless of any contemplated changes in the format of departmental undergraduate teaching, the Psychology Department is simply too small. Since the late 1960s, the Department has not increased in size, though its commitments to research and training have grown steadily. It has only 12 full-time professorial members on its faculty, two faculty members shared with other departments, and a fluctuating number of research associates, who often function as additional lecturers and supervisors of students though they are not carried on teaching funds. Despite its extremely small size, the Department maintains research support through more than two dozen different programs, projects, and contracts for investigative activities funded at a level exceeding \$1.67 million in the coming academic year. Together with the Institute portion of this departmental budget (a contribution that has remained essentially the same over the last three years), the total departmental budget in 1975-76 fell just short of \$2 million and will rise beyond this figure, for the first time in the Department's history, in 1976-77. If one adds commitments implied in such research activities (which make the Department more like an interdepartmental laboratory than many other academic structures around the Institute), together with the work load resulting from student enrollments of well over 1,000 and from service on Institute committees, the overload weighing on the small faculty becomes apparent.

Visiting Faculty and Research Staff

This obvious overcommitment was partly mitigated by outside help. As in previous years, the Department welcomed numerous visitors who participated less formally in instructional activities within the Department, while acting primarily as visiting associates in research. This year's visitors included Dr. Marie-Claude Hepp-Reymond from the Brain Research Institute of the University of Zurich, Dr. Gil Assal from the University Hospital in Lausanne, and the following research associates, postdoctoral students or guests who contributed to the work of various departmental laboratories: Drs. John Allum and Vincenzo Tagliasco in Professor Bizzi's laboratory; Drs. Miles Herkenham and Juarez Ricardo, as well as Dr. Patricia Goldman (from the National Institute of Mental Health) in Professor Nauta's neuroanatomy section; Dr. Jane Gwiazda in Professor Held's laboratory; Dr. Joseph Malpeli, for a second year, in Professor Peter Schiller's laboratory. Drs. Barbara Klein and Ann Cutler in Professors Jerry Fodor's and Merrill Garrett's section. Dr. Joseph Eichenbaum spent a year in Professor Chorover's laboratory, and Dr. Susan Udin her first full year in Professor Gerald Schneider's unit. Professor Potter sponsored Dr. Judith Kroll during her first postdoctoral year.

As in the past, a number of visiting faculty and visiting investigators added to the diversity of our offerings: during the fall term, Professor Charles Gordon Gross from Princeton acted as Visiting Professor, and participated in the proseminar and other teaching activities related to studies of brain and behavior. For the entire year, Dr. Kenneth Forster from Melbourne (Monash University) was a visitor to the Department, acting as research associate in psycholinguistics in the fall term and assuming a visiting faculty role in the spring when he taught the undergraduate subject in learning (9.40).

Also in the spring. Smadar Eshel from Harvard taught the social psychology subject (9.70), instead of Professor Potter who had asked to be relieved of teaching duties, and to have her appointment changed to that of a research associate, for the time being, beginning in January 1976.

Special Interdepartmental Activities

The Department also participated in the administration of the new Course XXV, with Professor Schneider acting as the Department's liaison member, and cooperated through intensive teaching with the joint Harvard-M.I.T. Program in Health Sciences and Technology (particularly by offering the Introduction to the Neural Sciences in the H.S.T. sequence, under Institute Professor Nauta, aided by Professors Bizzi and Graybiel). Similarly, there was continued cooperation in research and teaching with colleagues in the Department of Aeronautics and Astronautics (Professors Bizzi and Held collaborating with Professor Larry Young), and continued interchanges between the Department and the Research Laboratory of Electronics, especially through joint work in experimental phonetics by the Department's psycholinguistics group and the investigators under Professors Kenneth Stevens, Dennis Klatt, and William Huggins, at the R.L.E. There have been new joint activities, particularly in the form of shared student supervision, with Professor Lettvin in Biology. M.I.T.'s Clinical Research Center has provided bed space for brain lesion patients under study by Professor Teuber's group. Also significant was the interaction between the Psychology Department and M.I.T.'s Division for Study and Research in Education, which included a sharing of Professor Carey (who had a quarter appointment in D.S.R.E.), and the joint sponsoring of an additional visiting professor, Professor Hermina Sinclair DeZwart from the University of Geneva, for six weeks in early fall, 1975.

This outreach to other activities around the Institute is worth preserving but adds so much to the heavy burden carried by individual Department members that an increase in their numbers seems necessary in spite of the general constraints imposed on the Institute's growth at the present time. In this respect, the Department clamors for a suspension of any overall standstill rule, for those most responsible for maintaining the support of all the multifarious activities of this Department have now reached a state not unlike that of certain sea bottom creatures that have lived so long under the pressures of the deep that they would simply explode if hauled abruptly to the surface.

Since no one likes diagnosis without remedy, it should be said that these incessant strains would all be alleviated by the long overdue addition of one senior and two junior faculty members, who could share the present burdens, and look after developments in the undergraduate fields. There is no question that the present Department is too small, for growth should not stop with the middle teens.

HANS-LUKAS TEUBER

Sloan School of Management

The Sloan School is committed to improve the quality of management practice through responsible education, high quality research, and professional intervention.

Undergraduate Program

The number of students enrolled in the undergraduate degree program remained at about 120, while students majoring in science, engineering, and other courses, continued to elect management subjects.

Now in its second year, the Undergraduate Student Advisory Council focused on issues of placement and admission to the graduate program in management. Reports dealing with these subjects will be distributed to degree candidates in the fall to help their further career planning.

To provide orientation for students entering the program, the first of a series of luncheons was held for Course XV sophomores in the spring. Dean William F. Pounds and faculty members discussed curriculum and career opportunities with the new students. The School plans to continue such orientation programs on an annual basis.

Professor Peter Chen was coordinator for the Sloan School in M. I. T. 's Undergraduate Research Opportunities Program. Stanley M. Jacks and Esther Merrill again served respectively as chairman and program coordinator of the undergraduate program. They and our Undergraduate Program Committee members and counselors, Professors Chen, Thomas J. Allen, Roy E. Marsten, Jeffrey A. Meldman, and James M. Lyneis, continued to review the undergraduate program and to give individual counseling to undergraduates.

Graduate Program

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 1976 graduate class of 27 and 103 respectively, approximately the same numbers as in preceding years. Experiences with both programs continues to be good. The accelerated program meets a market need felt by mature students, and is the only program of its kind at a leading business school. Although demand is now more than adequate, increased visibility could result in a substantially higher demand, allowing us to expand the size of the program with no loss in quality. This move would, of course, require adequate facilities for both teaching and ancillary needs. Such space is lacking at the moment but there is confidence that the future size and development of this program, coupled with modification in the scale of some other current program offerings, would warrant investment in the required physical plant. The two year program affords more time for elective subjects and greater flexibility in scheduling.

Any modifications that may be made in these programs are designed to build upon a fundamentally healthy situation. A widely publicized survey places the School third (up from

fifth last year) on the dimension of "academic quality," thus ranking the School ahead of Harvard, but behind Chicago and Stanford, for the first time. If the School is to maintain its position as a top quality institution, it must continue to lead in program development and enrichment.

Applications for the master's programs reached an all-time high of 935, an increase over the prior year of 39 percent in domestic applicants and a decrease of 40 percent in foreign. The number of applications from women, 163, remained about the same, approximately 17 percent of all received. In contrast, the School experienced a growth of about 17 percent in the number of minority applicants (63). The previously increased efforts to recruit more minority and women applicants have helped achieve this advance and the School will continue to recruit.

The following data are descriptive of the Classes of 1976 and 1977, including entrants to the two-year program (TYP) in September of 1974 and 1975 and to the 12-month program (AGP) in June 1975 and 1976.

<u>Characteristic</u>	<u>AGP</u>		<u>TYP</u>	
	<u>1977</u>	<u>1976</u>	<u>1977</u>	<u>1976</u>
Sex: Female/Male	5/31	7/22	32/78	22/66
Age: Median/Range	27/22-39	28/23-34	23/20-44	24/19-46
Married/Single	18/18	19/10	27/84	29/59
% With Full-Time Work				
Experience	100%	100%	55%	58%
From: Countries/States	4/11	5/9	12/22	19/16
Mean Undergraduate Grade				
Point Average*	4.1	3.9	4.3	4.3
Median Admission Test				
Score**	628	655	613	607
Foreign/Minority	5/1	5/0	25/4	27/4

* On 5.0 scale (excluding some foreign students).

** National average is approximately 460.

Preliminary placement data on the Class of 1976 indicate an increase in average starting salary for Master's candidates of about 7 percent, from a mean salary of \$19,100 in 1975 to an estimated \$20,500 for 1976, the highest starting salary of all the major business schools. Financial institutions, particularly the commercial banks, and consulting firms continued to recruit aggressively, and there was a 15 percent increase in the number of organizations recruiting on campus. Many manufacturing firms came late in the season and, having been out of the job market for the last year or two, were less prepared to meet the increase in starting salaries that had taken place during that period.

Professor Michael S. Scott Morton, in his new appointment as Associate Dean, has assumed as his principal administrative responsibility the management of the Master's programs. Miriam Sherburne continued to serve as Program Coordinator and Harriet Schwartz as Program Secretary.

The purpose of the Sloan School's doctoral program is to prepare students for careers in either teaching or research, or for non-academic positions requiring advanced research and analytical capabilities. Strong demand for program graduates continues with most Ph. D. recipients accepting positions either with universities or with research organizations.

The program continues to attract a large number of excellent applicants from the United States and abroad. This year 26 people were accepted from a pool of 187 applicants, and 15 men and one woman entered the program. Four specialized in Management Science, one in Operations Research, three in Finance, one in Organization Studies, four in System Dynamics, and three in International Management.

As in 1974-75, the program's chief difficulty was lack of financial support as students were caught between rising costs and dwindling resources. It seems that the students' primary goal has shifted from making progress in the program to finding dollars to pay tuition, fees, and living expenses. Competition among the top business schools for the best applicants is extremely vigorous, so if the program is to attract high quality candidates, the School will have to develop new sources of support for doctoral students.

Professor Allen continued as Doctoral Program Committee chairman and Jane Browning has rejoined the School in a new post as coordinator of the program.

Alfred P. Sloan Fellows Program

Fifty-two members of the 38th Class of Alfred P. Sloan Fellows received the degree of Master of Science in Management in May 1976.

The Class of 1976 represented a number of interesting firsts. For example, the Sloan Fellows visited Algeria on their foreign management trip and 24 organizations were represented in the program for the first time. The organizations from the United States included: Nashua Corporation; Polaroid Corporation; Union Pacific Railroad; Panta Inc.; Rockford School of Medicine; US Department of the Interior; Federal Reserve Bank of Boston; Boston, Office of the Mayor; Portfolio Management Consultant; Carney Hospital; Macro Systems, Inc.; US Coast Guard; NATO; Northern States Power Company; The Children's Hospital; University of Nevada, School of Medical Sciences; Michigan State, College of Human Medicine. The organizations from other countries included: Sony Corporation (Japan); Fearnley & Eger (Norway); Kirsh Industries (South Africa); B. M. W. (West Germany); British Steel Corporation (Great Britain); National Institute of Public Administration (Malaysia); Neptune Maritime Ltd. (Hong Kong); Nippon Telephone & Telegraph (Japan).

The large number of new organizations was due in part to the introduction last year of the Health Management Executive Development Program which currently operates within the framework of the Sloan Fellows Program. This year saw the largest number of such first-timers in the program's history and on only one other occasion has the size of the class been as large. Thirty-two came from the private sector (compared to 33 the previous year); and 20 from the public sector (up three from the previous year). The strong interest from the public sector continues and will probably grow as more public sector organizations resolve to improve the management of their human, technical, and economic resources.

A member of the cadre of the management education department of the State University of Moscow, USSR was admitted as a member of this class, but he was recalled to the Soviet Union a few weeks before finishing his year as a Sloan Fellow. He was the fourth Sloan Fellow from the USSR. The Sloan Fellows Program remains the only degree granting management program outside the Soviet Union in which citizens of that country have participated.

The program demand and quality continue strong and backlog of applications has begun to build earlier than usual as more organizations begin to plan two or more years in advance for the nomination of their candidates.

Dean Peter P. Gil has continued, among his other tasks, to direct the program.

Health Management Executive Development Program

The new Health Management Executive Development Program, a 12-month program leading to the degree of Master of Science in Management, was inaugurated this year. The program aims at mid-career health care practitioners, educators, researchers, and administrators who desire an intensive management development experience in preparation for continued career growth and increased responsibilities in the health field. Six health professionals were admitted to this new program in June 1975: three medical school deans, two senior directors of nursing services, and an executive from the Department of Health, Education and Welfare. A continuing interest in the new program has been manifested by early applications for the 1976-77 year. Professor Edward B. Roberts continues as program director, while Dean Gil shares administrative responsibility for participants in this program since, as noted above, participants in the Health Management Program currently operate within the framework of the Sloan Fellows Program.

M.I.T. Program for Senior Executives

1976 marked the twentieth anniversary of the M.I.T. Program for Senior Executives. Howard W. Johnson, the founder of the program and present Chairman of the M.I.T. Corporation, greeted the twentieth anniversary class at a banquet in April 1976.

There are now more than 1,000 alumni of the program, and they occupy positions of leadership in companies and organizations both in this country and abroad. Heavy demand for one of the 28 spaces in the course continues despite the economic slowdown. Approximately one-third of the participants in each course come from abroad.

Professor Scott Morton served as chairman of the program's faculty committee, and Alan F. White, an M.I.T. alumnus (Sloan Fellow at M.I.T. in the class of 1970-71), continued as the program director.

M.I.T. Program for Urban Executives, June 1976

The ninth M.I.T. Program for Urban Executives was held at Endicott House and the Sloan School from June 6 to June 30, 1976. Part of the teaching load was carried by faculty from the Department of Urban Studies and Planning and the Department of Civil Engineering. Twenty-six participants from the United States and Canada attended. Participants were city and town managers, department heads, and other career managers. Cities represented in earlier programs continue to make nominations on a regular basis. Former Mayor of Boston, Consulting Professor John F. Collins, continued to serve as faculty chairman of the program, and Mr. White continued as program director.

Greater Boston Executive Program (GBEP)

The Nineteenth Session of the Greater Boston Executive Program was held from January 16 to April 23, 1976. The earlier decision to limit the number of participants to increase interaction among them has continued. The 15-week, one-day-a-week program included 17 class members representing nine organizations. The 1976 GBEP Alumni Reunion in April was well attended by alumni and alumnae with their spouses, and all participated in seminars given by Professors Phyllis A. Wallace and Leo B. Moore on that occasion. Patricia Macpherson coordinated the program.

Summer Programs

Members of the Sloan School faculty offered 12 special programs during the summer, 1975. Professor Stewart C. Myers and Richard A. Cohn, assisted by Professor Gerald A. Pogue of Baruch College, The City University of New York, offered two consecutive one-week programs for managers with interests or responsibilities in corporate financial management and planning. The first, Basic Concepts in Financial Management and Strategy, considered capital budgeting decisions, cost of capital, dividend policy, acquisitions and mergers, and methods of measuring the performance of a firm's pension fund. The second, Models for Financial Management and Long-Range Financial Planning, dealt with the design and application of financial models.

Advanced Software Engineering-Focusing on Operating Systems, a two-week program, was conducted by Professors John J. Donovan and Stuart E. Madnick. This program presented a view of advanced computer software systems, particularly operating systems, based upon the management of resources.

Two consecutive one-week programs were offered by Professors Peter Keen, Peter Lorange, Sitikantha Mahapatra, and Dr. John F. Rockart. Both programs, Management Control Systems and Long-Range Planning Systems, were designed to meet the needs of senior level line managers and staff controllers of primarily profit oriented, but also nonprofit, organizations.

Professor Jay W. Forrester and several additional members of the System Dynamics Group again presented System Dynamics, Methodology and Applications; Emphasis on Industrial, World, Urban, and National Issues. Lectures covered the fundamental principles and methodology underlying the study of multiple-loop feedback systems. Case studies illustrated issues in problem definition, model building, analysis, and policy design and provided examples of applications. Workshops were held in the areas of urban behavior, world evolution, industrial policy, and economic issues.

Professor Edgar H. Schein and Richard Beckhard also repeated the one-week "live-in" program New Horizons in the Management of Change and Organizational Development at Endicott House in Dedham. Professor Roberts in collaboration with other faculty led the two summer programs that he has given previously: the two-week Management of Research, Development, and Technology-Based Innovation, and the one-week The Dynamics of Health Service Systems, which aimed at reporting progress to date in the application of systems analytic methods to health care delivery. Professor J. Daniel Nyhart, who holds joint appointments in Management and Ocean Engineering, presented a one-week summer session on Ocean Resources Management: Legal and Policy Aspects.

A four-day program, The Implementation of Computer Systems and Models, led by Professor Keen, was intended both for users and for designers of computer systems. Finally, Professor Chen offered a one-week program, Computer System and Data Base Performance Evaluation: Modeling, Simulation, and Measurement, which was designed to provide a thorough understanding of the techniques used in evaluation of computer system and data base system performance.

These summer programs, designed to give specific post-experience training to managers functioning in a variety of positions and organizations, continued to draw participants from all over the world. In addition they provided the vehicles for curriculum development which will improve the quality of each of the larger residential and degree programs in the School.

Industrial Liaison Symposia and Seminars

Several members of the School's faculty participated in Industrial Liaison presentations during the year. In December, Professor Roberts chaired a symposium at Kresge Auditorium on management of research, development and technology based innovation. Several School faculty members reported on the status of their studies of effective management of research and development and on the commercial implementation of technological innovations. Dr. Gordon F. Bloom was a discussant at another symposium on advances in food production and distribution where he presented preliminary results of research efforts at M.I.T. to accelerate the introduction of new technology in food distribution. Professor Lorange presented an afternoon seminar in New York City on a conceptual scheme for long-range planning and then discussed implementation of this scheme in various corporate settings.

On April 8, the International Management Group, under the direction of Professor Richard D. Robinson, presented a one-day seminar in New York City on strategy options for international business in a changing world. Morning sessions dealt with significant environmental changes confronting international business. Afternoon sessions focused on opportunities and costs associated with possible strategic responses by international business.

Professors Arnaldo C. Hax of the Sloan School and Ernst G. Frankel of the Department of Ocean Engineering cochaired a production management symposium at Kresge Auditorium in May. Several faculty members reviewed the role of computers, operations research methods, and manufacturing technology in production management. During the spring semester, Professor Gary L. Lilien presented two seminars. In April, he conducted a seminar in Chicago on retail outlet planning, and in May, at M.I.T., he led one on advertising budgeting for industrial products.

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. 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 Manpower and Labor 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 research builds.

Organization Studies

Several faculty members continue to focus on 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 goal is to better understand how such interactions at different life stages lead to patterns of productivity, creativity, job satisfaction, and accommodation among different life concerns.

Professor Lotte Bailyn is continuing her study of accommodation patterns in educated adults, especially in dual career families. The differential impact of family and work issues on men and women at different life stages is of particular importance in this research. A volume on measuring work quality for social reporting purposes contains a chapter coauthored by Professor Bailyn and Professor Schein on such life-career considerations as an indicator of quality of employment. She also is finishing work on patterns and determinants of work involvement in technically based careers.

Professor John Van Maanen has been on leave at Yale University where he has continued research on 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. He 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.

Professor Ralph Katz continues 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. This work promises to lead to a more refined and complex theory of job satisfaction throughout the career than has heretofore been formulated.

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. Changing value patterns within the panel group as well as within society are of research interest, the latter question being investigated with Jay Paap by a re-administration to the 1974-75 class of Sloan Fellows of a survey originally done with the 1961 Sloan Fellows.

Dean Gil and Professor Schein are studying career paths of Sloan School alumni and are developing methods of analysis which permit identification of such patterns from career history data. Judy Gordon, a doctoral candidate, is working on a thesis which seeks to compare and contrast staff-line career paths.

Mr. Beckhard is surveying mid-career crises in high potential managers. Working primarily with cases uncovered in relation to his extensive consulting activities, Mr. Beckhard is generating hypotheses concerning the reasons why an increasing number of high potential managers are turning down promotions and leaving organizations in which they have high career potential. Mr. Beckhard and Professor Schein are exploring the value implications of these data in relation to societal changes in values.

Another major area of research relates to improvement of health care delivery through design and 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 projects and the scientific issues they 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 faculty members are actively engaged in planned change and organization development activities, and this applied or clinical focus of the groups continues to be a main source of strength.

These efforts are enhanced by the research projects undertaken by Professor Reuben T. Harris and Mr. Beckhard on the effects of different kinds of planned change interventions. 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 not only in health care delivery, but in industrial organizations using organization development activities, and urban systems attempting to improve urban management. Professor Harris has designed a survey to evaluate effects of a major ongoing organization development program on employee attitudes, costs, and profits in a number of the organization's work units. In addition, he has studied the relation of a health care organization's orientation toward patients and the formal structure of the organization, and 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 Moore continues to review a variety of experimental approaches with "management by objective" programs in a number of companies.

Manpower and Labor Relations

Research during the past year has centered on certain aspects of labor-management relations, federally funded employment and training policies, equal employment opportunity for women and minorities, international industrial relations, labor economics, labor law, and the management of human resources (personnel administration). This research is reported more fully in the latest annual report of the Industrial Relations Section, which is one of the five oldest in the United States, founded at M.I.T. in 1937.

Professor Wallace began research on the Learning Center at New England Telephone Company as a mechanism for change in connection with upward mobility for women and minorities within the company. She is collaborating in this preliminary research with Professor Bailyn of the Organization Studies Group, and Professor James W. Driscoll is also involved part time in the preliminary exploration. Professor Wallace's book, Equal Employment Opportunity and the AT&T Case, was published by the M.I.T. Press in January; and a manuscript, "Women, Minorities and Employment Discrimination," growing out of papers and proceedings of a conference funded by the National Science Foundation, is likely to be published by D. C. Heath/Lexington Books. One of her earlier papers, "The Impact of Equal Employment Opportunity Laws," presented at an Arden House conference, was published in April as a chapter in Women and the American Economy, edited by Juanita Kreps. Professor Wallace also is completing a monograph on the employment status of black women, for the National Council of Employment and Training (formerly the National Manpower Policy Task Force), of which she and Professor Charles A. Myers are members.

Professors Myers and Thomas A. Barocci, with assistance from Professor Wallace, supervised the second year of the three-year study of decentralized employment and training programs under the Comprehensive Employment and Training Act of 1973 (CETA). Field research is done by Sloan School graduate students and supported by a contract from the Office of Research and Development of Federal Employment and Training Administration, US Department of Labor. The 1975-76 studies have built on the 1974-75 research in Cambridge, Lowell, the so-called Balance of State (BOS), and two subgrantee areas in BOS: Newton and Quincy. In addition, New Bedford was added to the research areas during 1975-76. Two new graduate students began work this summer in most of the same areas, and another starts in the fall. An oral report was made by the research group to a large number of federal officials in May. This group included colleagues from Northeastern University who are studying experience in Boston under a sub-contract to the M.I.T. project. By the end of summer, 1977, a final report on this research will be written by Professors Myers and Barocci.

Professor Barocci worked with the Harvard-M.I.T. Joint Center for Urban Studies to initiate a project on economic development problems and prospects for the New England region, in collaboration with colleagues from other M.I.T. departments and in other Boston area universities. His monograph, The Canadian Job Creation Model and Its Applicability to the US, was published in January by the Joint Economic Committee of Congress, and another paper on the same topic will be published this summer.

Professor Driscoll has several research projects under way. One is a continuation of his earlier work on faculty collective bargaining, concentrating attention on political trust, participation, and the satisfaction of faculty members with participation in decision making, as factors affecting faculty interest in collective bargaining. He also is beginning preliminary research on union-management problem-solving efforts as reported in various studies and in the experience with the Scanlon Plan of labor-management cooperation. Finally, he has begun interviewing a number of staff officials in local firms to better understand the changing role of the personnel manager. This will be preliminary to a larger study, if funded, which would identify the alternative change strategies within their organizations and the results for human resource utilization.

In the international area, Professor Kenneth S. Mericle is revising for publication an earlier study he did of "Industrial Relations and Wage Policy in Brazil." A paper drawing on this study, "Corporatist Control of the Working Class: Authoritarian Brazil Since 1964," will appear in a book, Authoritarianism and Corporatism in Latin America. Mericle will utilize some papers from his earlier longer study of the Brazilian Motor Vehicle Industry, completed last summer under a grant from the US Department of Labor to the International Business Project of the Center for International Studies. He also has been working on an interdisciplinary research project on "New Perspectives on Urban Transportation: Strategies for Overcoming Barriers to Innovation." His part of this project has centered on patterns of labor relations and collective bargaining in the urban mass transit industry and the implications of these patterns for the adoption of new service innovations in mass transit.

Professor Michael J. Piore (a member of the group from the Department of Economics) continued his interdisciplinary involvement in the nature of labor markets of advanced industrial countries (particularly those in Western Europe), with particular reference to the role of immigrant labor, racial and ethnic minorities, the relationship of the educational system to the job structure, and the determination of wage and salary structures. He also is preparing a research monograph on illegal immigration to the United States for the National Council on Employment and Training, and is continuing his study of the process of wage determination in the United States.

Professor D. Quinn Mills's book, Government, Labor and Inflation, published last fall, is based on research on the experience with government wage stabilization policies from World War I up to wage and price controls during 1971-73 in which he was involved while a member of our faculty. He also is writing a text and case book on labor-management relations.

Senior Lecturer Jacks continued research on various current labor law questions, including the use of judicial equity powers to enjoin implementation of management decisions pending arbitration. Professor Emeritus Douglass V. Brown has a continuing interest in the effect of legalism on industrial relations in the United States, a topic on which he has published a number of papers in the past.

Finally, Professor Emeritus Paul Pigors and Professor Charles Myers completed the revision for the eighth edition of Personnel Administration to be published by McGraw-Hill this fall.

Economics and Finance

The Economics and Finance Group is the second basic disciplinary pillar upon which the School's research and teaching programs build. Professor Sidney S. Alexander, head of the group, was principally engaged in concluding research on the financial consequences of increased energy prices. Some of the results were published in Paying for Energy, a background study for a Task Force Report of the Twentieth Century Fund. Professor Alexander also has continued his study of the foundations of social policy. In particular he is working on an attempt to construct a basis for making interpersonally valid judgments of social, principally economic policy. He is, as an immediate target, trying to identify methods of choosing, or compromising, between utilitarian standards based on welfare and those based on procedure.

Professor Lester Thurow's research focused on the impact of US agricultural exports on the country's distribution of income. In particular, Thurow is concerned with what the impact of a large increase or decrease in agricultural exports would be. His publications included several articles on income distribution: "How the Rich Get Rich, and How They Can be Taxed," in Working Papers for a New Society, winter, 1976; "The Economic Progress of Minority Groups," in Challenge, March/April 1976; a chapter on equity concepts in the world of work in an edited volume, Measuring Work Quality for Social Reporting; and a new book, Generating Inequality, published by Basic Books in November 1975.

Professor Franco Modigliani, the current President of the American Economic Association, pursued the problem of redesigning the mortgage instrument and reforming thrift institutions with a view to insulating the housing market from the ravages of high and variable inflation. Results of research initiated last year appeared in part in the volume he edited with Professor Donald R. Lessard, New Mortgage Designs for Stable Housing in an Inflationary Environment. Professor Modigliani also has been concerned with encouraging and monitoring the concrete applications of proposals set forth in that volume.

Another major area of his research focused on the design of macroeconomic policies to insure a rapid recovery from the 1974-75 depression, while avoiding the danger of reviving inflation. This resulted in some publications, and formed the basis for testimony before Congress on pending legislation on reform of thrift institutions and mortgage markets, and on current monetary policies.

In relation to stabilization policies, Professor Modigliani has been concerned with the application of optimal control to problems of stabilization, and in particular, with the appropriate specification of the social welfare function and its implications for the optimum response of output and employment to exogenous or inherited inflation. He also is organizing a small conference of academic economists and central bankers similar to that put together in Finland last year. Scheduled to take place in Greece at the end of October, the conference will deal with various aspects of "stagflation" in open economies.

Professor Daniel M. Holland together with Professor Stewart Myers undertook a study of trends in corporate profitability and capital costs for a study group of the Committee for Economic Development. Their research seeks to evaluate the recent decline in corporate after-tax profitability and market valuation in a longer-run context -- over the full sweep of years 1929-1975. It relates closely to the International Business Project's exploratory study of international comparisons of the rate of return to capital, on which Professor Holland is engaged. A second and final meeting of the group participating in this latter exploratory project is scheduled for April 1977.

Professor Holland also continued research in property taxation, in particular the potential of a property tax for La Paz, Bolivia. He is preparing a paper on Jamaica's taxation of

unimproved value. He also presented a paper at the National Tax Association-Tax Institute of America Summer Symposium on the practical problems of corporate-personal tax integration, and has continued as Editor of the National Tax Journal.

Professor Edwin Kuh continued on half-time leave to serve as Executive Director of the National Bureau of Economic Research Computer Research Center for Economics and Management Science, an organization which conducts algorithmic and software development research on data analysis methods, econometric estimation, and mathematical programming. In addition, Professor Kuh continued his own work on statistical aggregation theory.

Professor Robert S. Pindyck worked with Professors Henry D. Jacoby and Morris A. Adelman on an interdepartmental study of the world oil market. Professor Pindyck developed econometric models to describe and predict international demands for alternative energy resources, and studied potential OPEC cartel behavior and the potential for international cartelization of other exhaustible resource industries. He also revised and reestimated the econometric model of the natural gas industry that he developed with Professor Paul W. MacAvoy last year, and used that model to perform policy analyses related to a variety of energy issues. In addition, Professor Pindyck is researching the application of control theory to macroeconomic policy. Professors Pindyck and Kuh recently had their NSF grant renewed for studying these and related issues in optimal control applications in economics. A number of published and unpublished papers related to this work appeared during the year, and a 1976 edition of Econometric Models and Economic Forecasts (coauthored with D. Rubinfeld), was published by McGraw-Hill.

Professor Robert C. Merton continued his research on the pricing of options and of corporate liabilities and more generally, on the operation of financial markets. His work is supported by the National Science Foundation. Several of his papers deal with the impact on option pricing of discontinuous underlying stock returns. Others deal with growth under uncertainty and with a reexamination of the capital asset pricing model. Professor Merton also continued as coeditor of the Journal of Financial Economics and associate editor of the Journal of Finance and the International Economic Review.

In addition to his work with Professor Holland, Professor Stewart Myers's research was devoted mainly to corporate finance. He published a paper on the valuation of financial leases (with former Sloan School students David Dill and Alberto Bautista), and edited a book, New Developments in Financial Management. He researched applications of option pricing theory to the firm's borrowing decision, and of the capital asset pricing model to the firm's investment decision.

Professor Lessard has been engaged in research in two areas: financial aspects of direct and portfolio investment, and alternative mortgage instruments for an inflationary environment.

In the international investment field he published a paper on gains from international portfolio diversification ("World, Country, and Industry Relationships in Equity Returns: Implications for Risk Reduction Through International Diversification," Financial Analysts Journal, January/February, 1976), and coauthored several additional papers on the likelihood of OPEC direct investment in industrialized countries with Professor Stephen J. Kobrin; and papers on financial factors and the international expansion of small country based firms on the tradeoff between inward direct and portfolio investment for developing countries, and on US investor recognition of corporate international diversification, all coauthored with Visiting lecturer Tamir Agmon of Tel Aviv University.

Professor Lessard proceeded with similar research emphasizing specific industries or regions. Together with Dr. Agmon and James Paddock of M.I.T., he completed a series

of working papers on the impact of financial factors on the behavior of OPEC member countries. Professors Lessard and Edward M. Graham are engaged in research on financing and ownership alternatives for large-scale extractive projects in developing countries. This project includes field studies in Peru and Chile and simulation studies of alternative financing/sales contract packages for ventures in Peru and Panama. An initial paper on this subject is scheduled for publication.

In the mortgage field, together with Professor Modigliani and other members of the Sloan School faculty, Professor Lessard completed a major study of alternative mortgage instruments for an inflationary environment. The results, including several papers on foreign experience with alternative mortgages, were published by the Federal Reserve Bank of Boston in a volume coedited by Professors Modigliani and Lessard (Alternative Mortgages for Stable Housing in an Inflationary Environment, FRBB Conference Series #14).

Professor Cohn was on leave at the University of British Columbia in 1975-76. Prior to his departure he completed work with Professor Stanley Fischer of the Department of Economics on alternative mortgage designs. Their conclusions appeared in December 1975 in New Mortgage Designs for Stable Housing in an Inflationary Environment, the final report of the Sloan School Mortgage Study directed by Professors Modigliani and Lessard. A review of the Mortgage Study by Professors Cohn and Lessard appeared in the May 1976 Journal of Finance. Professor Cohn also completed two papers on financial intermediation with Dr. Agmon. While on leave, Professor Cohn continued work on financial intermediation. In addition to examining various aspects of mutual life insurance, he presented a paper at the 1975 American Economic Association annual meeting on implications for thrift institutions of a removal of deposit interest rate ceilings. He currently is researching planned implementation of some of the new mortgage designs developed as part of the Sloan Mortgage Study effort.

Visiting Associate Professor E. Eugene Carter published an international finance textbook and a 210-page teaching manual. He also prepared testimony on oil and gas joint ventures which was presented to the Subcommittee on Monopolies and Commercial Law, Committee on the Judiciary, US House of Representatives and is working on other materials on international finance and organizational decision making.

Professor Fischer Black researched the behavior of economic and financial markets under the assumption that individuals and firms will attempt to take advantage of any profit opportunities they see. His work generally falls into two broad areas: the pricing of options and related securities, and the application of concepts from finance to economic theory. His publications during the academic year were in several areas of finance: the use of options, bank funds management in an efficient market, dividend policy, the pricing of commodity contracts, and investment policy. Professor Black currently is involved in research on numerical methods for solving option valuation problems and in empirical research on the ways in which stock volatilities change.

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. The research of the group can be roughly divided into context related research that deals with specific areas of management concern, and methodological research on general tools and techniques. Using this dichotomy, the application areas can be further subdivided into public and private sectors.

Chief concerns in the public area are energy, health, transportation, and state government. The work has been heavily interconnected with other parts of the Sloan School and M.I.T., particularly with the Energy Laboratory where Professor Jacoby is a member of the Steering Committee. Professor Jacoby is an architect of an Energy Policy Study Group and he, Professor Donovan, and a group of students have designed and implemented a New England Energy Information System and a generalized software capability called GMIS for data manipulation and analysis. Professor Gordon M. Kaufman and Visiting Professor Eytan Barouch have undertaken an extensive project to model the process of oil and gas exploration and permit better estimates of undiscovered oil and gas reserves. Professor Kaufman assisted the US Geological Survey, which recently revised its reserve estimate downward on the basis of his findings. The work is now being applied to the North Sea Petroleum province. Professor Jeremy F. Shapiro investigated the development of mathematical programming models of energy systems so as to be better able to evaluate US policy alternatives with medium term planning horizons. Professors Shapiro and Marsten are trying to link forecasting and mathematical programming models.

Two members of the group are studying health systems. Professor Glen L. Urban is conducting research in health maintenance organizations (HMO's). Recent Federal legislation requires employers to offer their employees options of this type if they exist in the employment area but very little is known about what attributes of the proposed services are really desired by the intended customers, or what demands or costs will result if various alternatives are offered. Professor Urban is designing and testing a behavioral model of the customer choice process. This model also is being applied to the design and marketing of new educational services. He also is working in models for the management of family planning systems. Dr. Rockart studied the planning and control aspects of health systems and expanded his research to budgeting and reporting in cultural organizations.

In the area of transportation, Professor Thomas L. Magnanti has studied large-scale transportation network problems through the decomposition techniques of mathematical programming. The identification and creation of technological aides for policy analysis in state governments is the thrust of work by Professor John D.C. Little, who worked with the Massachusetts Deputy Commissioner for Fiscal Affairs to bring into operation an on-line budget tracking system.

As food prices continued to rise, Dr. Gordon F. Bloom's work on productivity in the food industry took on increasing importance. Dr. Bloom has been a leader in facilitating the application of new techniques to the food industry through workshops, colloquia, and through his writings. In particular, a program on Technology Applied to the Food Industry (TAFI), which was started at M.I.T., is being extended to other universities. Dr. Bloom's current work focuses on food distribution to the elderly and incapacitated.

Professor Arnold I. Barnett's statistical work on victimization from crime reveals a remarkably high probability that people living in certain areas will have crimes committed against them. His research has extended to the study of other violent crimes and crime prevention.

In the private sector, a variety of work has been going on, especially in the areas of marketing and operations management. In marketing, Professors Silk and Urban 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 developed related techniques for a new product design and positioning, and Professor Silk is studying the qualities of advertising and their relationship to customer response. Professor Manohar Kalwani is studying the application of different concepts of entropy to modeling consumer behavior. Professor Lilien embarked on a major study of industrial

advertising, the ADVISOR Project, in which 12 cooperating companies have provided cross-sectional marketing data on 70 industrial products. The study seeks to determine how industrial advertising budgets are related to product and market characteristics. This work is expanding to the role of salesmen and their interactive effect with advertising in the industrial purchasing process.

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 often have collapsed as the designers have moved on to other responsibilities. Professor Hax is engaged in a project on hierarchical production and distribution systems which seeks to tackle these issues. In his work, models for higher level strategic decisions set constraints for more local tactical decisions from which the latter feed back information to the former. In this effort Professor Hax is working closely with Professor William A. Martin, who seeks to add automatic programming ideas to the design of such systems so that they will be readily adaptable to new managers and new operating conditions. Professor Magnanti, along with Professor Hax, is studying new methods of production and inventory scheduling using large-scale optimization theory.

The ability to extend knowledge and solve problems in context areas such as those cited above depends on continued basic methodological research. Considerable activity along these lines is taking place within the Management Science Group. Professor Michael S. Scott Morton is chairman of an American Accounting Association standing committee on Management Planning and Control and has taken on responsibility for preparing a position on concepts and research issues in management control. Professor Lorange is investigating formal planning systems, especially in the complex setting of multinational corporations. He is studying 12 large corporations to determine their effectiveness in adapting to environmental change. Professor Lorange also is researching the elements of successful administrative systems in small corporations. Professor Mahapatra is examining the efficiency and effectiveness of computer based planning and control models across organizations.

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 Shapiro is supervising the development of a modular system of mathematical programming packages at the National Bureau of Economic Research installation in Cambridge. He has also focused research effort on certain outstanding issues in integer and mixed integer programming. This work has been utilized in a project on water resource planning in Yugoslavia and will be used in the allocation of federal funds to US airport construction. Professor Magnanti has been attacking problems in combinatorial theory and nonlinear programming and has had a particular concern for optimization in large linear programming models and sensitivity in nonlinear optimization models. Professor Marsten has brought together two previously separate mathematical programming methods, branch-and-bound and dynamic programming, and discovered that substantive new computational efficiencies can thereby be gained.

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 are laying foundations for a computer

system architecture allowing multi-user access to a single data base and affording access to multiple and potentially incompatible data base management systems. In related work, Professor Chen 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 Scott Morton is studying the impact of advanced decision support systems on the organizations using them. Students working under his direction researched issues of systems implementation in specific settings. Professor Scott Morton has led in the development of a Center for Information Systems Research (CISR) which draws on industry funds for use in research on critical management issues of computer utilization. Professor Meldman investigated issues in computer aided legal analyses. Dr. Rockart embarked on a study of distributed computing power in large organizations.

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 Roy E. Welsch is developing robust nonlinear regression techniques and implementing them on easy-to-use computer systems. Recently he worked with Professors Little and Silk to use methods for calibrating nonlinear marketing models and determining their robustness.

System Dynamics

System dynamics research is now concentrated on the national socioeconomic model that has been under development for three years, with sponsorship from the Rockefeller Brothers Fund, the National Science Foundation, the Independence Foundation, and a number of individuals and corporations. The project is directed by Professors Forrester and Nathaniel J. Mass. The National Model consists of seven major sectors -- production, labor, household, financial, demographic, government, and international trade. Most of these sectors have now been completed in preliminary form, and individually tested through computer simulations. Assembly of the overall model out of the component sectors is under way. Initial computer simulation studies are leading to improvement of the model and to preliminary examination of business cycles and longer-term fluctuations in the economy. For examining many important national issues, only parts of the entire model are needed; the sequence of assembly is scheduled to allow study of a progression of critical questions even before the final sectors are completed. Even at the present stage of assembly, the National Model is beginning to raise important issues of behavior and national policy. It suggests that the short-term business cycle in the economy may be caused primarily by interactions between employment and inventories, contrary to the prevalent capital-investment theories of the business cycle, and that capital investment may be involved principally in generating much longer-term economic cycles, including a long wave of approximately 50 years' duration.

With preliminary sector descriptions becoming available, outside groups are being consulted for advice on improvement of the model. Interaction with potential users is growing as the model materializes and interest in the National Model within the public and private sectors is expanding rapidly. The Washington Post, Newsweek, and professional papers have carried articles on the work.

In stages during the next three years, the National Model should assist in further understanding business cycles, the possible role of a 50-year wave in the economy in causing the present recession to be deeper than expected, the sources of simultaneous inflation and unemployment, energy shortage, the relationships between rising population and the standard of living, and the pressures from growth impinging on environmental limits.

Other activities in the system dynamics area also should be noted. Professor William A. Shaffer completed a doctoral dissertation on the dynamics of the criminal justice system in Massachusetts. Also, a variety of curricula is being developed for teaching basic concepts of system dynamics, such as feedback loops and computer modeling, from elementary school through university and graduate school. A new nine-month intensive program in system dynamics is being introduced within the Sloan School.

The Management of Science and Technology

Research here primarily concerns the dynamics of generating technical innovation and the processes which determine the circulation of technical information between organizations. Professor Ralph Katz has taken over research initiated several years ago by Professor George Farris at the level of the technical group. The makeup and supervision of technical groups continue to be topics for intensive research.

Professor Allen continues his work on technology transfer. His major concerns are with the acquisition of new technology by organizations and the effective dissemination of this information within organizations. More recently his attention has turned to this same problem at the national level. The first country to be investigated was the Republic of Ireland. The Center for Policy Alternatives conducted a similar study on Brazil that employed many of Allen's techniques.

Results from the national studies note differences in the ways in which various disciplines structure themselves for international communication. A field experiment is under way in which communication patterns in one discipline are compared under conditions in which the economic relevance of the discipline changes radically. Professor Allen completed a book which will bring together almost a decade of his research in this area.

Professor Roberts continued to work on system dynamics problems relating primarily to technology and health issues. He is preparing to replicate his study of new ventures, in the medical field.

Professor Eric A. von Hippel's continued research focuses on better evaluating how the manufacturer of an innovative industrial good gains an accurate understanding of the user need for that good. Previous research has shown such "accurate understanding of user need" is a key to successful industrial good innovation. Research into innovations in the field of scientific and analytic instruments, semiconductor and electronic subassemblies, and production equipment manufacture shows that the locus of innovation is most frequently in the user organization, rather than the supplier of the innovation.

The Joint M.I.T. - Harvard Program on the Management of Technology under the auspices of the Sarnoff endowments continues to develop. Professor Roberts continued the joint seminar in the area. The seminar focused on the commercial exploitation of technology in industry, government, and university settings.

Professor Allen concluded his joint research project with the Center for Policy Alternatives and the Department of Political Science involving an evaluation of government policy to stimulate innovation in four Western European countries and Japan. Results of this research should be valuable in formulating US policy in this important area. As the group achieves a greater understanding of how technological innovations come about and are diffused, it will be possible to stimulate the process of such diffusion on a much wider scale, both at the level of a small system such as a laboratory and a large system such as the R&D establishment of a country.

Corporate Strategy, Policy and Planning

During the past academic year, the Policy Group made a small but decisive step toward the launching of "industry studies" and the related issues of government regulation of industry as a principal focus of its research.

The first effort was the Seminar on the Strategic Issues Facing the Oil Industry which was intended to bring together the research interest of Professors Graham, Henry S. Marcus (Course XIII), and Zenon S. Zannetos. An in-depth analysis was made of the strategic issues regarding the various facets of the oil industry (production, refining, transportation), of the various functions of management (finance, operations, planning and control, information systems, and organizational structures), the various dimensions of corporate strategy (pricing, diversification expansion, innovation, vertical integration), and the impact of US as well as host country legislation on the strategy of oil companies.

A second group research effort was initiated to study the impact of the conglomerate firm on the shipbuilding industry. This project, which may have long-term potential, is supported by the Office of Naval Research on an exploratory basis. Principal investigators are Professors Hax and Zannetos. Their team includes Professors Graham, Marcus (Course XIII), Stewart Myers, and Michael Porter (Harvard University).

Research on the conglomerate and the shipbuilding industries is aimed at three main questions: 1) the present structure of the US shipbuilding industry and the evolution of the industry to its present form; 2) the general advantages and disadvantages of conglomeration and the generation of hypotheses explaining its rise and decline; and 3) the generation of hypotheses regarding the impact of conglomeration on the internal structure, strategy and planning and control systems of affected firms, and the relationships of affected organizations and the customer.

As can be seen, initial work will focus on description of structures and the generation of hypotheses regarding conglomerate business behavior. Later, if feasibility results are encouraging, the focus will proceed to hypothesis testing.

On an individual basis, Professor Graham is continuing work on the economics of international extractive industries, and has started research on technology transfer and its impact on US international trade. Professor Zannetos is still investigating oil economics, tanker rates, organization structures, and strategic planning.

International Management

Professor Robinson is engaged in the preliminary stages of researching the role that large Japanese trading companies will play in shaping the structure of international business in the next five to 10 years. Interviews with corporate planners and development executives of the US subsidiaries of nine of the largest trading companies are complete. The next phase of the study will examine their success in moving into new fields of operation such as technology, "off-shore" trading and engineering, and construction.

Three projects concern Brazil. Professor Mericle completed an extensive study of the Brazilian automotive industry based upon fieldwork conducted in 1974. His study of industrial relations and wage policy in Brazil will result in a booklength monograph. Finally, faculty members and students are working in collaboration with the Center for Policy Alternatives on a project sponsored by the Projecto Ciencia e Tecnologia. It examines alternative policies for the support of economic growth and development. Shing Fung, a doctoral

student, completed extensive field research and is working on analysis and reporting of the results.

Professor Kobrin is conducting a quantitative cross-national study which attempts to isolate conditions under which political instability and disruption result in increased risk for foreign investors. He has completed a study of the environmental determinants of foreign direct investment and is also working on a cross-national test of the convergence hypothesis.

A study of the British-American Tobacco Company in India has been undertaken in line with a continuing interest in the response of foreign business enterprises to changing economic and political conditions in host countries. Field research was conducted in India by Vinod Dar, a doctoral student.

Professor Nyhart is working on the legal/regulatory framework for the management of ocean technology and resources. He is currently engaged in research exploring the regulation of offshore technology under extended jurisdiction, and recently completed studies of the legal structure of the ocean mining industry and of legal aspects of ocean thermal energy conversion.

Professors Graham and Lessard are engaged in a research project involving the economics of international minerals industries. The analysis concerns the economic implications of national ownership of copper mining ventures and related downstream activities in third world countries. Interviews were conducted in Chile and Peru, and primary hypotheses will be tested through simulation for cases in Peru and Panama.

In conducting an analysis of the International Bauxite Association, Professor Graham is examining factors affecting the organization's probable success or failure in its efforts to regulate world bauxite prices.

Health Care Management

During 1975-76 the Sloan School began a new executive educational program in health care management, increased the scope of related research, and continued efforts to expand faculty and resources in this relatively new area.

The School furthered its active collaboration with the Association of American Medical Colleges in an ongoing three-phase program involving the development and presentation of management education programs for the AAMC's constituent medical schools. Mr. Beckhard and Professor Roberts, representing the applied behavioral sciences and the management sciences, respectively, exercised joint responsibility for design and ongoing faculty leadership of these activities, with active involvement of Professor Schein, Dr. Rockart, and numerous faculty from other universities. Phase I involved more than 100 deans of the 114 North American medical schools in a one-week management program. Over 60 medical schools already have participated in the follow-up Phase II teams program emphasizing problem solving of real issues identified by the medical schools. Phase III was attended by 13 institutional teams seeking to accelerate programs of managerial improvement initiated by the earlier phases. Additional sessions of all phases of this M.I.T./AAMC program are scheduled for the coming year. During the past year, an additional Phase I-type program was developed and presented for 20 directors of teaching hospitals, and a similar program for medical department heads is under consideration. In a related activity with the AAMC, Dr. Rockart continued a short course for the business and planning officers of the medical schools, which more than 150 persons have attended thus far.

Professor Roberts continued his five-day special summer course on application of system dynamics to health service systems. Literature on this subject is expanding. Last year

Professor Roberts published a book on the policy analysis of urban heroin addiction. His latest book is on the delivery of human services.

Mr. Beckhard, aided by Drs. Irwin Rubin, Ronald Fry, Eric Herzog, Mark Plovnick, and Nina Rosoff, expanded their development and pilot implementation of a series of educational intervention programs. Funded by the Robert Wood Johnson Foundation, the project aimed at bringing about change in various health institutions. The new curricula already have resulted in one book on developing health teams, with another book in progress on educational interventions in health fields. The group's principal efforts are to prepare organizational development and change materials for health care organizations, to test these materials in multiple field settings, to determine the extent to which such materials can be used without the active intervention of outside consultants, and to determine what kinds of new curricular materials or educational strategies can be inserted into medical school and post-graduate programs for health care personnel to improve their overall effectiveness.

In addition to the research interests mentioned above, progress was made by Professor Urban in developing a model of consumer response to health services and in testing it in the pilot operation of the M.I.T. Health Plan, a new health maintenance organization. Structured interviews with 447 enrollees and prospective members of the plan generated a forecast of consumer acceptance and led to refined design of the planned health services.

Professor Harris broadened his research on the client orientation of health care organizations, carrying out fieldwork in a sample of 12 ambulatory care organizations. Preliminary data analysis from 218 staff members and 527 patients suggests that the informational perspective the organization takes toward its patients is related to the patients' evaluation of the quality of care received. Professor Harris recently extended his studies into the military health system as well.

Dr. Rockart advanced into the data analysis stage of his studies of "disease costing" in in-patient and out-patient settings. His latest interest is on the possible role of distributed information processing systems to aid patient management in hospitals. Research initiated earlier by Professor Silk in collaboration with Professor Alvin Drake of the M.I.T. Operations Research Center was continued this year by Professor Drake during Professor Silk's sabbatical. Their studies seek to better understand the motivation of blood donors, and are funded by the US National Center for Health Services Research.

New efforts were undertaken to transfer research approaches developed earlier in the area of technology management to problems of health care technology. Professors Roberts and von Hippel collaborated with Dr. Stan Finkelstein, M.D., to examine factors affecting development and commercialization of health innovations. They have begun initial studies of user-innovator interfaces in regard to clinical laboratory instrumentation, and a research design was completed for examining entrepreneurial activities in the health care area.

Major efforts were directed at moving the health management area toward having a critical mass of program, faculty, and supporting resources. Much time was devoted to developing comprehensive plans for launching a major research and teaching center on health care management, and substantial funding is sought to implement these plans. An extensive network of collaborative linkages was developed with Boston area and national health institutions to aid in undertaking this center.

The Health Management Executive Development Program experienced its first year of operation in conjunction with the Sloan Fellows Program. As part of this program, Professors Harris and Roberts collaborated with Visiting Professor Norman Stearns, Associate Dean of the Tufts Medical School, in developing and implementing a year-long Seminar in Health Management. It was attended by 20 leaders of medical schools and hospitals, government health agencies, and health related corporations for comparative assessments of management style and effectiveness. A new group of Health Management Executives has been admitted for a similar 1976-77 Seminar, and further program development is under way.

A Concentration in Health Management was approved for participants in the regular two-year and AGP Master's degree programs, and additional Ph.D. student interests were encouraged. Recruiting of faculty interest continued. Jeffrey Harris, an M.D. and health economist, joined the Department of Economics faculty, and he will add new course offerings to the area in the fall.

STAFF CHANGES AND PROMOTIONS

Two individuals joined the Sloan School with the rank of full professor: Professor Black came to us from the University of Chicago as Professor of Finance; and Dr. Wallace, who was formerly a Visiting Professor, joined the School in the labor relations area. Professors Shapiro, Scott Morton, Mills, and Stewart C. Myers were promoted to full professor.

Professor Mason Haire was on personal leave of absence last year. Professor Little researched his field of marketing during his year-long sabbatical. Professor Thomas M. Hill spent the spring semester teaching at the Administrative Staff College at Henley, England, and completed a manuscript on planning and control.

We were fortunate to have with us as Visiting Professors in the Management Science Group, Dr. Barouch from the Department of Mathematics, Clarkson College of Technology, and Geoffrey P. E. Clarkson from the Manchester Business School, University of Manchester, England. Professor Shan S. Kuo of the University of New Hampshire was a Visiting Professor with the Management Information Systems Group.

Professors Magnanti, Pindyck, Madnick, Marsten, Lorange, Lessard, and Van Maanen were promoted to Associate Professor. Professor Welsch maintained a half-time appointment during the academic year so that he could continue research with the National Bureau of Economic Research.

New Assistant Professors appointed include Dr. Zvi Bodie who came to the Sloan School from the Boston University School of Management; Dr. Driscoll from Cornell University; Frederick L. A. Grauer from Stanford University; Dr. Kalwani from Case Western Reserve, Ohio; and Dr. Mass who received his Ph.D. in Management from the Sloan School.

Professor Cohn spent the academic year at the University of British Columbia, Canada, while Professor Grauer completed research earlier initiated at Stanford University.

Nancy Gaspard, on leave from the Boston College School of Nursing, joined the Organization Studies Group as a Visiting Associate Professor; Christoph Haehling von Lanzanauer of the University of Western Ontario joined us as a Visiting Associate Professor in Management Science for the academic year; Allen Sinai, on leave from the University of Illinois, joined the Economics and Finance Group, as a Visiting Associate Professor for the academic year; and Dr. Stearns of the Tufts School of Medicine joined the Health Management Group as a Visiting Associate Professor.

Robert M. Alloway, formerly with the Harvard Business School, joined us for the academic year as Lecturer. Drs. Barocci and William H. Gruber joined the Industrial Relations Group and Management Science Group respectively as Lecturers for the academic year. G. Allen Moulton of the Laboratory for Computer Science joined the Sloan School for the spring semester as a Lecturer in Management Science. Dr. Martin Zimmerman, a Research Associate working with the Sloan School group engaged in energy studies, has been named as Lecturer with the Management Science Group.

Samuel E. Bodily of Brigham Young University served as an Instructor with the Operations Research Group for the spring term 1976. Mr. Fry, a former SSM student, was appointed as a Research Associate in the Organization Studies Group to work specifically in the health research area. The staff of the Center for Information Systems Research was increased by the addition of C. Lawrence Meador as a Research Associate. He also will act as Assistant Director for the Center. Mr. Plovnick was appointed as a Research Associate in the Organization Studies Group to study health management.

Research Fellows for the academic year 1975-76 included Richard H. Day and George Richardson, both of whom studied with Professor Forrester and the System Dynamics Group. Dr. Albert A. Marcotte of the Boston University School of Management also served as a Research Fellow for the academic year, spearheading the development of the Management Game and its implementation with the Executive Development Programs.

Peter J.H. Baily of the Polytechnic Institute of Wales joined the Sloan School's Marketing Group as a Visiting Scholar for the spring semester. Dr. Joseph M. Mellichamp of the College of Commerce and Business Administration, University of Alabama was a Visiting Scholar with the Organization Studies Group. Michael Knowles, a Visiting Scholar with the Organization Studies Group, came from Monash University, Australia. Dr. Ib Eriksen of the Norwegian School of Economics and Business Administration joined the Sloan School as a Visiting Scholar in the area of Management Science. Visiting Scholar Lauri J. Pentti of the Finnish Institute of Management studied with the Organization Studies Group.

We are pleased to announce the change in title of Patricia M. Macpherson to Administrative Assistant in the Dean's Office. She was formerly with the Manpower and Labor Relations Group of the Sloan School. Changes in titles include the promotion of Alan F. White to Director of Executive Development Programs and Lecturer, while Professor Scott Morton was named an Associate Dean with principal responsibility for the direction of the Master's programs. Dr. Rockart was named to the position of Director of the Center for Information Systems Research, a post vacated by Professor Scott Morton.

There were two additions to the Sloan School staff. Pamela W. Turner, new SSM Director of Recruitment and Placement, is a Sloan graduate who previously was associated with Arthur D. Little, Inc. Charline P. Mahoney, the new SSM Programming Analyst, was formerly a computer analyst for the Charles Stark Draper Laboratory.

We record with regret several departures from the Sloan School. Professor Mills left to join the staff of the Harvard Business School. Professor Farris resigned to assume a teaching post at the European Institute for Advanced Studies in Management, Belgium. Professor Keen joined the faculty of Stanford University. Leslie Clift Hruby, former Director of Recruitment and Placement for the Sloan School, is now on the staff of Digital Equipment Corporation.

Finally, Professor Haire announced his retirement at the end of the academic year. We shall all miss Professor Haire's contributions to the Organization Studies area and his collegiality within the School.

WILLIAM F. POUNDS

School of Science

The science departments at M. I. T. play a dual role in research in that they seek new knowledge and study the application of basic knowledge in the solution of real problems. It would be shortsighted to work only on problems that trouble society today for it is also important to preserve the vitality of basic science and to strengthen its capacity to increase the reliable base of knowledge on which future advances are based. At M. I. T. these twin goals are represented both in instruction and research.

In September 1975, the number of undergraduate majors in the School of Science was essentially the same as in 1974 (1,113 in 1975 and 1,110 in 1974). The number of regular graduate students was up 4.3 percent (1,012 compared with 970 the preceding year).

This year two new science subjects (5.40 General Chemistry and 18.01X Mathematics) were offered to freshmen as alternate ways of satisfying Institute requirements. Chemistry 5.40 was offered both terms by Professor Alan Davison to provide a broader introduction to the basic ideas and substance of chemistry. Mathematics 18.01X, taught by Instructor Gerald A. Anderson, offered the content of 18.01 with more lectures and tutorial help.

This was the first year for the new Course XXV Interdisciplinary Science Master's Program, whose objective is to prepare students for positions in industry, government, education, and medicine where breadth as well as specialization are important and where more than a bachelor's degree is required. The development of modern industrial technology and the evolution of a more interdependent society has resulted in an important need for scientifically trained individuals who are looking ahead to employment in production, planning, and government. In this course a student may develop an individualized program with a faculty advisor. Specified programs were offered in Animal Cell Science, Science Education, and Environmental Chemistry. Twelve graduate students were enrolled in the fall term and 16 in the spring.

This year Professor John M. Buchanan has served as the Faculty Counselor for the Course XXV Interdisciplinary Science Program. In September 1975, there were 15 undergraduate majors, compared with 17 the year before.

RESEARCH

The research volume for the School is expected to be \$21,480,000 for fiscal year 1976 compared with \$19,828,000 for fiscal year 1975. (These figures do not include expenditures in the interdepartmental laboratories where School of Science faculty are involved.) This expected increase of 8.3 percent is about the amount necessary to cover increased costs due to inflation.

The astronomy program received a boost from the development of a cooperative arrangement with the University of Michigan and Dartmouth College. The three institutions joined forces to raise funds to move the University of Michigan 1.3 meter telescope to Kitt Peak

and build a new observatory. This move was made possible by gifts from McGraw-Hill, Inc. and from the Sloan Foundation. The McGraw-Hill Observatory was dedicated on November 14, 1975. Even before the dedication, this telescope was used in its new location for the optical identification of an X-ray nova discovered using the SAS-3 X-ray satellite.

FACULTY

Professor John M. Deutch will succeed Professor Glenn A. Berchtold as Head of the Department of Chemistry, effective July 1, 1976. During Professor Berchtold's five-year term as Department Head, the number of undergraduate majors in chemistry increased 30 percent and sponsored research increased significantly.

Professor Michael S. Feld will be Director of the Spectroscopy Laboratory, succeeding Professor Richard C. Lord. Professor Peter A. Wolff will be Director of M.I.T.'s Research Laboratory of Electronics, succeeding Professor Henry J. Zimmermann. Professor Daniel J. Kleitman was appointed Chairman of the Applied Mathematics Committee, succeeding Professor Harvey P. Greenspan. Professor W. Gilbert Strang was appointed Chairman of the Pure Mathematics Committee, succeeding Professor Franklin P. Peterson.

Professor David Baltimore, American Cancer Society Professor of Microbiology in the Department of Biology and head of the tumor virology group at the M.I.T. Center for Cancer Research, was named one of the three recipients of the 1975 Nobel Prize in Medicine and Physiology.

Professor Jule G. Charney, Alfred P. Sloan Professor and Head of the Department of Meteorology, received the William Bowie Medal, the highest award of the American Geophysical Union. Professor Sidney M. Hecht (Chemistry) received a National Institute of Health (NIH) Career Development Award. Professor Frank Press, Robert R. Shrock Professor and Head of the Department of Earth and Planetary Sciences, was the Killian Lecturer this year. Professor John Ross, Frederick G. Keyes Professor of Chemistry, was elected to the National Academy of Sciences. Dr. Nevin S. Scrimshaw, Head of the Department of Nutrition and Food Science, was named Institute Professor. Professor Henry M. Stommel, Professor of Oceanography in the Department of Meteorology, and Institute Professor Emeritus Victor F. Weisskopf, were among five American scientists elected foreign members of the Soviet Academy of Sciences.

Professor Samuel C. C. Ting of the Department of Physics received one of the 1975 E. O. Lawrence Awards for his work that led to the discovery of the J particle. Professor Carl I. Wunsch of the Department of Earth and Planetary Sciences received the Texas Instruments Award, given each year to a young scientist in any science. Professor B. Clark Burchfiel has been appointed Professor of Earth and Planetary Sciences and will come from Rice University in January 1977. Dr. Jeffrey Goldstone of Cambridge University has been appointed Professor of Physics and will join our faculty in spring, 1977.

Professors Lord of the Department of Chemistry and William T. Martin of the Department of Mathematics and the Division for Study and Research in Education (D. S. R. E.) retired this year. Professor Lord has been Director of the Spectroscopy Laboratory for 30 years. Professor Martin was Head of the Department of Mathematics for 21 years and was Director of the D. S. R. E. from its establishment in 1973 until June 30, 1975.

Institute Professor Norman Levinson died on October 10, 1975, after a long illness. Professor Levinson had been on the faculty of the Department of Mathematics for 38 years, and had made major contributions in both pure and applied mathematics. He had served as Head of the Department from 1968-1971 and as Acting Head in 1951-52.

Professor Mac V. Edds, Jr. died suddenly on November 29. He joined the faculty of the Department of Nutrition and Food Science as Professor of Neurobiology in January 1975, and also was Executive Director of the Neurosciences Research Program.

ROBERT A. ALBERTY

Department of Biology

This year, 397 undergraduate students concentrated in the life sciences and 147 were awarded the Bachelor of Science in biology; the previous year's figures were 412 and 144, respectively. Between July 1, 1975, and June 30, 1976, 19 Doctors of Philosophy and eight Masters of Science were awarded. Two Ph.D.s and two M.S. degrees in Biological Oceanography were awarded under the Joint Program with Woods Hole Oceanographic Institution. There were 110 graduate students in the Department during the past year. The Department was awarded an NIH Institutional National Research Service Award in the area of cellular and molecular biology effective July 1, 1975, to be conducted under the overall supervision of Professor Gene M. Brown. Approximately 34 undergraduates participated in research programs during the regular academic year. Professor Robert A. Weinberg again coordinated our undergraduate research program.

The second John L. Asinari Award for undergraduate research in the life sciences was presented jointly to Laurel Fischer and Richard Mulligan. Offered jointly by the Departments of Biology and Nutrition and Food Science, the award will be given annually to a senior or seniors in the life sciences for the most outstanding undergraduate research conducted in our departments. Professor Ethan R. Signer received the Graduate Student Council Award for outstanding graduate teaching.

The project laboratories offered by the Department are an important part of our undergraduate teaching program. To broaden our scope of teaching during 1974-75, we offered for the first time two project laboratories simultaneously. The new subject 7.021 Experimental Immunology was offered.

RESEARCH

The research by members of the Department is described in the publication "Research Summaries," available at departmental headquarters.

FACULTY

Associate Professors Malcolm L. Gefter, Harvey F. Lodish, and Paul R. Schimmel, were promoted to full Professors, and Assistant Professor Weinberg to Associate Professor. Associate Professor Annamaria Torriani-Gorini received tenure, to become effective July 1, 1977. Graham C. Walker was appointed Assistant Professor of Biology. He received his Ph.D. in 1974 from the University of Illinois, Urbana-Champaign, Illinois, after which he held a Postdoctoral Fellowship in the Biochemistry Department, University of California at Berkeley. Frank Solomon, newly appointed Assistant Professor of Biology, will be associated with the Center for Cancer Research. Professor Solomon earned his Doctor of Philosophy from Brandeis University in 1970. Prior to his appointment, he was a Research Associate at M.I.T. in the Cancer Research Center. Howard R. Horvitz has been appointed Assistant Professor. He received his Doctor of Philosophy from Harvard University in 1974, and is presently a Postdoctoral Fellow at the Medical Research Council, Laboratory of Molecular Biology, Cambridge, England. Several members of our faculty were on sabbatical during the year: Professor Gefter spent the spring term at the Albert Einstein College of Medicine in New York; Professor Vernon M. Ingram was on sabbatical for the fall term to devote full time to his research at M.I.T.; Professor Uttam Lal RajBhandary was on sabbatical for the academic year carrying out research at the MRC Laboratory of Molecular Biology in Cambridge, England; and Professor Schimmel spent the academic year at the University of California at Santa Barbara. Visiting faculty members were: William Haseltine from Harvard University; Joel A. Huberman, Roswell Park Memorial Institute, Buffalo, New York; Ronald P. McCaffrey, Children's Hospital Medical Center, Children's Cancer Research Foundation and Harvard Medical School; Moselio Schaechter, jointly with the Department of Chemistry, from Tufts University; and Stephen G. Waxman from the Harvard Medical School.

Professor Bernard S. Gould, Professor of Biochemistry and Undergraduate Registration Officer of Biology, was awarded the Gordon Y. Billard Award for special service of outstanding merit performed for the Institute. Professor Gefter received the Pfizer Award in Biochemistry for 1975 for his outstanding contributions to our knowledge of DNA replication. This prize is presented annually by the American Chemical Society for outstanding biochemical research to a scientist under the age of 35. Professor David Baltimore shared the Nobel Prize in Medicine and Physiology for 1975 for his discovery of reverse transcriptase, a discovery that opens a new area of research in virology and is of great importance in cancer research. We are particularly gratified that the work leading to this award was carried out in this Department.

BORIS MAGASANIK

Department of Chemistry

Bachelor of Science degrees in chemistry this year were awarded to 60 undergraduates (nine in February and 51 in June). Most are attending graduate school in chemistry, medicine, or related areas, or are employed by industry. Masters of Science were awarded to five students in September, one in February, and two in June. Doctors of Philosophy degrees were awarded to eight candidates in September, 14 in February, and 12 in June. One Doctor of Science degree was awarded in June. To date, the Department has awarded 1,458 Ph.D.s and 358 Master's degrees.

RESEARCH

Research is carried out by members of the faculty, postdoctoral fellows and associates, and graduate and undergraduate students continued at an active pace in a variety of fields, within chemistry and associated disciplines. The following is a description of a few representative research programs in progress in our laboratories.

Professor Carl Garland and his research group are carrying out a variety of macroscopic measurements on systems near critical points and order-disorder transitions. This work involves multicritical (tricritical and higher order) points, which are significant since they represent points where qualitative character of a phase transition changes from a continuous second-order cooperative effect to a discontinuous first-order effect.

This work on multicritical points required new experimental techniques, two of which were developed in this group recently for studies of ammonium crystals. The first one, a new interferometric technique, was developed for measuring the amplitude of very small ac displacements. Utilizing a spherical Fabry-Perot interferometer, the technique is more sensitive and less susceptible to acoustic vibrations than previous methods. This technique was used to measure displacements as small as 4×10^{-4} Å, and the theoretical sensitivity in a well-isolated environment is about 10^{-5} Å. Application of the method to the measurement of the piezoelectric constant of ND₄Cl crystals permitted a study of the variation in the order parameter very close to the order-disorder transition. The technique is quite general and can easily be adapted to other measurement problems.

An ac calorimetric technique also was developed for measurements at high pressures, and has been applied to the investigation of the order-disorder transition in NH₄Cl. Heat capacity data obtained near the "lambda" transition at 1,500 bar and 3,000 bar is equal in precision to that usually obtained at 1 atm. This new method, which helped to clarify the nature of the multicritical point in ammonium chloride, is a useful general tool for studying any phase transformation at high pressures.

In addition to investigations of solid-state transitions such as those in ammonium halides and various ferroelectric crystals, the group also studied critical phenomena in fluids. The major emphasis was on ultrasonic studies of dynamical effects in pure fluids (xenon) and binary liquids (triethylamine-water). Such experiments test and extend current mode-mode coupling theories.

Professor Sidney M. Hecht's current research interests are centered in the following three main areas:

Cytokinin Antagonists

Cytokinins are hormones which are believed to be necessary for cell division, growth, and differentiation in all plants. To facilitate study of the mechanism by which cytokinins promote their effects in plants, we designed, synthesized, and characterized two structural classes of specific anticytokinins, i. e., compounds which interfere with cytokinin utilization by plants. In collaboration with Professors Skoog and Helgeson at the University of Wisconsin and scientists at the US Department of Agriculture (Beltsville), we showed that the cytokinin antagonists oppose the action of cytokinins in promoting growth and retarding senescence in, e. g., tobacco explants. It was shown that the compounds also can be used to oppose cytokinin-mediated effects in the germination of seeds and growth of seedlings, in the maturation of fruit via ethylene production, and in the bud-breaking process.

Cytokinins also have been found to have physiological effects in mammalian cells, and have been used as anticancer agents in clinical trials with some success. We have been working with cultures of transformed cells (the growth of which are also regulated by cytokinins) and have found that in this system the "anticytokinins" act as structural analogs of the cytokinins (which they are) and reinforce the cytokinin-mediated effects.

Synthesis of Bleomycin

Bleomycin is the name given to a family of antibiotics derived from *Streptomyces*. The compounds differ only in the substituent attached to the "C-terminus" of the peptide-derived antibiotic. Bleomycin is of interest because it has clinically useful activity against lung and skin cancer, and is in increasingly wide use in this country and in Japan (where it was identified by Umezawa and his coworkers). We worked on the total synthesis of bleomycin B₂, MW 1342 with 19 asymmetric centers, in the hope that a total synthesis will facilitate the preparation of analogs with improved anticancer activity.

Transfer RNA Modifications and the Mechanism of Protein Biosynthesis

Transfer RNA is a polynucleotide of MW 25,000 which participates as a key species in protein biosynthesis by inserting the appropriate amino acid into a growing polypeptide in response to a given codon triplet on the associated messenger RNA. There is increasing evidence that tRNA also serves other functions, e.g., in the regulation of cellular processes. We are interested in tRNA function and especially in the role of modified nucleotides in the tRNA primary sequence in enhancing tRNA function. Therefore, we made selective alteration in tRNAs at single sites to permit the study of the role of the modified nucleotides.

Professor William H. Rastetter's research efforts center around two principal areas, a) the development of new synthetic methods and their application to natural product synthesis, and b) the study of reactive heterocycles implicated in biochemical transformations. Projects within each area are briefly outlined below.

Synthetic Methods/Natural Product Synthesis

Two of our synthetic targets are the natural products gliotoxin and enterobactin. Gliotoxin is one of a class of naturally occurring epidithiodiketopiperazines displaying a broad range of physiological properties, including the growth inhibition of a variety of organisms. We developed new methods for the synthesis of epidithiodiketopiperazines directly from amino acids, and plan to screen the synthetic materials for their potential as chemotherapeutic agents. Our gliotoxin related work is directed also toward the synthesis of the 6-5 fused dihydrobenzene ring system of the natural product.

Enterobactin, a macrocyclic triester of serine, is produced by bacteria such as *Escherichia coli* for use in ferric iron transport. We developed methods for large ring lactone synthesis which may be applied to a synthesis of enterobactin. The synthetic approaches include the use of a ferric template for the closure of the enterobactin 12-membered ring.

Biomechanism/Reactive Heterocycles

Four reactive heterocyclic systems studied in our laboratory were 1, 2-dithiolanes, oxaziridines, arene oxides, and oxepin oxides. A 1,2-dithiolane, lipoic acid, is implicated

in a α -ketoacid decarboxylase enzyme systems. Our goal is an in vitro duplication of the enzymatic oxidative decarboxylation of pyruvate to acetyldihydrolipoic acid. Our approach employs the Merrifield resin, commonly used in solid phase peptide synthesis, to aid in the isolation and purification of the desired product.

Flavin derived oxaziridines may be involved in flavin cofactored enzymatic oxidations, and may be particularly well suited to undergo C-O bond homolysis. The diradical species so produced would resemble the photo-excited state of the corresponding isoalloxazine 5-oxide, a species thought capable of oxygen transfer to a variety of substrates. We currently are synthesizing fat soluble isoalloxazine 5-oxides for use in model systems to test this hypothesis. Flavin oxaziridines may also be involved during the emission of light by certain bacteria. Thus, the homolysis of the flavin oxaziridine C-O bond and emission of light would generate the isoalloxazine 5-oxide. This ground state itself may be involved in bacterial aldehyde oxidation. A model system for this biological reaction is contemplated also.

Arene oxides and oxepin oxides are strongly implicated in the activation of aromatic substrates by oxidizing enzymes. We studied the use of arene oxide intermediates in a "biogenetic-type" synthesis of gliotoxin (vide supra). We also studied the synthesis and reactivity of oxepin oxides as models for the involvement of these compounds in biogenesis and carcinogenesis.

Professor Richard R. Schrock's research interests are synthetic and mechanistic organo-transition metal chemistry and homogenous catalysis. He explored the fundamental reactions of early transition metal complexes (metal = Nb, Ta, Zr, W, Mo) which contain multiple metal-carbon bonds.

In general the goals are: to develop the little-known organometallic chemistry of the early transition metals, to explore the possibility of useful stoichiometry reactions involving such "reagents," and to discover any potentially useful catalytic reactions based on the new complexes.

Professor Schrock presently has five graduate students. Three synthesized new Nb and Ta complexes and studied stoichiometric reactions. Another studied the catalytic reactions. The fifth attempted to extend some of this chemistry to Zr, Mo, and W.

FACULTY

Professor John M. Deutch, a physical chemist and member of the M.I.T. faculty since 1970, became Head of the Department on July 1, 1976. He succeeded Professor Glenn A. Berchtold, who returned to research and teaching after serving the customary five-year term as Department Chairman.

Dr. Richard C. Lord, professor of chemistry and director of its Spectroscopy Laboratory, retired after 34 years at M.I.T., 30 of which were in the Department of Chemistry.

Professors Christopher T. Walsh and Mark S. Wrighton were promoted to the rank of Associate Professor.

Dr. F. Read McFeely joined the staff as an Assistant Professor in physical chemistry. Professor Richard H. Holm left the Department to accept a position at Stanford University.

We were saddened by the death of Dr. Frederick G. Keyes on April 14, 1976.

Professor John Ross was appointed Chairman of the Faculty. He also was elected to the National Academy of Sciences.

Professor John S. Waugh, the Arthur Amos Noyes Professor of Chemistry, was awarded the 1976 American Chemical Society's Irving Langmuir Award in Chemical Physics for contributions to the field of magnetic resonance and its application to chemistry and physics.

Professor Peter Weyerstahl of the Technical University of Berlin, Germany was a Visiting Professor in the Department. Other visiting faculty and scientists were: Robert L. Blakeley of the University of Queensland, Australia; Kageyasu Akashi of the University of Tokyo, Japan; Ender E. Erdik of the Ankara University in Turkey; Ki-Hyup Kim of the Seoul National University in Korea; Esteban Marlina Boggetto of the University of Mexico in Mexico City; Kazu Nishigaki of the Kobe University in Victoria, Australia; Bernhard F. Schramm of the University of Heidelberg, Germany; and Takashi Yasumura of the Kyushu University in Fukuoka City, Japan.

The Department was privileged to sponsor a series of lectures provided by the Arthur D. Little and Karl Pfister Visiting Professorships. Arthur D. Little Visiting Professor P. G. deGennes of the Université de Paris-SUD lectured on "Flexible Polymer Solutions: Neutron Experiments and Static Scaling," "Dynamics of Flexible Chains. I. The Coil Stretch Transition in Dilute Solutions. Possible Applications to Drag Reduction in Turbulent Flows," and "Dynamics of Flexible Chains. II. Dynamic Scaling for Entangled Systems." Professor Samuel Danishefsky, Karl Pfister Visiting Professor, from the University of Pittsburgh gave three lectures: "Stereospecific Syntheses of Vernolepin and Vernomenin," "A. New Dienes for the Diels-Alder Reaction. B. An Asymmetric Synthesis of Steroids from 2,6-Lutidine," and "Applications of Activated Cyclopropanes to Organic Syntheses."

GLENN A. BERCHTOLD

Department of Earth and Planetary Sciences

Student enrollment remains about the same as in previous years, with 116 graduate students and 69 undergraduates. The distribution of students in the Department's various fields is as follows: geology and geochemistry, 19; planetary science, 21; geophysics, 38; oceanography, 38. One hundred of the graduate students received financial assistance, mostly research assistantships on various projects. We were able to employ 55 undergraduates on research projects, most of them as research assistants.

Curriculum Changes

The geology curriculum expanded to include a year-long course in field geology. This course emphasizes basic principles of field geology, and covers topical aspects of modern field work from ERTS image analysis to ground water evaluation. In addition to field and laboratory exercises around M.I.T., the course includes four weeks of fieldwork during January in the Big Bend-Marathon Basin country of southwest Texas.

Visiting Professors Charles F. Park, Jr. and Claude J. Allegre offered courses in economic geology and the geochemical basis of ore deposits.

RESEARCH

Professor Carl Wunsch made considerable progress in understanding the oceanic internal wave field. The ocean as a whole appears to be in some form of radiative equilibrium of internal waves with the field being at a virtually universal energy level with purely isotropic propagation. One large source of internal waves, a seamount, was discovered, but the field surprisingly returns to the background equilibrium in a very short distance by mechanisms that are mysterious. He also found that in the near equatorial region the linear waveguide model of internal waves is confirmed in observations, and permits one to describe the forced monsoon response in very simple theoretical terms. At the very high frequency end of the internal wave band, where the physics shades into turbulence, Professor Wunsch found a complete partition as a function of frequency and wavenumber of wave energy versus non-propagating "fine-structure."

Professor John Sclater and Dr. Barry Parsons obtained an important result relating depth of ocean, heat flow, and age of the sea floor. They showed that for sea floors older than 80 million years, the depth as a function of age flattens rather than continuing to deepen as a function of the square root of age. This discovery has major implications for thermal convection in the upper mantle, perhaps establishing the amount of heat delivered by convective processes. In February and March, Professors Sclater, John Dickey, and Sean Solomon and Dr. Parsons established the position of the Indian Ocean triple junction within 5 km. The three-plate boundary seemed to have a ridge-ridge-ridge configuration, which was expected, but it is probably unstable, which was not expected.

The George R. Wallace, Jr. Geophysical Observatory, dedicated in May 1975, and directed by Professor M. Nafi Toksöz, boasts sensitive seismometers and other geophysical instruments located in an environmentally controlled underground vault. This machinery can detect seismic waves generated by earthquakes throughout the world. Their data is telemetered directly to M.I.T. to be recorded 24 hours per day. When analyzed, data provide valuable information on the internal structure of the earth and the nature of earthquakes. Several instruments in the Observatory, such as the tiltmeters, are unduplicated elsewhere. The Observatory also is the focal point for M.I.T.'s New England Seismic Network consisting of six remote telemetered stations designed to monitor local earthquake activity in eastern Massachusetts and central and southern New Hampshire. At least three additional stations are planned for installation this summer. The New England region has a long history of seismic activity and the network will help to evaluate present day levels of seismicity and seismic risk along with providing information on the crustal structure. Supplementary data is also obtained from the Northeastern US Seismic Network Consortium, of which M.I.T. is a participating member.

To further test driving force models for plate tectonics, Professor Solomon and colleagues studied the relative and absolute motions of the plates in the early Tertiary, a time before the separation of the last two major fragments of Gondwanaland and thus a time of plate geometries significantly different from the present. The plate velocities predicted for that period by current driving force models do not show a simple dependence on plate type or on plate boundary type. Neither oceanic character nor active subduction appears to be a sufficient condition for rapid plate motion, and the asthenosphere beneath continents does not appear to exert significantly more drag on the overlying lithosphere than that beneath

the oceans. Theoretical plate velocities do not agree well with motions predicted from the hypothesis of fixed hot spots. At least some of the seamount chains supposed to be products of plate motion over a hot spot may be due to intraplate deviatoric tensional stress associated with plate boundary forces. The bends in Pacific seamount chains are hypothesized to be due to a change in the intraplate stress field as the northern boundary of the Pacific plate changed from a ridge to a trench.

Professor Peter Molnar and Dr. Paul Tapponnier are studying the tectonics of Asia, and find that the pattern of deformation there is very similar to the slip-line field for plane plastic indentation problems. India acts as an indenter, and Eurasia north and east of it seems to behave plastically. The high altitudes of Tibet and the Himalayas are a consequence of the large mean stress near the indenter, India. Major strike slip faults in Central Asia have the sense of motion expected from the analogous slip-line fields. The zone of extension yet further north and east, Lake Baikal, Siberia, and northeast China, corresponds to the regions of tension far from the indenter in the core when the plastic material is bounded. From the elevation of Tibet they estimate the "yield stress" of Asia to be a few to several hundred bars. Thus, Professor Molnar and Dr. Tapponnier have a way of treating the large scale tectonics of continents quantitatively.

Professor Keiiti Aki and his colleagues have made progress in understanding the nature of short period seismic waves, with important applications. They have been able to predict the ground motion above a sedimentary basin due to a nearby earthquake, an important factor in the destruction of buildings. They have revised the three-dimensional seismic velocity anomalies for central California and the island of Hawaii, thus providing new insights into the structure of the lithosphere in these regions. They have developed a model of the seismic source connected with volcanic tremors. Professor Aki's group has also been involved with automatic detection and identification of seismic signals, an important initial result for use in an automated earthquake prediction network. Progress is being made on transmission seismic holography, which may make possible the detection of inhomogeneous regions of the lithosphere.

Professor Tanya Atwater and graduate student Ken MacDonald discovered that transform faults are not perpendicularly aligned with slowly spreading mid-ocean ridges, as had been previously thought. The geometry is established in such a way as to shorten the faults. This result is important because it allows comparison of the energy dissipated by transform faulting with that involved in emplacement of material at the ridge. The energy involved in the latter process in turn constrains the models which one may construct for ridge crest dynamics and formation of oceanic lithosphere.

Fluid permeability in rocks is of critical importance both in the extraction of geothermal energy from buried hot rocks and in models currently used to explain earthquake premonitory phenomena. Permeability is difficult to measure in rocks, and it would be useful to find a simple correlation with more easily measured properties. One of these is electrical conductivity, and Professor William Brace and colleagues have discovered a simple relationship which seems to predict measured laboratory values not only for porous sandstones but also for dense crystalline rocks. This may provide some way of estimating permeability of in situ crustal rocks.

Professor John Southard and his students continued studies on erosion of marine bottom sediment with the newly developed bottom flume, a device which creates a controlled and remotely observable current of sea water over an undisturbed area of the sea floor. Flow strength necessary for incipient erosion, as well as rate and mode of continuing erosion, can be studied in detail in the natural environment without artificial disruption of the sediment bed. They have found that, in areas of fine mud populated by burrowing organisms, delicate surficial aggregates of sediment are eroded at surprisingly low current velocities,

of the order of 8-10 cm/sec. One area in which this flume has been used is the New York Bight, in cooperation with the National Oceanic and Atmospheric Administration. Sediment there is a mixture of sand and mud with a rich bottom fauna, with much of the fine material derived from New York City sewage sludge. The fine sludge-rich material was found to be set into motion by very gentle currents, and as this material is winnowed away, current ripples are rapidly generated in the residual sand. The sewage sludge can thus be widely disseminated by the normal regime of waves and currents, and become readily assimilated into the natural fine-sediment environment rather than remaining concentrated and segregated for long periods of time.

Partitioning of nickel between olivine and silicate melt has been determined in the system forsterite-albite-anorthite at temperatures between 1250°C and 1450°C by Professor Hart and graduate students Karleen Davis and Bruce Watson. A principal result is the demonstration of a major dependence of the partition coefficient on melt composition, as opposed to the temperature dependence which was heretofore considered dominant. The low nickel content of island arc andesites may no longer be evidence against a derivation of andesite by direct melting of mantle peridotite; and the high nickel content of many oceanic basalts is no longer incompatible with significant amounts of olivine crystallization during magma ascent.

Professor Hart, working with Chris Brooks and David James, surveyed all Rb-Sr-Sr isotope data on continental and oceanic volcanic rocks and found systematic isochron relationships, probably reflecting derivation from an aged and heterogeneous mantle. A new model was formulated for continental volcanism in which melts are derived by tectonic reactivation of old subcontinental lithosphere. The oceanic data, in conjunction with Pb isotope data, suggest that the source region of oceanic volcanics became chemically heterogeneous during a major mantle event about 1.7 billion years ago.

The research group led by Professor Roger G. Burns was active in a variety of projects involving the geochemistry of transition elements in deep-sea manganese nodules, the earth's mantle, the moon, and gem minerals. In the Manganese Nodule Project, research centered on explaining why nodules from certain regions, most notably the seafloor beneath the north equatorial Pacific, contain significant concentrations of nickel, copper, and cobalt, making these manganese nodules potential ore deposits. Electron microprobe and scanning electron microscope measurements of the nodules have led to a better understanding of how the extremely small minerals found in nodules concentrate the strategic metals into their crystal structures. Sponsored Research Staff member Virginia Mee Burns has discovered evidence of dissolution and recrystallization processes which took place inside certain nodules at later stages of their growth histories, and which caused the metals to be enriched in the nodules after they formed. Some offshoots of this research, resulting from a new classification of the crystal chemistry and structures of host manganese oxide minerals (some of which are found in nodules), have been an explanation of the adverse fixation of nutrient metals in certain soils and interpretations of cell reactions taking place in LeClanché and alkaline batteries.

An important new area of research, which was developed during the Ph.D. thesis project of Chien-Min Sung, is the measurement of the kinetics of the olivine→spinel transition at high pressures and temperatures, simulating conditions found in the earth's mantle. Dr. Sung designed and built a new type of diamond anvil press capable of generating temperatures and pressures of up to 1000°C and 250 kb, which was used to observe the rate at which common olivine transforms to the more dense spinel phase. Results of the kinetics measurements have applications to the origin of deep-focus earthquakes and to the driving mechanism for plate motion along subduction zones.

The radio-interferometry group of Professors Irwin Shapiro and Charles Counselman obtained data over a five-year period which shows that the compact extragalactic source, 3C 345, consists of two components, and that these appear to be separating at about three times the speed of light. This result differs from the M.I.T. group's initial 1971 discovery of "faster-than-light" apparent expansions in an important way: here, for the first time, enough data were available to determine the structure of the source in a model-independent manner; that is, the source was not assumed to consist of two components, but rather was shown to consist of two components. Very recent data indicate that the separation velocity is now increasing with time. Many theories have been put forward to attempt to explain these rather startling results. So far none has proven satisfactory. The group also developed a technique for the elimination of the 2π ambiguity in very long baseline interferometry ("VBLI") phase measurements for the determination of baseline vector components. This elimination potentially reduces the uncertainty in baseline and earth-motion determinations to the millimeter level for few-kilometer baselines. The technique was tested in 11 independent determinations of a 1.24-kilometer baseline. The results scattered by only a few millimeters in all three coordinates. With the use of other recently developed techniques for the calibration of atmospheric delays, it should soon be possible to determine intercontinental baselines with centimeter-level uncertainties, and thus to measure tectonic plate motions directly over a few years' interval of observation.

Professor Gordon H. Pettengill was involved in several planetary observing programs using ground-based radar, with emphasis on the mapping of Venus, surface reflectivity and orbits of the Galilean satellites of Jupiter, and the rings of Saturn. The maps of Venus have disclosed the presence of large-scale (order of 1,000 km), very rough surface features with irregular but sharply defined boundaries, whose origin is probably tectonic. The observations of the four large satellites of Jupiter show that Europa and, to a lesser extent, Ganymede have extremely rough but highly reflective surfaces probably consisting of water ice. Io and Callisto also have rough but not unusually reflective surfaces. The rings of Saturn seem to scatter radio energy very efficiently and in a manner almost, but not quite, consistent with the optically observed radial distribution of ring material.

Professor Thomas B. McCord and his colleagues continued their work on the composition of the surfaces of terrestrial bodies using reflection spectra. Photometric imaging of Mars during the 1973 opposition revealed a huge ring of H₂O frost and fog that was pulsed from the regolith in the vicinity of the centrally located Solis Lacus dust storm. The volume and distribution of the H₂O provide information about atmospheric circulation and thermal structure at the onset of the storm. Photometry of small areas (200-400 km diameter) indicates that all bright areas and dust clouds are composed of the same basic unit, while dark areas show regional variations. The dark areas are composed of basaltic and ultrabasic materials, and the bright areas are composed of weathering products of the dark areas. The bright area dust is composed principally of clay minerals, ferric oxide, and calcium carbonate, and its formation has been a huge sink for volatiles. Between 10^2 and 10^5 gcm⁻² of H₂O and 10^1 - 10^4 gcm⁻² of CO₂ were irreversibly consumed over geologic time.

The mineralogy of the surface of 70 asteroids was worked out using our collection of reflectance spectra for about 200 asteroids. There appear to be nearly equal numbers of metal-silicate and carbonaceous chondrite-like asteroids and a few metal-rich objects. Mineral assemblages like those found in meteorites are common, although ordinary chondrite material appears much more common among meteorites than among asteroids.

FACULTY

Dr. Stanley Hart joined the Department as Professor of Geological Geochemistry. Professor Wunsch was promoted to a full professorship, and Professors Dickey and Christopher Goetze advanced to associate professorships. Professors Frederick Frey and John Lewis were on sabbatical leave during the year.

Professor Wunsch received the Texas Instruments Foundation Founders Prize. Professor Lewis received the Macelwane Award of the American Geophysical Union. The Mineralogical Society of America Award for 1975 was presented to Professor Burns. Professor Shapiro received the Albert A. Michelson Medal of the Franklin Institute, and the Twenhofel Medal of the American Association of Petroleum Geologists was presented to Professor Emeritus Robert Shrock. Professor Frank Press was named Killian Lecturer for the 1975-76 academic year.

FRANK PRESS

Department of Mathematics

This year's report on the Mathematics Department begins on a sad note. On October 10, 1975, Norman Levinson, Institute Professor, Professor of Mathematics, and former Head of the Department, died after a five-month illness. Professor Levinson was the heart of mathematics at M.I.T., a man who combined creative intellect of the highest order with human compassion and an unremitting dedication to science and to excellence in its pursuit. He dedicated 46 years of his life to mathematics and to this Institute.

Much of Professor Levinson's early work centered around Gap and Density Theorems, the results of which were published in 1940 in the distinguished series, American Mathematical Society Colloquium Publications. He then decided to shift his field to Non-Linear Differential Equations, and the substantial results he subsequently obtained from this work were officially recognized in 1954, when the American Mathematical Society awarded him the Bocher Prize, which is awarded once every five years for outstanding work done in the US in the field of mathematical analysis. The work Professor Levinson did on general methods in random signal theory, and in particular on seismic signal processing, led to greatly improved seismic geophysics prospecting techniques and vastly enhanced oilfield discoveries.

After this, Professor Levinson went on to work in probability, complex programming, and, more recently, in analytic number theory. Since 1859, a string of mathematical giants had attempted (unsuccessfully) to prove a result in analytic number theory known as the Riemann Hypothesis. About two and a half years ago, at age 61, Professor Levinson proved the strongest result yet known in the direction of the Riemann Hypothesis, and he was still making substantial progress on the problem when his illness came.

The scope and depth of his work in mathematics were recognized by his scientific colleagues in 1967, when he became the fortieth mathematician in the National Academy of Sciences.

In addition to his research career, Professor Levinson had an extremely successful career as a teacher. He supervised over 35 doctoral students, many of whom moved on to successful careers in mathematics themselves. In 1971 he was awarded the Chauvenet Prize of the

Mathematical Association of America for an outstanding expository paper published in English. It appears that Professor Levinson is the only person ever to have received both the Bocher Prize for outstanding research in analysis and the Chauvenet Prize for outstanding exposition.

In 1971 Professor Levinson's many contributions to M.I.T. were recognized when he was made an Institute Professor. He will be long remembered by the Department and by the Institute.

The year saw a change in chairmanship of both the Applied and Pure Mathematics Committees. Professor Daniel Kleitman, as Chairman of the Applied Mathematics Committee, succeeds Professor Harvey Greenspan, who for the past nine years led the development within the Department of the current strong group in applied mathematics. Professor W. Gilbert Strang took over as Chairman of the Pure Mathematics Committee from Professor Franklin Peterson, who completed a three-year term in that position. Professor Arthur Mattuck continued as Chairman of the Undergraduate Committee in the Department, and Professor Michael Artin succeeded Professor Strang as Chairman of the Graduate Committee.

This year also witnessed the establishment of a Department Council, replacing the former Departmental Committee. The Council's primary functions are to provide for close coordination and liaison within the Department, for discussion of all issues and proposals affecting its basic structure, and for consideration of recommendations for tenured appointments. It consists of the Head of the Department (who acts as Chairman of the Council), the Chairmen of the Applied Mathematics Committee and the Pure Mathematics Committee, the Chairman of the Undergraduate Committee, and five additional tenured faculty members, one appointed by the Department Head and two each by the Committees on Applied and Pure Mathematics.

Undergraduate Program

Because fewer new teaching positions are available in mathematics these days, the number of undergraduate mathematics majors has declined somewhat both nationally and at M.I.T. in recent years. In 1975-76, however, the number of new sophomore majors went up, so the trend may have bottomed out. Comparative figures are:

	<u>1974-75</u>	<u>1975-76</u>
Total number of majors	254	243
New sophomore majors	53	65

Seven senior mathematics majors won NSF Fellowships for graduate study. The Putnam team placed fourth nationally, with two members winning honorable mention.

The Department is trying two new ideas for the service courses this year. We bought a few small programmable calculators, and are writing problems in the calculus and differential equations courses which will require the calculators for their solution. We hope this will be helpful to less abstract-minded students, who learn more from doing concrete calculations than reading formulas and theorems. We also plan to make short videotapes of troublesome topics in these subjects, or of supplementary material, for students to screen on playback machines. M.I.T.'s new cable TV system started operation this January, offering possibilities for mass instruction.

Graduate Program

Applications for admission to the graduate mathematics program totaled 306, out of whom 133 were admitted and enrolled. Funding continues to be tight; nevertheless, 33 new students were fortunate in obtaining funding, as follows: teaching assistantships, nine; NSF Fellowships, seven; Danforth Fellowships, three; Applied Mathematics Fellowships, two; National Fellowships (minority), one; funds from the US Army, one; foreign grants, seven. Three students were self-supporting.

During the year, an M.S. program was developed for students specializing in statistics. This is a departure from the custom of the last 10 to 15 years of admitting only Ph.D. candidates. The program will provide enough background and experience to develop useful statisticians for industrial positions. For doctoral students specializing in statistics, it will provide enough applied background to make meaningful the more theoretical coursework that will follow. Finally, we hope the subjects will attract students from other departments with specific applied problems, which would enliven the program.

FACULTY

Promotions and new appointments in the Department for the year are as follows: Steven Kleiman was promoted to full Professor; Associate Professor Richard Stanley was granted tenure; Norberto Kerzman, Eugene Kleinberg, and James Mark were promoted to Associate Professors; Michael Proctor was promoted from Instructor in Applied Mathematics to Assistant Professor; and Richard Melrose and Dorian Goldfeld were appointed Assistant Professors.

Visiting Professor Michael Rabin from The Hebrew University of Jerusalem taught subjects in decidability and the theory of computation. Visiting Professor Klaus Hepp was on a joint appointment with the Departments of Mathematics and Physics. A professor of Theoretical Physics at the Eidgenössische Technische Hochschule in Zürich, he is a world leader in mathematical physics. Dr. Michele Vergne, of the Centre National de la Recherche Scientifique (CNRS) in France, also visited the Department this year, and taught a graduate seminar in group representations. She will be visiting our Department again in spring, 1977.

In the area of faculty achievements, Professor C.C. Lin was awarded the Timoshenko Medal for 1975 by the American Institute of Mechanical Engineers. It was presented to Professor Lin "for outstanding contributions to fluid mechanics, especially to hydrodynamic stability and turbulence, superfluid helium, aerodynamics, and galactic structures."

Professor Stanley received the Polya Prize by the Society of Industrial and Applied Mathematicians. This prize is given approximately every three years "for outstanding work in combinatorics and discrete mathematics." Professor Stanley was awarded the prize for determining the maximum number of faces of a given dimension in a convex polyhedron. The prize is shared with Professor Richard Wilson (Ohio State) and Professor Endri Szemerédi (Budapest).

On leave during the 1975-76 academic year were Professors Louis Howard (California Institute of Technology), I.M. Singer (Institute for Advanced Study), David Schaeffer (Institut des Hautes Etudes Scientifiques -- IHES -- France) on a Sloan Foundation Fellowship. In the fall, Professor Mark (Kitt Peak National Observatory) and Professor George Thomas were

on leave, while in the spring Professors Lin (China), Peterson (IHES), Kleiman, Richard Dudley (Aarhus, Denmark), Victor Guillemin (IHES), and Richard Schafer were on leave.

KENNETH MYRON HOFFMAN

Department of Meteorology

The year saw modest growths in student enrollment and support for faculty research. No substantial curricular changes took place, but Ph.D. and M.A. program guidelines were clarified and sharpened. The Department had the pleasure of welcoming the first visiting delegation of meteorologists from the People's Republic of China.

Graduate Program

Reflecting additional research support and countering the national trend, graduate student enrollment increased from 52 to 59. Of these, five were women, two were native minorities, and 16 were foreign nationals. Nine Doctors of Philosophy (six in meteorology and three in physical oceanography) and seven Masters of Science were awarded.

RESEARCH

The Weather Radar Project directed by Senior Research Associate Pauline M. Austin developed instrumentation and techniques for making radar measurements in storms, observed storms, and studied storm structure and precipitation mechanisms. A radar system was constructed for participation in the Global Atmospheric Research Program's Atlantic Tropical Experiment (GATE) during summer, 1974. Extensive measurements were made from a shipboard installation in the tropical Atlantic Ocean. The data taken there and the observations made locally served as a basis for quantitative descriptions of precipitation patterns in tropical disturbances and in New England storms. Of particular interest is the effect of cumulus convection on the vertical transport of heat and momentum. The project developed a numerical kinematic cell model in three dimensions to help in interpreting the observed distributions of radar reflectivity in terms of up- and down-draft characteristics.

Professor Robert C. Beardsley, who transferred to the Woods Hole Oceanographic Institution, continued as a Lecturer to supervise the research of two graduate students. One completed his thesis on the sensitivity and predictability of mesoscale eddies in a model ocean, and the other completed his research and the organization of data obtained in a 1974 field experiment designed to study the winter-time currents and sea-level and density variations over the continental shelf south of New England.

Professor Jule G. Charney continued to research desert-monsoon circulations in collaboration with Research Associate Edwin K. Schneider and scientists at NASA's Goddard Institute for Space Studies (GISS). He hypothesizes a biogeophysical feedback mechanism at desert margins, according to which a decrease of vegetative cover leads to an increase of albedo, a decrease of precipitation and therefore a further decrease of vegetation. This theory received additional confirmation in its geophysical aspects from numerical studies with the

GISS general circulation model. He and Professor Eugenia Kálnay de Rivas collaborated in testing another of his hypotheses, that the statistical properties of certain weakly turbulent rotating fluid flows which form as instabilities of laminar stationary flows can be inferred from a knowledge of the mathematically possible but unstable periodic flows which result from breakdown of the stationary flows. Preliminary tests with highly truncated mathematic models of the circulation of a rotating differentially-heated annulus seemed to confirm his hypothesis. If further confirmation is obtained from more general tests, the method will be applied to the problem of inferring the climate directly from the mathematical models of coupled atmosphere-ocean circulations. Professor Charney also collaborated with Professor de Rivas and Research Associate Lee-or Merkin on numerical studies of orographically induced cyclogenesis. Three of his doctoral students completed dissertations, one on equatorial wind-driven ocean circulations, another on the formation of Indian monsoon depressions, and the third on the stability of finite-amplitude baroclinic waves. A fourth student is nearing completion of a thesis on the formation of hurricane rain bands as a boundary-layer instability phenomenon.

Professor John E. Hart completed a study of the circulation of the polar ocean driven by wind stresses on the ice pack. He showed that the asymmetry of the circulation can be explained by taking into account secondary baroclinic instabilities of the primary, frictionally driven, stationary, laminar flow. He also completed a combined experimental and theoretical study of the dynamics of the periodic regimes that develop in a two-layer differentially rotating fluid.

Professor Edward Lorenz investigated the extent to which certain gross properties of the weather, such as temperatures averaged over a continent or a hemisphere, are predictable a month or more in advance. It is generally accepted that details of the weather pattern are not predictable at this range. Numerical solutions of medium-sized atmospheric models have been extended over many months. Some of these solutions indicate extended range predictability. Current investigations are addressed to the question as to whether this apparent predictability results from oversimplification of the models.

Professor Erik L. Mollo-Christensen studied the dynamics of nonlinear internal and surface waves including source dynamics, scattering and refraction phenomena, thermohaline interactions, topographic generation, modulational instability, modulational resonant interactions, and focusing and breakdown. Research tools used in these studies include satellite observation, laboratory experiment, and computer processing and analysis.

Professor Reginald E. Newell's group enjoyed success in studies of the multifarious observations which characterize climatic fluctuations. Monthly mean sea surface temperature data for the Pacific were subjected to a principal component analysis, with the finding that the first component, after seasonal variations are removed, has a time series whose temperature changes precede those of the mean temperature of the tropical troposphere by about six months. Significant variance of the tropical tropospheric temperature also originates from volcanic eruptions. However, when the sea surface temperature contribution was removed from the observed mean temperature changes, it was found that the eruption of Mt. Agung in 1963 reduced the temperature of the tropical troposphere only by 0.5°C , in contrast to the observed increase in the tropical stratosphere of 5°C found previously.

Professor Ronald G. Prinn and Research Associates Derek Cunnold and Fred N. Alyea continued the development of a three-dimensional atmospheric circulation model which includes all relevant ozone chemistry. This model is used to study dynamical processes and the nature of the transports of minor constituents in the stratosphere and mesosphere. In addition, the model is used to examine the effects of hydrogen chloride from the space shuttle and fluorocarbons from spray cans and refrigeration equipment on atmospheric ozone. The model also may be used to investigate the implications of the increased use of

fertilizers for atmospheric ozone. As the world emphasis of research on these issues shifted to the measurement of minor constituents of the stratosphere, Drs. Cunnold and Alyea became particularly concerned with the problem of the interpretation of such measurements in consideration of the substantial variability of the atmosphere. They are currently advising scientific groups concerned with stratospheric measurements on planning to maximize the usefulness of the data to be obtained.

Professor Prinn also developed models for the sulfuric acid and sulfur clouds on Venus and suggested that the red markings on Jupiter, including the Great Red Spot, are due to the production of red phosphorus from phosphine. His work with Professor John S. Lewis of the Department of Earth and Planetary Sciences on atmospheric evolution culminated in a book entitled "Origin and Evolution of Planetary Atmospheres" to be published by Freeman and Company.

Professor de Rivas developed a fourth-order finite-difference scheme for the general circulation model of the Goddard Institute for Space Studies. The scheme produces more accurate forecasts than those now made with a second-order scheme. She also completed a three-dimensional model for the atmospheric circulation of Venus, started research on the four-day circulation of Venus, and finished a study of steady, stratified flows over mountains with Research Associate Merkine. In addition, Professor de Rivas developed a two-layer model for the study of flow over topography. This model is used to obtain a steady state solution of the atmosphere in the presence of asymmetric forcing. She also developed a conservative difference scheme for isentropic coordinate models which includes heating and should permit extended integrations in time.

Professor Frederick Sanders and his students examined the structure and dynamics of extra-tropical storms which are directly or indirectly associated with cumulus convection. A physically consistent picture of the relatively large, relatively long-lived thunderstorm systems of the Central United States is beginning to emerge. With respect to the tropics, attention focused on the formation of long-lived convective storms in relation to the large-scale flow fields in which they are embedded. Also, estimates of winds derived from satellite observations of cloud motions were applied to a dynamical model previously developed by Professor Sanders for the prediction of hurricane tracks.

A field program conducted by Professor Henry M. Stommel uses 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 the University of California, University of Miami, Nova University, the Woods Hole Oceanographic Institution, and the National Institute of Oceanography of India. The western tropical Indian Ocean exhibits the most extreme variability of current regimes of any ocean due to the seasonally shifting wind systems. Therefore, it is a favorable part of the ocean in which to test the dynamical theories constructed to explain the ocean's response to variable forcing, and hence an important test area for developing ideas eventually to be applied to joint atmospheric-oceanic climate models.

Professor Stommel is currently cochairman, with Professor Allan R. Robinson of Harvard University, of the US POLYMODE Organizing Committee. POLYMODE is a joint US/USSR program to be carried out in the Western North Atlantic. The main field effort, to be carried out from July 1977 to July 1978, is designed to provide information on the geographical distribution of mesoscale eddies and their interaction with the mean ocean circulation. This work is a follow-up to the 1973 Mid-Ocean Dynamics Experiment (MODE-I), initiated by Professor Stommel. The main outlines of the joint program have been set, and work is proceeding on detailed planning for the many fieldwork components, including moorings,

shipboard density measurements, satellite data, free-drifting float studies, theoretical work, and other techniques. Professor Stommel is also a member of the US/USSR Joint POLYMODE Organizing Committee and of the US POLYMODE Density Committee. He is the Principal Investigator responsible for the POLYMODE Executive Office, located at M. I. T.

Professor Peter H. Stone collaborated with the Goddard Institute for Space Studies (GISS) on simulating seasonal changes with a global general circulation model, and on the development of diagnostic methods for analyzing Pioneer photopolarimeter UV images of the Venus atmosphere. He also extended his earlier work on the parameterization of atmospheric eddy fluxes to include the effects of spherical geometry for use in simplified general circulation models. Professor Stone directed student research on the development and application of simplified models of seasonal change on the earth and Mars, the parameterization of stratospheric eddy fluxes, the dynamics of the Walker circulation, and the development of simple heat balance climate models.

FACULTY

The Department was saddened by the death of Professor Emeritus Victor P. Starr. Discovered by C. -G. Rossby while still an obscure observer in a Florida weather station, Professor Starr rose to international eminence for his fundamental studies of large-scale eddy transports in the general circulation of the atmosphere.

Professor Hart returned to Colorado University to pursue his mountain naturalistic studies as well as his scientific research. Glenn R. Flierl of Harvard University was appointed Assistant Professor of Physical Oceanography and David A. Randall of the University of California at Los Angeles was appointed Assistant Professor of Meteorology. Ronald Prinn was promoted to Associate Professor. There were three visiting professors: Arnt Eliassen, Director of the Institute of Geophysics of the University of Oslo; Edwin Kessler, Director of the National Severe Storms Laboratory of NOAA; and Yoshimitsu Ogura, Director of the Laboratory for Atmospheric Research of the University of Illinois. Other visitors for extended periods were Drs. Andrea Buzzi, Antonio Speranza, and Anna Trevisan of the Institute of Physics of the University of Bologna, and Dr. John W. Kidson of the New Zealand Meteorological Service.

Honors and Awards

Professor Charney was presented with the highest award of the American Geophysical Union, the William Bowie Medal, for "outstanding contributions to geophysics and for unselfish cooperation in research." Professor Stommel was elected a foreign member of the Academy of Sciences of the USSR, an honor which is bestowed on foreign scientists only once every five years. John C. Willett's thesis, "Fair Weather Electric Charge Transfer by Convection in an Unstable Planetary Boundary Layer," won the Department's C. -G. Rossby Award for the most outstanding doctoral dissertation.

JULE G. CHARNEY

Department of Nutrition and Food Science

Research and educational activities of the Department showed continued growth as measured by the increased numbers of postdoctoral associates, graduate students, and undergraduates, while the number of faculty remained unchanged.

A major development in educational policy was the establishment of a separate curriculum in Neural and Endocrine Regulation leading to a Master of Science and a Doctor of Philosophy. This brings the number of graduate curricula in the Department to five including Nutritional Biochemistry and Metabolism, Food Science and Technology, Toxicology, and Biochemical Engineering.

More than 250 research and review papers were published or accepted for publication during the past year.

Undergraduate Program

Enrollment in the undergraduate curriculum in Applied Biology, Course VII-2, continued to increase. Fall registration was 116, including 23 seniors, 50 juniors, and 43 sophomores. Since the establishment of the program in 1971, 61 students have graduated. The faculty continued to be active in UROP and in other modes of interactions with undergraduates as shown in the following table.

<u>Undergraduate Student-Faculty Interactions Outside of Course Work</u>						
<u>Year</u>	<u>Number of UROP Students</u>		<u>Number of Undergraduate Seminars</u>	<u>Number of Freshman Advisors</u>	<u>Pre-Med Students Advised</u>	<u>VII-2 Students Advised</u>
	<u>Fall</u>	<u>Spring</u>				
1970-71	7	14	--	--	--	--
1971-72	34	56	2	12	65	11
1972-73	60	86	8	9	39	25
1973-74	103	102	6	6	42	55
1974-75	103	118	11	10	45	94
1975-76	102	112	9	12	49	116

During summer, 1975, 63 undergraduates were able to do research full time. Of these, 39 received UROP and faculty funds, 12 had National Science Foundation/Undergraduate Research Participation Grants (NSF/URP), and 10 had faculty research grants; two received academic credit. Summer research opportunities were further increased by funding of an NSF/URP grant for 14 students. Associate Professor Charles Cooney is project director.

Last spring and during this year's I.A.P., we had our Fourth and Fifth Symposia on Undergraduate Research. Now held each semester, the symposia are followed by student-faculty socials for discussion. Over 30 students continued or initiated UROP projects over I.A.P.

Graduate Program

The September enrollment of 159 regular graduate students as degree candidates was an increase of 20 from the previous year. Fifteen students received the Master of Science and 16, the Doctor of Philosophy. Applications to all of the programs greatly exceed the availability of resources to support graduate students. On the basis of current applications and funding, further increase in the total number of students is anticipated.

As in 1974-75, foreign students constituted 32 percent of the total student body. Two were students from Canada, nine from Europe, fifteen from Central and South America, four from the Middle East, nineteen from Asia, and three from Africa. Women constituted approximately one third of the graduate students in the Department. This year, three women enrolled in the Biochemical Engineering Program, a field which has been traditionally all male. Recruitment of minority students was pursued actively, and a brochure was prepared for distribution to potential minority applicants.

Conferences and Summer Courses

The Thirteenth Annual Underwood Prescott Memorial Symposium was held on September 30, 1975. Dr. J. George Harrar, President Emeritus of the Rockefeller Foundation, delivered the Memorial Lecture on Food for the World. On September 11-12, the Department hosted a Workshop on Critical Needs in Food Science and Engineering sponsored by the National Science Foundation and coordinated by Professors Marcus Karel and Daniel I. C. Wang. On March 24-26, Professor Wang coordinated a joint US/USSR Conference on Single Cell Protein under National Science Foundation sponsorship. In total, 44 seminars and conferences covered all disciplines represented in the Department.

Four one-week Summer School subjects were attended by industry, government, and university scientists. Enzymes and Their Use in Analysis and Clinical Diagnosis was directed by Professor George Wolf, with 32 attendees. Advances in Human Nutrition Knowledge, directed by Professor Vernon R. Young, was attended by 41, and 58 enrolled in Professor Wang's Fermentation Technology. Engineering Foods: Technological, Nutritional, and Marketing Implications, directed by Professors Karel and Samuel Goldblith, had 35 enrollees.

During summer, 1976 five courses will be given: Enzymes and Their Uses in Analysis and Clinical Diagnosis, with Professor Wolf; Advances in Food Science and Technology, with Professor Karel; Advances in Human Nutrition Knowledge, with Professor Young; Fermentation Technology, with Professor Wang; and Concepts and Techniques in Experimental Pathology and Toxicology of Natural and Man-Made Agents, with Professor Paul M. Newberne.

Clinical Research Center

This past year was exceptionally busy with approximately 20 active projects. There were 172 admissions for a total of 2,915.5 days of patient care, and 642 outpatients were seen in 1,691 visits. The Center's 12 beds are usually filled, while many ambulatory individuals and patients are under study as half-day admissions or outpatients.

The core laboratory is now well-equipped and can do most determinations expected in a general hospital. This year its 41,423 determinations included 1,371 urinalyses, 6,988 hematology studies, and 21,006 chemical analyses. The specimen laboratory has processed 7,656 urine and stool collections and prepared them for analysis.

The International Nutrition Planning Program (I.N.P.)

The I.N.P. Program was established by the Department in 1973 in cooperation with the Center for International Studies and the Departments of Economics and Political Science. Last year it enrolled 18 students and one special student (eight from Nutrition and Food Science, four from Economics, three from Political Science, one from Urban Studies, one from Mechanical Engineering, and one from the Brandeis University Health School). Three advanced study fellows enrolled in the program, one each from Brazil, Morocco, and Zambia. A one-month workshop in March-April attracted 21 participants and one observer, all from Asia.

FACULTY

Promotions within the Department included Nevin S. Scrimshaw to Institute Professor, Michael C. Archer to Associate Professor of Food Chemistry, James M. Flink to Associate Professor of Food Engineering, and Loy D. Lytle to Associate Professor of Psychopharmacology. New appointments included James G. Fox as Associate Professor of Laboratory Animal Medicine (a joint appointment with the Medical Department), Reinaldo Gomez as Assistant Professor of Food Microbiology, Shimon Mizrahi as Visiting Assistant Professor of Food Engineering, Linda Haverberg as Instructor, and Louis Kopito as Senior Research Scientist. Robert Stickney, Professor of Mechanical Engineering, now holds a joint appointment in this Department and in the Department of Mechanical Engineering.

We were saddened by the untimely death of Mac V. Edds, Jr., Professor of Neurobiology and Executive Director of the Neurosciences Research Center.

Other changes included the resignation of F. James Levinson, Assistant Professor of International Nutrition, and the change of appointment of William M. Rand from Associate Professor to Lecturer.

Professor Lytle received the Alfred P. Sloan Foundation's Fellowship in Neurosciences. Professor Hamish N. Munro gave the second Boyd Orr Memorial Lecture of the British Nutrition Society. Professor Newberne received the 1975 American Feed Manufacturers Veterinary Medical Research Award for contributions in research as it relates to production of livestock and poultry. Professor Scrimshaw received the Conrad A. Elvehjem Award for Public Service in Nutrition, sponsored by WARF Institute, Inc., and administered by the American Institute of Nutrition. He also received the McCollum Award of the American Society for Clinical Nutrition and was named a fellow of the American Academy of Arts and Sciences. Professor Steven R. Tannenbaum was the 1976 Fred M. Tanner Lecturer of the Chicago Section of the Institute of Food Technologists, and Professor Richard J. Wurtman gave the Flexner Lecture at the University of Pennsylvania. Visiting Lecturer Ricardo Bressani received the McCollum Award of the American Society for Clinical Nutrition and an honorary D.Sc. from Purdue University.

NEVIN S. SCRIMSHAW
MARCUS KAREL

Department of Physics

The pattern of activity in the Department during 1975-76 recalled that of the preceding year. Faculty size fell slightly from 87 to 85; the number of graduate students remained unchanged at 245; and the total number of undergraduate majors (sophomore year upward) rose from 293 to 303. Degrees awarded totaled 107 S.B.s, 11 S.M.s, and 48 Ph.D.s, all significant increases over the previous year.

It was again an excellent year for research. Perhaps the most dramatic single development was the wealth of data pouring in from M.I.T.'s X-ray satellite, SAS-3. New objects, the "bursters," were discovered. A number of binaries in which one partner exerts very strong gravitational forces on the other were identified as either neutron stars or black holes. The M.I.T. tokamak, the Alcator, was improved beyond the noteworthy performance reported last year. The study of the collisions of excited atoms promises to provide new insights into, and to uncover new modes for, the interactions of atoms and chemical reactions generally. The M.I.T. "bag" model had further successes in describing properties of elementary particles, for example providing a prediction of the dependence of the mass of the particle on its spin which is in astonishingly good agreement with experiment. In dealing with more massive amounts of matter (for example, in the collision of atomic nuclei), the question of how energy and matter are transferred from one nucleus to another is the focus of various approaches by members of the nuclear research group. Discovery of the "nuclear molecule" apparently formed by two carbon nuclei exemplifies a special mode of motion of two nuclei. The M.I.T. Bates Linear Accelerator is now a working tool for the study of nuclei. One result is the demonstration of the strongly differing shapes of two rare-earth nuclei such as gadolinium and erbium. M.I.T. groups continue important experiments at the Brookhaven National Laboratory, the Fermi National Laboratory, the Stanford Linear Accelerator, and at the European Center for Nuclear Research in Geneva, Switzerland.

ASTROPHYSICS*

Research took place in virtually every wavelength range except for the traditional optical part of the electro-magnetic spectrum.

The major event of the past year was the successful operation of the X-ray satellite, SAS-3. Launched in May, and a continuous source of new data throughout the year, this M.I.T.-designed-and-constructed satellite functioned flawlessly as the only X-ray observatory currently in orbit. Significant results included the discovery of several X-ray "bursters" -- sources of intense ten-second bursts of X rays, with repetition rates ranging from several per day up to as many as several per minute. Some of these X-ray bursters appear to be located in the globular clusters, a fact which has raised interest in the possible relation of these peculiar X-ray sources to the neutron stars and black holes that may be contained in

* For a more extensive discussion, see also the report of the Center for Space Research, under whose aegis much of the research of members of the division is carried out.

such clusters. Ongoing theoretical study would link the bursts to thermonuclear explosions in the surface layers of neutron stars.

In another area of investigation with SAS-3, observations of several binary X-ray stars yielded information on properties of the binary systems, including data on the masses of the neutron stars contained in these systems. Related theoretical work on the upper mass limit for neutron stars will help to resolve the question of whether the X-ray source Cyg X-1 is a black hole or condensed nuclear matter. Other work with SAS-3 included a general survey of the positions of galactic X-ray sources to accuracies much better than $\frac{1}{2}$ arc minutes, the highest positional accuracy ever achieved in X-ray astronomy.

Optical observations of X-ray source counterparts were made at the new McGraw Hill Observatory on Kitt Peak, Arizona, which was recently established by an M.I.T., Dartmouth, University of Michigan collaboration. These observations, and those performed recently at Cerro Tololo Interamerican Observatory in Chile, were coordinated with X-ray coverage using SAS-3.

Even as the observations with SAS-3 continue, experiments are under way for the next generation of satellite-borne X-ray observatories.

A solar wind experiment was put into orbit on two Naval Research Laboratory Earth satellites, Solrad 11 A and B. Significantly, the experiment was designed and developed by undergraduates under supervision of staff members, an outgrowth of a UROP program. The experiments are working well and provide rapid measurements of solar wind properties. An additional unusual feature is that solar wind parameters are made available in real time in support of an ongoing international study of the earth's magnetosphere.

Balloon-borne experiments continued on the angular distribution of the cosmic background radiation, apparently the remnant of a primeval "big bang," using a radiometer operating in the millimeter and submillimeter region. The background radiation has been found to be isotropic to 0.1 percent with a 90 percent confidence limit; this indicates that the velocity of the solar system relative to the average rest frame determined by the universe is less than 300 km/sec.

Radio astronomy research included spectroscopic studies of our own and other galaxies, and the use of very long base-line interferometry (VLBI) to achieve ultra-high resolution in studying astrophysical phenomena. Dark interstellar clouds, dark globules, infrared sources, and molecular clouds were studied in transitions of formaldehyde, carbon monoxide, carbon monosulfide, methanol, ammonia, hydroxyl, hydrogen, and water using telescopes at the Haystack Observatory, and various great radio telescopes throughout the world. These studies allow direct measurements of the chemical, physical, and evolutionary properties of interstellar matter, particularly with respect to the regions where new stars are or will be formed.

In collaboration with the Smithsonian Astrophysical Observatory and the Naval Research Laboratory, VLBI studies progressed on H₂O maser sources in space. Results on 12 sources indicate that a typical source is a collection of bright spots, each having an apparent size of the order of an earth's orbit diameter (one astronomical unit), with the entire complex occupying a region of the order of one-tenth of a light year in size. The systems must be unstable, with lifetimes of the order of 300 to 1,000 years, and are probably associated with a very early epoch in the process of star formation.

VLBI measurements of the polarization properties of OH maser sources by M.I.T. and the California Institute of Technology yielded the first definitive measurements of magnetic fields in such sources. A clear Zeeman pattern established that the fields are a few

milligauss, a weak field by terrestrial standards, though it represents enormous magnetic energies on a cosmic scale.

Measurements with the 300-foot telescope of the National Radio Astronomy Observatory (NRAO) of quasar-galaxy pairs yielded a narrow hydrogen absorption line in the case of the galaxy NGC 3067 seen against the quasar 4C32.33. This establishes with certainty that quasars are not local objects, and adds confidence to the assumption that the very large redshifts of quasars are cosmological.

Observations of radio-emission from normal galaxies over several years have shown that the nucleus of the nearby spiral M81 is a time-varying radio source, sometimes changing its strength in a few days. This implies that the galactic nucleus of M81 is very small, that it may be only a few lightdays in size, and that it is the first normal galaxy observed to exhibit time-varying behavior.

In collaboration with the University of Arizona, and using its 28-inch telescope on Mt. Lennon, a systematic search in infrared astronomy is under way of sources listed in the Air Force Cambridge Research Laboratory (AFCRL) catalogue. As fewer than 20 percent of the sources were found, the catalogue was revised, thereby providing impetus for the incorporation of considerable redundancy in the design of NASA's Infrared Astronomical Survey (IRAS) sky survey (the limit of which will be 1,000 times more sensitive than the AFCRL survey), and yielding a long list of bright objects suitable for a variety of observational studies dealing with cosmic debris and stellar evolution.

Another new program studied peculiar, hot stars, using the 1.3-m telescope at Kitt Peak National Observatory. These studies have provided the first infrared observation of a nova at maximum light, thereby placing constraints on the temporal evolution of the ejected "shell" of matter; led to the conclusion that the X-ray emitting region of the bright X-ray nova AO620-00 is small, probably comparable to that of Sco X-1; and furnished strong evidence that the cluster found near the rapid-burst X-ray source MXB1730-335 is a compact globular cluster.

Theoretical investigations in the Astrophysics division emphasized the study of astrophysical plasmas, magnetohydrodynamics, and high-energy phenomena. Analysis of solar wind phenomena suggests that, in early epochs of a star's existence, the stellar wind must carry away a far larger amount of a star's rotational energy than now occurs with the sun. This may involve a magnetic acceleration of the wind to much higher streaming velocities (an order of magnitude), with little change in mass flux, an effect hitherto considered mainly in relation to pulsars, etc. Extension of the calculations to the relativistic regime has shown that a relativistic MHD plasma can flow smoothly through the Alfvén critical point.

Studies of the steady-state plasma flow from a magnetized star showed that the magnetic stream function obeys a well-defined, quasi-linear, second-order differential equation. This discovery allows one to formulate correctly boundary conditions of the problem and to remove a variety of controversial, unproven assertions found presently in the literature.

Investigation continued into the possibility that stars like the sun acquire a surface coating of relatively heavy elements early in their histories. If the sun has such a coating, then it may be possible to account for the otherwise exceptionally puzzling inability of experimentalists to detect neutrinos that are expected to emanate from the solar interior.

A statistical analysis of the spatial distribution of relatively nearby galaxies revealed little evidence in support of the commonly accepted theory that our own galaxy is a member of an enormous supercluster of galaxies. Another statistical study found new support for the

interpretation of the observed redshifts of distant galaxies and quasars as being due to the overall expansion of the universe.

The behavior of novae having oscillations in their decay light curves was successfully modeled in terms of a white dwarf star plus ejected matter that fails to escape, giving rise to a "bloated dwarf." With reasonable values of the parameters, the bloated dwarf can pulsate with periods of the order of one to ten days and decay in a matter of months. The increase of temperature with decreasing optical luminosity observed in novae follows naturally from the model. Theoretical predictions from the model are compared with the optical continuum and line data from several novae and show excellent agreement.

ATOMIC, PLASMA, SOLID-STATE & GENERAL PHYSICS*

The study of highly excited atoms included the first clear observations of ionization by tunneling of hydrogen-like atoms in an electric field. Although the theory has since been developed and refined by numerous workers, the very first experiments pointed to serious deficiencies. The problem is of both practical and theoretical importance because field ionization is being increasingly used to detect highly excited atoms, and may play a useful role in isotope separation. Related studies included the detailed mapping of the complex structure of highly excited atoms in very strong electric fields, high resolution infrared spectroscopy of highly excited atoms, and development of a precise method for measuring the polarizability of an alkali ion, including the first measurement of a quadrupole polarizability.

The nature of atomic and molecular collisions involving excited states has emerged as a problem of central importance in atomic and molecular physics. The study of inelastic collisions involving changes in the fine structure state of an alkali colliding with a rare gas was pursued by two new techniques made possible by the advent of tunable lasers. In the first, a high resolution laser is utilized to excite a selected velocity band in a gas; collisions are sensed by monitoring the decay fluorescence. The second technique uses crossed atomic beams to provide high collision-energy resolution, and a tunable laser to excite the alkali. The two methods give consistent results where their ranges overlap. For several alkali/rare-gas systems, the results are in good agreement with theory, but in others they are in serious disagreement. The problem appears to lie in the calculations of alkali/rare-gas excited state potentials.

Laser physics advanced along a variety of lines during the past year. Methods of saturation spectroscopy were applied to observe the velocity-dependence of molecular collisions, and to study the lineshape of very sharp resonances in carbon dioxide. Relaxation processes in ammonia were studied by a novel adiabatic rapid passage technique. Multi-photon absorption in nitric oxide was observed using a tunable infrared laser. Work in the area of precision measurements included ultra-high resolution measurements of an 11 micron band in CO₂ -- an important near-infrared spectroscopic standard -- and the study of superconducting junctions at radio-frequencies through the visible spectrum. Laser developments included a continuously tunable high energy pulsed carbon dioxide laser, a new configuration for exciting molecular nitrogen and rare-gas halide lasers. Multiple-ionized atoms, produced from solid targets by laser heating, were used to study charge exchange cross sections.

* More extensive discussions of this work are presented in the Reports of the Center for Materials Science and Engineering, the Health, Science and Technology Division, the National Magnet Laboratory, the Research Laboratory of Electronics, and the Spectroscopy Laboratory.

In nonlinear optical experiments with high-power CO₂ lasers, at the National Magnet Laboratory, noncollinearly phase-matched 4-photon mixing in germanium was successfully used for the efficient generation of quasi-tunable high-power infrared radiation in the 8 μm region. This technique may have the potential for providing an infrared source for the uranium laser isotope separation in UF₆.

In the area of plasma research, a study of the effect of impurities and plasma instabilities was carried out by examining ultraviolet and soft X-ray spectra from the Versator I machine. Work began on a superclean machine, Versator II, intended for the development of new diagnostic techniques. Advance in the production of high intensity microwave radiation was achieved by the use of a relativistic electron beam in a plasma configuration. Power up to 1.7 GW was observed at 10 cm.

Cyclotron resonance breakdown and heating of plasmas with high-power submillimeter lasers in high magnetic fields was demonstrated at the National Magnet Laboratory. Extension of this technique would provide an important new diagnostic tool for transport studies in tokamaks.

The operating characteristics of the Alcator machine were extended in the thermonuclear regime to a peak density of $7 \times 10^{14} \text{ cm}^{-3}$, with an ion and electron temperature of 1 keV and a confinement time up to 20 msec. The machine is capable of operating over a wide range of densities; at low density, plasma heating is dominated by collective effects, while in the high density regime plasma heating is due to discrete particle-particle collisions. Low heating by a wave-particle resonance process (Landau damping) has been observed with Alcator, providing the first experimental evidence for that process in the thermonuclear regime and permitting plasma heating by the injection of microwave power in that regime.

Study of phase transitions continues to occupy a central role in the physics of collective matter. Part of the attractiveness of the subject is the opportunity to describe a wide variety of physical systems by simple physical laws which are essentially independent of the local physical interactions. Illustrative of this is success in the application of percolation theory to the study of phase transitions in multi-component systems. Percolation is a problem of general interest which is relevant not only to statistical physics but also to such disciplines as geology, agriculture, engineering, and communications. A dilute magnetic alloy with only nearest-neighbor bonds is perhaps the simplest percolative system. The theory predicts that, below a critical concentration, the system breaks into finite clusters, and long-range order cannot occur at any temperature. At the critical concentration a new type of multi-critical point, exhibiting a variety of critical behavior, is expected. Neutron scattering experiments have been carried out on a dilute antiferromagnet and have yielded novel results. A model based on classical spins which form self-avoiding clusters is in quantitative agreement with experiment over the full range of temperatures studied. If the result is confirmed by other experimental tests, it will represent an important advance in percolation theory.

The study of liquid crystals provided a second avenue of advance in the study of critical phenomena. Molecules in a liquid crystal can be orientationally ordered, and can be ordered spatially in planes. Each plane behaves like a two-dimensional system within which the molecules can move freely. A study of fluctuations by light scattering near a transition between the two phases yields results which raise questions about the application of scaling laws to liquid crystals, and also about the validity of a proposed model which describes ordering in liquid crystals on the basis of the theory of superconductivity. The problem is important not only because of its fundamental interest, but because liquid crystals represent a state intermediate between liquids and solids, an area of practical importance about which little is understood. The study of liquid crystals is also of biological interest; the

ordering of molecules in a cell membrane is believed to play an important role in the functioning of the membrane.

Advances also occurred in our understanding of the structure of solids. One line of development was in the application of a chemical bond approach to solids. The aim is to develop methods for describing properties of a solid without the need for calculating the full bond structure. Magnetic and electric properties are the first to be investigated with this approach. Sensitive experimental techniques, based on essentially classical methods, were developed to measure the temperature and pressure dependence of the susceptibility and reflectivity of materials. Measurements of the pressure dependence of the reflectivity of selenium yielded results which are good for assaying human body fluids for a wide variety of proteins. The method uses light scattering spectroscopy to detect the early stages of the agglutination reaction of antigen-coated carrier particles by the corresponding antibody in solution. The diffusion coefficient of the carrier particles is measured; as the carriers cluster in an agglutination reaction, their diffusion constant decreases. The technique has been applied to measure the absolute concentration of hormones connected with pregnancy and ovulation. The sensitivity is comparable to that of the radio-immunoassay. The method promises to be an important diagnostic tool in medicine and an analytical tool in biochemistry.

The molecular microscope group has almost completed a second-generation scanning pinhole microscope designed for a resolution of 1-10 μm , with a mass filter to produce pictures based on differing molecular weights. Initial applications will include exploratory studies of spatial variations in the permeability of epithelial tissues to D_2O , CO_2 , O_2 , and He. A first-generation scanning desorption molecule microscope has been completed, with initial micrographs based on H_2O , CO_2 , and H ions desorbed from test patterns made from Si and A μ . Developmental work continues on a continuous biochemical assay designed to have sufficient speed, sensitivity, and specificity to monitor metabolism of single mammalian cells with a time constant of about 10 sec. In conjunction with the scanning pinhole microscope, this should make possible the mapping of suitable enzymes with 1-10 μm resolution in a single tissue slice without use of stains or fixatives.

CENTER FOR THEORETICAL PHYSICS

Particle Theory

Analysis of field theoretical models by semi-classical methods was successful in exposing many fascinating and unexpected features. First, it was possible to prove the existence of previously unnoticed states describing particles whose stability is assured by new conservation laws arising from topological considerations. In some examples these particles are spin 1/2 fermions, even though the model does not possess fermion fields. Interactions of the new particles with conventional particles have been described, and unexpected degeneracies have been found. A physical consequence of these degeneracies is a possible explanation of CP violation and of the η - π mass difference. We envision continuing this research in the coming year and hope to illuminate further the structure of field theory.

More effort was devoted to investigating the M.I.T. Bag Model of hadrons. This is a model of hadrons made of permanently confined quarks. Initial work on the model stressed the phenomenological aspects, since, in contrast to other approaches to the problem of hadron structure, these could be successfully exposed without a great deal of technical development of the model. This year work in this area continued with the examination of unconventional hadron states: mesons with more than the usual quark and antiquark, baryons with extra valence quark antiquark pairs, and hadrons with six and higher numbers of quarks. Some

early success was achieved in identifying the low mass spin zero positive parity meson resonances with two quark two antiquark bag states. We also found it possible to calculate the mass spectrum of high spin, highly deformed, string-like bag states, and found a linear Regge trajectory with a slope in good agreement with that observed.

Work also was devoted to the question of whether or not the cores of neutron stars could contain a quark-matter phase. The equation of state for relativistic quark matter was calculated to greater accuracy, perhaps sufficient to answer this question.

Finally we started to stress the technical development of bag model quantum theory which will be needed to obtain more refined phenomenological applications and to answer more subtle questions than so far attempted.

Nuclear Theory

In nuclear theory, considerable effort was devoted to understanding the observable properties of nuclei in the context of quantum many-body theory. At the most elementary level, nuclei may be described as a non-relativistic collection of nucleons interacting solely through static two-body forces. Under these assumptions, infinite nuclear matter was studied to explore the validity of various perturbative and variational techniques. Approximations thus justified in nuclear matter were applied to a variety of nuclei throughout the periodic table, and yielded excellent agreement with experimentally measured energies and nuclear density distributions. At a more fundamental level, the nucleus is now beginning to be studied as a relativistic many-body system comprised of both nucleons and mesons. In spite of serious limitations in knowledge about strong interactions, modest successes have been achieved in exploring specific aspects. For example, the long-range component of the nuclear force has been calculated from meson exchange, contributions of meson currents to electromagnetic matrix elements have been studied, the role of meson-nucleon resonances has been investigated in nuclear reactions, and practical formulations of a meson and nucleon field theory have been explored.

Given a tentative understanding of nuclear many-body physics, the rich variety of excited states presently experimentally accessible was studied. Very simple rotational, vibrational, and collective states were calculated in quantitative agreement with experiment. Explorations of more exotic states, such as ultra-high spin states or "abnormal" states of matter created in heavy ion collisions, were by necessity highly speculative.

Complementary to the study of states of individual nuclei is the theory of nuclear reactions. Investigations include such topics as statistical reaction theory, electron scattering, high energy proton scattering, fragmentation in relativistic heavy ion collisions, pion scattering, and deep inelastic heavy ion reactions. The formulation of a microscopic theory of collective motion received particular emphasis as a general theoretical physics problem which is especially relevant to nuclear physics. In addition to substantial theoretical progress in understanding collective dynamics, practical calculations progressed to the point of yielding semi-quantitative agreement with experiment.

EXPERIMENTAL NUCLEAR AND PARTICLE PHYSICS*

Research productivity of the members of this division remains high in spite of continuing budgetary pressures. The fields represented are nuclear reactions (especially with heavy

* For a more extensive discussion, see the report of the Laboratory of Nuclear Science, under whose aegis much of the research of members of the division is carried out.

ions), medium energy nuclear physics, and high energy particle physics. Following are the most notable of this year's results.

Nuclear Reaction and Heavy Ion Physics

The heavy-ion group continued study of reactions between heavy ions with the aid of tandem Van de Graaff accelerators, principally the facility at Brookhaven National Laboratory. The group initiated new experiments at the Berkeley Superhilac Accelerator. Highlights of this work are an indication of a very short-lived nuclear "molecule" formed by two colliding carbon nuclei; details of the behavior of inelastic scattering between two nuclei under conditions where the relative kinetic energy at the moment of contact is all absorbed by "friction" ("deep inelastic scattering"); studies of fusion of intermediate mass nuclei, using a newly-constructed Recoil-Mass Spectrograph; and detection of fission fragments formed in a fusion-fission process under conditions where a short-lived superheavy nucleus might be identified (Berkeley).

Medium Energy Physics

During 1975-76, faculty members, senior and junior research staff, and graduate and undergraduate students of the Department engaged in nuclear structure research with the Bates Linear Accelerator. This facility, one of the pivotal installations in the field, delivered about 2,100 hours of electron beam operation for thirteen experiments involving physicists from 17 institutions in the United States and three foreign countries.

The most active area of research involved electron scattering utilizing the high resolution magnetic spectrometer. An improved detector system for this instrument, designed and installed during the year, constitutes a major technical development. Measurements of elastic electron scattering are aimed at determining the distribution of charge and magnetism in nuclei. They have shown striking variations in the shape of deformed rare earth nuclei. For example, gadolinium appears football-shaped, whereas erbium and ytterbium seem to have narrow waists with bulges at the ends. Other measurements are beginning to show the detailed spatial distributions of magnetic dipole and higher moments in a variety of nuclei. Inelastic electron scattering leading to rotational excited states of rare earth nuclei yielded excellent verification of recent theoretical models. In other nuclei, such experiments discovered many new excited states, for example a state in ^{24}Mg at 15.1 Mev with six units of angular momentum, very strongly excited through magnetic interaction with the electrons.

Other experiments utilize high energy photons generated by the electron beam. Production of positive and negative pions by photons on carbon, boron, and deuterium were examined at energies near threshold. Results support a model in which the pion is produced from a single bound nucleon. In another experiment, protons were ejected by photons from ^{16}O nuclei, leaving ^{15}N in the ground state or an excited state. The results suggest that this process may involve an internal excited state of a nucleon.

High Energy Physics

Following a year of spectacular discoveries, 1975-76 was a year of exploiting the successful methods, producing a large volume of highly interesting new results. The group which discovered the J particle in the previous year exploited the same equipment at Brookhaven National Laboratory, with some modifications, to make a very sensitive search for the production of "charmed" particles, predicted by currently popular theories. The results show that, if such particles exist in the predicted mass range, they either are not produced

with the expected probability under the conditions of the experiment or they do not decay in the expected manner. The apparatus also was used to study the distribution of single hadrons, and correlations between pairs of hadrons emitted at large angles with the beam.

At present, this group is preparing a major experiment at the Intersecting Storage Ring Facility of the CERN laboratory. They will study the dynamics of the production of mu-meson pairs and search for new particles decaying into such pairs. It is an extension of the Brookhaven experiments to much higher energies.

The Counter Spark-Chamber group obtained important results in three areas: hadron-nucleon reactions, hadron-nucleus reactions, and electron-nucleon reactions. Their greatest effort is concentrated on experiments with the spectrometer facility at the Fermi National Accelerator Laboratory developed by this group in collaboration with others. The first fully evaluated results on elastic scattering of protons, antiprotons, pions, and kaons by protons and neutrons represent the most precise and reliable measurements of these cross-sections to date, giving valuable insight into the nature of the interactions involved. In an extension of these experiments, the group is measuring inelastic reactions in which the observed particle differs in kind and energy from the incident one. Last year members of this group reported exciting results from the study of intra-nuclear cascades at high energy. This work demonstrated that, for particles emitted in the forward direction, heavy nuclei behave like hydrogen, a totally unexpected result. Further studies have shown that particles emitted at large angles from heavy nuclei behave differently. This is a new area of high energy nuclear physics to which this group is adding special insights.

The annihilation into neutral mesons of antiprotons striking protons with 1-2 Gev energy is being studied in a continuing experiment. Some members of this group collaborated with a group at the Stanford Linear Accelerator Center to study the production of hadrons by high energy electrons striking protons and neutrons. The results represent one of the most striking supports for a model of fractionally charged constituents of hadrons (quarks).

The accelerator physics collaboration group is studying hadron-proton interactions at 8, 15, and 147 GeV/c. Their main concern at 8 and 15 GeV/c is with understanding the diffraction dissociation of the nucleon. This is a process of major importance which occurs in hadron-nucleon collisions and which has eluded explanation for many years. By careful analysis of interactions on protons induced by incoming negative and positive pions, they developed a two-component model that can account for all the known features of this important process. This clears up a long-standing problem in high energy physics. Work at 147 GeV/c concentrated on the complexities of the interactions at these energies. Studies were done with the aid of the bubble chamber at the Fermi National Accelerator Laboratory. M.I.T. developed the concept of a hybrid bubble chamber spectrometer which utilizes the superior characteristics of both a bubble chamber and counter hodoscopes. This concept has been implemented at Fermilab and adopted at a major research facility at CERN for their new high energy accelerator. M.I.T.'s is the first group to use this unique hybrid spectrometer. The results of this experiment show that, at the high energy involved, a simple quark model can predict some of the interaction dynamics. In particular, the group demonstrated that the cross-section for producing an interaction on the target proton by the incoming pion projectile (with the pion projectile remaining undisturbed) is the same as the cross-section for the pion projectile undergoing an interaction leaving the target proton undisturbed. This result is understood in a quark model framework. In addition, this work shows that in high multiplicity events the particles are emitted in charged clusters, a result not heretofore predicted by any theory. The group has received approval for an experiment at the Fermilab to study high energy kaons, which will be the first of its kind. This experiment could yield data to help explain the dynamics of interactions in this high energy regime.

FACULTY

The following faculty members received promotions during the year: Associate Professors Wit Busza, Michael S. Feld, and John Negele received tenure; Min Chen was promoted to Associate Professor; Philip C. Myers and Edward Wright were appointed Assistant Professors; and Dusan Lysy and Karl Van Bibber were appointed Instructors.

Visiting Professors included Hans Bethe, Claude Cohen-Tannoudji, Jeffrey Goldstone, Satio Hayakawa, Klaus Hepp, Werner Kanzig, Harry Morrison, and Judit Nemeth; while Daniel Murnick and Claudio Rebbi were Visiting Associate Professors.

On leave during the Academic Year were Professors W. Carlisle Barber and H. Eugene Stanley. On leave during the spring term were Professors Michel Baranger, David H. Frisch, Robert Jaffe, Ernest Moniz, Bruce Patton, and Charles Thorn. Professor Stanley and Instructors Richard Freeman and Sunny Yuen resigned.

Professor Bernard T. Feld received the 1975 Public Service Award of the Federation of American Scientists. Professor Anthony P. French received a 1976 Distinguished Service Citation from the American Association of Physics Teachers and was appointed Chairman of the International Commission on Physics Education. Professor Lee Grodzins was elected Chairman of the American Physical Society Forum on Physics and Society. Professor Ali Javan was awarded the Frederick Ives Medal of the Optical Society of America. Professor Samuel C. C. Ting was among five scientists who shared the 1975 Ernest O. Lawrence Memorial Award of the US Energy Research and Development Administration. Institute Professor Emeritus Victor F. Weisskopf was elected President of the American Academy of Arts and Sciences. Professor Peter A. Wolff was appointed Director of M.I.T.'s Research Laboratory of Electronics.

HERMAN FESHBACH

Spectroscopy Laboratory

Professor Richard C. Lord retired as Director of the Spectroscopy Laboratory after 30 years of service, and was succeeded by Professor Michael Feld. Over the past year, Professors Feld and Ali Javan and their coworkers made progress in several areas of laser spectroscopy.

By means of a tunable $5\mu\text{m}$ spin-flip Raman laser, two-photon spectroscopic studies of the nitric oxide molecule (NO) were carried out. In addition to observation of a two-photon Doppler-free resonance, a series of stepwise excitations was used to study the position and Λ -splitting of several J lines in the first hot band of NO. The Λ -doubling constants measured for this band differ from those in the ground state so that a vibrational dependence is observed in this experiment. A novel use was made of a capillary waveguide to provide high intensity fields and eliminate diffraction limiting effects for the two-photon work.

The velocity dependence of collision-broadening cross-sections for both self-broadening and broadening by xenon of an infrared transition in NH_3 was studied by measuring laser saturation resonance linewidths for molecules with specified velocities along the laser propagation direction. For self-broadening, the velocity dependence is that expected for inelastic collisions with a predominantly dipole-dipole interaction potential, plus smaller contributions due to shorter range forces; whereas for Xe broadening, the magnitude and velocity dependence of

the collision-broadening cross-section is in better agreement with velocity changing collisions in the pressure range studied.

The techniques of optical nutation, free induction decay, and other coherent transients are being extended to coupled Doppler-broadened three-level systems. The transient response of a molecular gas sample (NH_3 or CH_3OH) is analyzed by probing the time dependent transmission of a weak tunable infrared field when a strong resonant saturating field is suddenly turned on or off. These experiments, still in progress, will provide techniques for measuring molecular relaxation times and to study interesting radiative effects.

A laser-nuclear experiment now in progress aims at measuring properties of excited nuclei with lasers in the visible part of the spectrum. This is possible because the optical pumping induced in the atomic levels by the laser is coupled to the nucleus via the hyperfine interaction. At the atomic resonance peak, a highly anisotropic distribution of γ -rays is expected, and this anisotropy acts as a very sensitive indicator of the resonance condition. The initial experiments are being done on a metastable level of the Ba-137 nucleus with the electronic levels pumped at 553 nm by a narrow-band tunable dye laser.

Professor Jeffrey I. Steinfeld's research group uses tunable semiconductor lasers in ultra-high-resolution spectroscopy and infrared double resonance experiments. The infrared absorption spectrum of vinyl chloride has been measured in the 940-cm^{-1} region at a Doppler-limited resolution of 10 MHz, a resolution about three orders of magnitude better than in previous studies. The detailed analysis of this spectrum is now in progress. The same tunable diode source was also used to probe the transient absorption in laser pumped sulfur hexafluoride. The power-broadened absorption profile directly observed in this way provides important information about the mechanism of the multiple-infrared-photon, isotopically selective dissociation process.

Professor Robert W. Field and his students continued their investigation of the BaO molecule by optical-optical double resonance (OODR). Analysis is now complete of the fluorescence spectrum that results when BaO absorbs two dye laser photons, and several previously unobserved singlet and triplet states have been located. OODR is proving to be a valuable new technique for the observation of otherwise inaccessible electronic states which have considerable chemical significance because of their metastability. Analysis of perturbations in the electronic spectra of SiO and SiS is complete and is under way for N_2^+ and BeS. The study of spectroscopic perturbations provides insight into collision-induced transitions between electronic states and also permits characterization of unknown states. Tunable laser induced fluorescence spectra of CF_3NO and CSCl_2 have been recorded. Dr. John Lombardi proved that the excited state thus populated in CSCl_2 is a triplet and that OODR spectroscopy will provide an opportunity to examine the triplet manifold of this molecule.

RICHARD C. LORD

George R. Wallace, Jr. Astrophysical Observatory

The George R. Wallace, Jr. Astrophysical Observatory is an active teaching facility as well as a sophisticated scientific installation. It consists of two telescopes (one 16-inch and one 24-inch) housed in separate domes, a computer facility designed to control the 24-inch and process data on-line, and a support building.

The Observatory steering committee is appointed by the Dean of the School of Science and chaired by Professor Thomas B. McCord of the Department of Earth and Planetary Sciences. Committee members are Professors Alan H. Barrett, Bernard F. Burke, George W. Clark, Susan G. Kleinmann, and Institute Professor Emeritus Bruno B. Rossi, all of the Department of Physics; Professor R.A. Albery, Dean of the School of Science; and Professor Irwin I. Shapiro of the Department of Earth and Planetary Sciences. Professor Herbert S. Bridge of the Department of Physics and the M.I.T. Center for Space Research advises and assists the committee. This body prescribes observatory policy and determines the direction of observatory development. Professor McCord serves as the Director of the Observatory. Michael Brookes remains Chief Engineer with Andrew Tomer as site manager and technical assistant.

During fall, 1975, the 16-inch and 24-inch telescopes were used regularly by students enrolled in subjects 12.111 Survey of Astronomy, 12.113 Astronomy I, and 12.143 Experimental Optical Astronomy. A total of 89 students enrolled in these subjects. The 63 students enrolled in subsequent subjects 112.12 and 112.16 during the spring term frequently used the facility as well. Examples of student research projects carried out with the 24-inch telescope were: obtaining spectra of fresh mare craters; millisecond resolution photometry of unusual stars; differential photometry of selected BO-B3 stars; asteroid photometry; search for variability in NOVA CYGNA, looking for changes in color as a function of intensity. Typical 16-inch projects were: observing Mars occultation of third magnitude star; interference filter astrophotography; high magnification of planetary observations.

The Wallace Observatory continues to be used for development and testing of new instruments which are later used at major observing facilities around the world. Such instruments as the vidicon polarimeter, CVF infrared spectrometer, and various photometers are tested.

From summer, 1975 through spring, 1976, the 16-inch telescope was scheduled for observing on 85 percent of total nights, and the 24-inch, for 87 percent of total nights. This represents a usage increase of 43 percent on the 16-inch and 25 percent on the 24-inch from last year. As expected, the telescopes were more heavily scheduled during the academic year than in the summer, and were oversubscribed during several months. This was the second full academic year during which the observatory has been regularly scheduled.

Publications

Faculty publications for 1975-76 included: Michael Brookes, James Gettys, and Steven Paavola, "Wallace Operating System Manual," Telescope Automation (Hugenin and McCord, editors), 1975; James Gettys, "An Interactive Data Collection Program for Use with an Automated Photometer and Telescope," Telescope Automation, 1975; Maureen Hugenin and Thomas B. McCord (editors), Telescope Automation, proceedings volume from the International Conference on Optical Telescope Automation held at M.I.T. on April 29-May 1, 1975; Ervin Lyon and Michael Brookes, "Plan to Implement Computer-assisted Astronomical Observing," Telescope Automation, 1975; Thomas B. McCord, "The George R. Wallace, Jr. Astrophysical Observatory," Bulletin of the American Astronomical Society, Vol. 8, No. 1, 1976; Thomas B. McCord, Steven H. Paavola, and Grant Snellen, "The M.I.T. Automated Optical Telescope," Telescope Automation, 1975.

THOMAS B. MCCORD

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 introductory comments and my own reports on the Graduate School and the Institute's several housing programs.

DEAN OF THE GRADUATE SCHOOL

As I attempt to assess my first year as Dean of the Graduate School, I recall the kind and self-effacing assistance I was fortunate to receive from my predecessor, Dean Emeritus Irwin W. Sizer, and the capable staff he left behind as he moved to his new post-retirement responsibilities. To discharge the responsibilities of the office with a new and part-time dean and a reduced staff, Deans Jeanne Richard and John Turner took on additional responsibilities. In addition, Yvonne Littlewood was promoted at mid-year from a secretarial position to a staff position as Assistant to the Dean to recognize her added responsibilities. To Dean Sizer and to the staff, I take this occasion to express my sincere appreciation.

I also must express my appreciation to the members of the Committee on Graduate School Policy who individually and as a group were most supportive of their new Chairman. The Committee approved a new mode of operation and agreed to undertake a significant review of several areas of policy and procedure. Five sub-committees were established to address these latter issues. These new sub-committees and their chairpersons are: Subjects and Performance Evaluation, Professor Gordon Pettengill; Thesis Policies, Professor Glenn Williams; Foreign Students, Special Students, and Related Programs, Professor Allen Henry; Tuition and Fee Policies, Professor Robert Logcher; Financial Support Structures, Professor George Koster. I anticipate that the major results of these studies will become apparent during the coming academic year, and I therefore plan to review this work in my report for the academic year 1976-77, rather than to attempt predicting the outcomes at this time.

I also am pleased to report my perception of the relationship between the Graduate Student Council and the Graduate School Office, which continue to be mutually cooperative and constructive in the tradition which characterized Dean Sizer's tenure.

Under the dynamic leadership of Max Donath, the Graduate Student Council (G.S.C.) continued to grow as an effective and productive organization with the concerns of graduate students as its focus. A major effort of the Council was an orientation program for incoming graduate students last September. As an example of student-administration cooperation, the '75 Orientation Committee, chaired by Robert Reynolds, used a Graduate School Dean's office as an "Information Center" for new graduate students who needed assistance. The Information Center remained open the entire week prior to Registration Day, and was staffed completely by students. It was a success, and plans are under way to use the Graduate School Office again in September 1976.

The Graduate Student Council continued to provide strong support for a number of graduate oriented activities, such as: The Tech Wives, The Muddy Charles Pub, THE GRADUATE newspaper, and teaching awards for instructors of graduate courses. The Council also sponsored a luncheon for all departmental graduate office secretaries to coordinate and improve communications and activities regarding graduate students at that level.

The G.S.C. has served actively on various Institute committees in efforts to seek solutions in problem areas such as grading, athletics, registration procedures, funding for graduate students, guidelines for research and teaching assistantship responsibilities, and current practices in the funding of undergraduate and graduate extracurricular activities.

Robert Mann will be the new president of the G.S.C. for 1976-77, and plans are under way for an Orientation Program for September 1976 under the leadership of Candace Gibson.

Despite the depressing national economic trends and the decline in general financial support for graduate education, applications for admission to M.I.T.'s graduate programs continued at high levels in both quantity and quality. Total graduate enrollment increased by approximately 100 over the preceding academic year, and currently we are predicting another enrollment increase of 100 for September 1976. The enrollment of regular graduate students for the past fall term is set out in Table I and the numbers of graduate degrees awarded during this academic year are set out in Table II.

Minority graduate student enrollment at M.I.T. continued to rise in 1975-76 as a result of ongoing efforts to recruit minority students for graduate study over the past seven years. The number of minority graduate students at M.I.T. has risen from 16 in 1968 to 155 in 1975, an increase of almost an order of magnitude in seven years.

In addition to recruitment of minority students, we have continued to give considerable attention to minority graduate students on campus. An array of support services has been developed to ease the transition of these students from undergraduate to graduate life considering difficulties in adjustment which minority students may have moving into the mainstream of campus activity.

During the year, the Black Graduate Student Association, a subset of G.S.C., was formed to pull together the diverse interests and needs of black graduate students and to provide interesting extracurricular and cultural activities of special interest to the M.I.T. black community. The Black Graduate Student Association worked closely with Dean Turner in sponsoring activities and in providing minority graduate student representation on such Institute committees as the Talbot House Committee, Medical Advisory Board, C.A.P., E.O.C., and the Graduate Council Executive Committee.

In 1975-76, Master's degrees were awarded to 29 minority graduate students, an all-time high of seven Ph.D.s were awarded to black students, contrasting the eight awarded over the past 15 years.

Indicative of the quality and breadth of scholarship endemic to the minority graduate students admitted to M.I.T. is the awarding of national fellowships and awards for 1975-76. The Ford Foundation awarded more than 12 of its fellowships to M.I.T. black graduate students, while other students received awards from the National Fellowships Fund, Bell Laboratories, Western Electric, IBM, Danforth, National Institutes of Health, Arthur D. Little, Council for Opportunity in Graduate Management Education, and DuPont. Xerox gave M.I.T. an additional minority graduate fellowship for 1976-77. The Graduate School Office continues to award the prestigious Fort Fellowship to an M.I.T. undergraduate minority student who has been admitted for graduate study to the Institute. The Fort Fellowship has been very effective in attracting minority seniors into graduate degree programs at M.I.T.

While we are greatly encouraged by the success of our programs for minority graduate education, we are far from satisfied. Accordingly, we are in the process of developing a new approach to our recruitment and support efforts for minorities. Concerned faculty members whose departmental assignments can be modified will spend considerable time in cooperation with Dean Turner in the establishment of better ties with appropriate undergraduate institutions, to provide counsel on graduate opportunities generally in their disciplines, and, where appropriate, to recruit students for their disciplines at M. I. T. These faculty members will become the local support persons within the departments to provide whatever additional assistance the new minority students may need. This effort will require financial support and other guidance over and above that currently available. Toward these dual needs, we are forming an Alumni Steering Committee and some initial seed money already has been generously given by a member of that committee.

Although the enrollment of women in M. I. T. 's graduate programs is increasing at a moderate rate, their overall proportion is still small. In 1970-71, women comprised eight percent of the regular graduate student body (260 in a total of 3,250); in 1975-76 the enrollment of women increased to 13 percent in a larger total student body (487 in a total of 3,603).

At the same time, higher proportions of women continue to be enrolled in those areas which traditionally have attracted women. For example, enrollments this past year were Architecture (41/158 -- 30 percent), Urban Studies (41/103 -- 40 percent), Biology (41/124 -- 33 percent), Nutrition (49/156 -- 31 percent), and an average of 30 percent of the total enrollment in the School of Humanities and Social Sciences (excluding enrollment in the Department of Economics).

It should be noted that active recruitment in the past few years plus the increasing interest in graduate business/management degrees nationally has resulted in the establishment of a new record by the Sloan School where enrollment of women reached 25 percent of the total in the S. M. programs.

One of M. I. T. 's greatest challenges remains that of attracting women to the engineering and physical science fields where they traditionally have been underrepresented -- particularly in engineering where they comprise only five percent of the total enrollment -- which in turn, represents over one-half of the total Graduate School enrollment at M. I. T.

Of a total of 1,346 graduate degrees awarded at M. I. T. during this past academic year, 127 or nine percent were awarded to women. Of these, 93 were Master's (including M. Arch., M. Arch. A. S., and M. C. P. as well as S. M. with and without specification). Thirty-two women were awarded Ph. D. s primarily in the Social Sciences and two women earned Engineer's degrees, one in the Joint M. I. T. -Woods Hole Oceanographic Institution Program. These data show little change from 1974-75 when 112 of a total of 1,325 degrees were awarded to women or eight percent. The fact is that the total number of doctorates awarded during the year remains the same as earlier years, at 32, while the Master's degrees increased from 80 to 93. This is because the largest numbers of women graduate students are still found in Architecture, Urban Studies, and the Sloan School where most students pursue graduate work in Master's programs. There continues to be a dearth of Ph. D. s awarded to women in Engineering and Management.

Three years ago, through the generosity of Cecil and Ida Green, a fellowship fund was set up to provide financial support for graduate students. During the past few years these fellowships have been awarded primarily to women entering M. I. T. 's graduate programs, and they have proven to be important aids to women in financing their first year of graduate study at M. I. T. To date, 12 women have received support from this source.

In addition to the Green Fellowships, the Graduate School Office continues its annual competition for the Collamore-Rogers Fellowship for an outstanding continuing woman graduate student. Monies for this award come from long-standing endowed funds which were given to M. I. T. for the express purpose of helping women in their graduate studies.

As Federal fellowship programs continue to decrease, increased efforts have been made in recent years to seek financial support for graduate students at M. I. T. from industry. At the same time, certain industries, eager to attract more women and minorities into science and engineering fields, have established fellowship programs specifically for the support of such students. During 1974-75, M. I. T. graduate women were the recipients of fellowship awards from IBM, Xerox, and Arthur D. Little.

Another indication of the academic quality of M. I. T. graduate women is the presentation of dissertation fellowships to three women through the highly competitive American Association of University Women fellowship competition (only 70 are awarded nationally). In addition two women who won coveted Danforth Foundation Fellowships (65 awarded nationally) are pursuing graduate work at M. I. T. in the Departments of Mathematics and Political Science. Other women students received scholarship aid in national competitions from Wellesley College, the National Science Foundation, and Bell Laboratories for their graduate work at M. I. T.

In the past, no centralized efforts to recruit women have been made -- with the notable exception of those made by the Sloan School. In an attempt to increase the pool of women applicants, Dean Richard is preparing a recruiting campaign in consultation with women graduate students, all of whom were members of an ad hoc subgroup of the Committee on Educational Policy which met during the past year to look into issues relating to the education of women at M. I. T. An important element will be the continued coordination of a program in which women currently enrolled in graduate programs volunteer to write personal letters to women accepted for admission in their areas of study. These women writers share their experience and knowledge of M. I. T. and answer any questions prospective women graduate students might have about the Institute. As part of this program, all prospective women applicants are invited to visit the M. I. T. campus (usually during the first week of April) to meet with students and staff in their respective areas. These meetings are followed by an informal reception which for the past three years has been hosted by Mrs. Laya Wiesner at the President's House.

Although women always have valued an M. I. T. education and degree, it has long been the case that, in some instances, their isolation in certain research areas and their difficulty in finding mentors and role models has put a certain personal cost on the value of their education. During the past year, the Graduate School Office in cooperation with the Dean for Student Affairs Office, through Deans Richard and Anne Thompson has sponsored various activities to bring graduate women together. During the fall term and I. A. P., a series of luncheon discussions and other events were held at which women new to the M. I. T. environment shared experiences. These efforts have received positive response, and we intend to continue them next year.

In his report for 1974-75, Dr. Sizer provided a comprehensive summary of the recent discouraging trends in the financial support for graduate students. Unfortunately, we have not seen a reversal in this downward trend during 1975-76. For example, the total income from endowed funds available to the Graduate Office to award for unspecified graduate student support during 1976-77 covers only 65 full-tuition scholarships. The identification of new forms of financial support for graduate students is of highest priority. We currently are working with the Institute's Development Office to seek major additional resources for this purpose.

Nevertheless, we are fortunate that the large research volume on the campus provides not only high intellectual stimulation and opportunities for graduate study and research, but also

financial support to about one-third of our graduate students in the form of research assistantships. In fact, the combination of support from the research programs in the form of research assistantships and from the academic program in the form of teaching assistantships provides financial support for almost one-half of the entire regular graduate student population.

In addition, the Institute's students continue to fare well in national competitions for Federal fellowship support. Over the past decade, M. I. T. students have received nine to 11 percent of the total number of National Science Foundation Fellowships awarded, and even though the total number of these fellowships is declining, this year proved to be no exception to that remarkable performance.

Finally, industrial and private foundation support becomes increasingly important in the face of Federal cutbacks. For 1975-76 we will have significant support from this sector. These Fellowships include: a grant to support a graduate fellowship in biochemistry from the Corning Glass Works Foundation; five new and four continuing fellowships in the life sciences and biomedical engineering from the Health Sciences Fund; one fellowship for a woman and one for a minority in physics, electrical engineering, or computer science from the IBM Minority/Women Fellowships program; one fellowship in biomedical sciences from the Johnson & Johnson Associated Industries Fund; two new and two continuing fellowships in the School of Engineering from Rockwell International; and one fellowship for a woman or minority in physics, electrical engineering, or computer science from the Xerox Corporation Palo Alto Research Center.

Table III provides an overview of the multiplicity of sources of financial support for regular graduate students. The reader is cautioned, however, that a single table is at best an incomplete reflection of the total picture since support shifts constantly throughout the academic year in accordance with changing status of students, early terminations of degree programs, and so on. Because of the statistical problems created by this constant change, the data in Table III are intended as a representative snapshot. For the purpose of this count, a full award was considered to be at least full tuition support during the fall term of 1975. Many awards carried additional sums to assist students in meeting living costs.

As scholarship and fellowship support becomes less readily available, increasing numbers of graduate students are turning to the Student Financial Aid Office for assistance in the form of loans or in jobs supported in part by the College Work-Study Program. The information on these forms of support appears in Table IV.

Finally I would like to comment briefly on a small but important program, graduate study abroad.

In fall, 1975, the responsibility for administering the various competitions for grants for graduate study abroad was transferred to the Graduate School Office from the Dean for Student Affairs Office (Foreign Study Office). Yvonne Littlewood worked with and provided staff support for the Foreign Scholarship Committee.

The Foreign Scholarship Committee was chaired this past year by Professor Martin Abkowitz and was composed of 10 faculty members from various departments throughout the Institute and a graduate student member. After the initial screening by the Foreign Scholarship Committee, four applications were submitted to the Institute of International Education for the Fulbright-Hays and related grant programs. Three applicants passed the preliminary application stage by the National Screening Committee. Of these three, one received an ITT International Fellowship to Norway, a second was awarded a German Academic Exchange Service (DAAD) grant through a separate competition and so withdrew his Fulbright-Hays application, and a third is still awaiting a final decision from Switzerland. Although the DAAD initially offered M. I. T. only one direct scholarship, two students were awarded grants for

study and research in the Federal Republic of Germany. The Foreign Scholarship Committee nominated two M. I. T. seniors to the Winston Churchill Foundation in competition for scholarships for graduate study at Churchill College, Cambridge University. One of the nominees was awarded a scholarship, but turned it down in order to accept a National Science Foundation Graduate Fellowship. He will be attending Churchill College on his NSF Fellowship.

Of major concern to the Committee is the small number of applications received for the various competitions. The Committee is therefore planning a major effort for next fall to increase awareness within the graduate student body of these unique opportunities for study abroad.

HOUSING

For undergraduates, the Institute has one of the most flexible of all university student housing programs. Although all first-year students are required to live in an Institute house, fraternity, or the M. I. T. Student House, upperclass students may opt to stay on campus for up to a total of eight terms in residence or to move off campus if they choose. This flexibility, while it certainly contributes to student satisfaction, causes great difficulty in estimating how many beds will be available each September for first-year students. Nevertheless, staff members of the Office of the Dean for Student Affairs have established a remarkably good track record in predicting where the incoming students will decide to live.

We also have endeavored over the last 15 years to construct new housing and renovate older housing to provide comfortable accommodations of some quality and taste with considerable variety in style of living arrangements. Student response indicates that this program has succeeded for, over the years, more upperclass students have opted to remain on campus. Thus at the present time, we estimate that, in steady-state, for each additional 400 students in the total undergraduate body, we must provide 300 additional beds within the Institute housing system.

For several reasons, the Institute embarked a few years ago upon a program of increasing the size of the undergraduate body slightly. The opening of the new West Campus House for undergraduates made it possible to absorb the resulting increments in first-year students without too much overcrowding. However, the projected target of 1,100 new first-year students in September 1976 is expected to result in pushing the overcrowding in the undergraduate houses to what the Dean's staff regards as an absolute limit.

Since new house construction is so expensive (currently about \$25,000 per student bed over and above the land costs) and since only a small fraction of the total capital cost of new student housing can be amortized from rental income at rates prevailing at M. I. T., we are hesitant to move into additional new construction until such time as significant gift money is available. We are therefore exploring other alternatives to meet the predicted over-demand in September 1977 if we are to maintain a first-year class size of 1,100, which is the current target figure.

We have embarked on a program to develop two independent residences -- a fraternity for approximately 50 men and a cooperative for about 50 women -- in an older apartment house, formerly owned by the Northgate Community Corporation, on Massachusetts Avenue, a few blocks north of the main Institute buildings. This was done both because we need more undergraduate housing and because we are anxious that the size of the independent residence group, the fraternities and M. I. T. Student House, does not continue to decrease.

The process is now well under way, and some students will live in the building during the renovation extending over this coming academic year.

The ever-increasing demand from married students (mostly graduates) for on-campus housing also caused us this year to re-evaluate the Faculty Housing Program in Eastgate. During the construction of this married student project, the decision was made to assign some of the apartments in the building for faculty use. The objective was to provide close-in housing for a relatively short time and particularly for new younger faculty. We had hoped to augment this "first step" by constructing other close-in housing for faculty of all levels and staff, however, economic reversals made it impossible to bring these new programs to fruition. The same economic problems have made it impossible to construct additional married student housing despite the increase in population which has taken place over the past several years. The decision was made this past December to ask the faculty members living in Eastgate to terminate their residency in time to make their apartments available for student occupancy in September 1976.

MEDICAL DEPARTMENT

The Institute and the greater Boston medical community suffered a major loss in February when Dr. Albert O. Seeler, Director of the Medical Department, died very suddenly in the prime of life and at the height of his career. In his report which follows, Dr. Melvin Rodman, now Acting Director of the Medical Department and, for many years, Associate Director under Dr. Seeler, speaks to the tremendous contributions Dr. Seeler made to this institution.

In February, as we came to grips with the implications of our loss, we soon realized that Dr. Seeler was truly irreplaceable and that our task was to seek a successor who, with the assistance of the staff, might so re-structure the Department as to fill the void formed by Dr. Seeler's passing and guide the Department along the same course of development Dr. Seeler had laid out. Toward this goal, Dr. George Thorn, Chairman of the Medical Administrative Board, assembled a Search Committee of 10 distinguished doctors in addition to himself as Chairman. The Committee undertook a nationwide search and at this writing appears to be drawing its deliberations to a close.

Although the Committee has yet to complete its task, I want to express in this report, our most sincere thanks and appreciation to each member and particularly to Dr. Thorn who has exhibited extraordinary leadership. I also must express the Institute's appreciation to each member of the Medical Department for their exemplary performance during this trying interlude following Dr. Seeler's death and to Dr. Rodman, who took over and continued to handle the reins as Acting Director for a long period under sometimes most difficult circumstances.

KENNETH R. WADLEIGH

TABLE I REGULAR GRADUATE STUDENT ENROLLMENT, FALL TERM 1975

	Foreign*	Women	Minority**	Total
School of Architecture and Planning	53	89	50	261
School of Engineering	594	91	38	1,724
School of Humanities and Social Science	59	60	30	270
School of Management	98	74	9	336
School of Science	233	173	28	1,012
Total	1,037	487	155	3,603

* Includes Canadians

** Includes Black Americans, Puerto Ricans, Mexican-Americans, and American Indians

TABLE II GRADUATE DEGREES AWARDED, 1975-76

Advanced Degrees Conferred	M. Arch. M. C. P. M. Arch A. S.	S. M.	Engineer	Sc. D.	Ph. D.	Total
September 1975	11	155	8 2(WH)*	15	99 5(WH)*	295
February 1976	23	195	24	26	118 4(WH)*	390
June 1976	52	426	60	20	99 4(WH)*	661
Total	86	776	94	61	329	1,346

* 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, 1975 - Total regular graduate student enrollment 3,603

FELLOWSHIPS AND TRAINEESHIPS AWARDED BY M. I. T.		Percentage of Total Enrollment
National Institutes of Health Traineeships	168	
National Science Foundation Energy Traineeships	22	
Energy Research and Development Administration Traineeships	14	
HUD Minority Intern Program	10	
Environmental Protection Agency Traineeships	7	
National Defense Education Act Traineeships	3	
HEW Domestic Mining and Mineral Fuel Traineeships	2	
Department of Transportation Traineeships	2	
M. I. T. Endowed and Other Fund Fellowships	208	
Industrial and Foundation Fellowships	<u>93</u>	
Subtotal	<u>529</u>	15%
 FELLOWSHIPS AWARDED BY SPONSORS TO M. I. T. STUDENTS		
National Science Foundation Graduate Fellowships	148	
Department of Labor Dissertation Grants	7	
National Institutes of Health Fellowships	3	
Environmental Protection Agency Fellowships	1	
Hertz Foundation Fellowships	<u>19</u>	
Subtotal	<u>178</u>	5%
 STUDENT ASSISTANTSHIPS		
Research	1,366	
Teaching	<u>438</u>	
Subtotal	<u>1,804</u>	50%
 SPONSORED STUDENTS		
<p>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.</p>		
U S Army and Related Programs	111	
U S Navy and Related Programs	175	
Foreign Countries and International Programs	225	
Industry and Foundation	<u>114</u>	
Subtotal	<u>625</u>	17%

TABLE III (continued)

		Percentage of Total Enrollment
TOTAL STUDENTS CONSIDERED TO HAVE FULL AWARDS	3,136	87%
SUMMARY BY SOURCES - FULL AWARDS		
Federal Fellowships and Traineeships	387	11%
Graduate Student Staff	1,804	50%
Industrial and Foundation Awards	112	3%
M. I. T. Endowed and Budgeted Funds	208	6%
Students Sponsored by External Sources	625	17%
TOTAL FULL AWARDS	3,136	87%

TABLE IV GRADUATE LOANS, FY 1976

Source	Number of Loans	Total Amount
M. I. T. Administered		
NDSL	-	-
Technology Loan Fund		
Guaranteed	248	\$ 462,428
Non-Guaranteed	207	415,121
Foreign/Subsidized	<u>152</u>	<u>263,450</u>
Total M. I. T. Administered	605	1,140,999
Bank-Guaranteed Loans	336	243,707
Total Long-Term Loans	941	1,384,706
Short-Term Loans	<u>227</u>	<u>109,143</u>
TOTAL BORROWED	1,168	\$1,493,849

Medical Department

On February 12, 1976, this Department was dealt a devastating blow by the tragic and sudden death of Dr. Albert O. Seeler. Over the course of 20 years, Dr. Seeler shaped this Department, forged its direction, selected its staff, established and maintained its standards of excellence, even created its style. His influence on those who worked here with him was profound and ennobling.

This was, then, a very sad but very busy year for the Medical Department. The number of visits to the Department increased by about 8 percent to reach 103,670. Although the Off-Hours Clinic visits were slightly below last year's level, the use of this facility by the M. I. T. community continues to be high. There were 5,978 visits to that clinic this year. The number of visits to the Lincoln Laboratory was 7,041, up 13 percent. Including the Off-Hours Clinic and the Lincoln Laboratory, the total number of visits to the Medical Department for the year was 116,689, an increase of slightly over 7 percent.

The M. I. T. Health Plan has continued to grow, reaching a membership of almost 5,000. Health Plan members now make about 25 percent of all visits to the Department. Further expansion of the Health Plan membership has had to be tempered by concerns about the adequacy of space available to provide services.

The severe lack of space which has been, and continues to be, the Department's most critical problem has been partially alleviated by the temporary acquisition of nearby space, resulting in a net gain to the Department of about 4,000 square feet. The Psychiatry and Social Work Services, the Business Office, and part of the Health Plan staff moved to these new quarters.

Internal moves within Building 11 will meet the acute needs of the record room, X-ray film storage, and some of the needs of the physician and nursing staff. However, this additional separation of vital clinical services increases the problems inherent in fragmentation of facilities, both in terms of record transport and communications, and in the reduction of interpersonal contact among the staff. A new facility remains an urgent need.

Some of the space freed in Building 11, the Homberg Memorial building, will be used to accommodate a restructuring of the Surgical Service. In order to assure better continuity of care for its patients, the Department has changed the status of three surgeons from part- to full-time. Dr. John V. Pikula, Dr. Julius Goldblatt, and Dr. Charles Eades are now available to patients on a full-time basis.

The number of visits to the gynecological service continues to increase, rising by 16 percent this year. Despite the addition of a highly trained and skillful gynecological nurse-midwife (Helena McDonough), the need for additional physician time continues, and a search for another full-time obstetrician-gynecologist is under way.

Because of concern that some women in the M. I. T. community might be at risk for the development of a particular kind of malignancy if they had been exposed to diethylstilbestrol (DES) before their birth, the Gynecological Department undertook a survey program. Information was supplied through letters to all women students and through an article in Tech Talk; women with known or possible exposure to DES in utero were urged to be in touch with a member of the Department who helped to evaluate the medical history and, when

appropriate, referred these patients for further examination and tests. Although only 26 women were interviewed for possible DES exposure, nine subsequently were found to have physical evidence of such exposure. Evaluation is incomplete in seven others. The Department will continue this program.

Of increasing concern has been the large number of health survey examinations performed each year. This year, more than 5,000 such examinations were conducted, necessitating the expenditure of many hours of professional time. Skepticism as to the value of these surveys to the patient, expressed by many, is shared by most members of the staff. Indeed, there is some apprehension that inappropriate reliance by the patient on the annual check-up may in some instances delay his seeking needed help.

Of the approximately 5,200 health surveys done, more than 1,700 were accomplished by the use of a medical questionnaire plus several tests and, in many instances, a brief visit with a physician. This mode of examination is being looked at as a possible method to be used for all health surveys in the Department.

This year the Department has been able to offer several programs of patient education. Under the direction of Karen Holmes (Coordinator for Health Education and Information) and Marguerite Heywood (Assistant for Health Education and Information) and with the help of members of the Gynecologic, Pediatric, Psychiatric, and Social Work services and others, programs concerning pregnancy, maternity, infant and child care, miscarriage, nutrition and weight control, and cessation of smoking are being conducted. Despite the fact that both Ms. Holmes and Ms. Heywood are leaving the Department, continuation and expansion of these activities is planned.

The computer program designed by Andrew M. Thomson has continued to increase in usefulness. It has reached a level of reliability sufficient for it to be used for accounting purposes in addition to its well established functions in gathering administrative and diagnostic information. Carsten Mortensen has succeeded Mr. Thomson in charge of the program.

The continuing dramatic rise in the cost of hospitalization has had a serious impact on M. I. T. students. Admission to hospitals outside the Department may be necessary for major surgical procedures, injuries, or serious illness, and for any of these reasons when the student is out of the Cambridge area. Insurance adequate to cover the expense of these admissions has been urged for many years, but each year, some student has had the unfortunate experience of needing hospitalization without having adequate insurance coverage. In 1976-77, all M. I. T. students will be enrolled in the student insurance program unless they apply for a waiver of this requirement and can demonstrate coverage by a policy at least equal to the standard program. The Medical Advisory Board has been helpful in carefully considering alternative solutions to this problem, and has concurred in this decision.

With the resignation of Dr. Franklin Aldrich from his position as Head of the Environmental Medical Service, Dr. Melvin H. Chalfen has assumed direction of that service. He also will continue to carry on his clinical responsibilities half-time at the Medical Department. The increasingly complex Federal and state regulations are particularly demanding of the time of professional and support staffs of the Environmental Medical Services.

The Arteriosclerosis Center, formerly under the administrative aegis of the Medical Department, has been transferred to the Division of Health Sciences and Technology.

Personnel

Staff appointments during the year were as follows: Joyce Bishop, R. N., Supervisor of Nurses, Off-Hours Clinic; Linda Buchwald, M. D., Neurologist; Carleton Cappuccino, D.M.D., Dentist; Frank Castronovo, Visiting Scientist; Peter Cuevas, M. D., Surgeon; Joseph Gerstein, M. D., Physician; Laurence Greenberg, M. D., Ophthalmologist; Charles Hatem, M. D. Physician; Ruby Jackson, M. D., Obstetrician-Gynecologist; Jeltje Koumans, M. D., Dermatologist; Deborah Leone, R. N., M. S., Supervisor of Nurses, M.I.T. Infirmary; Carsten Mortensen, S. B., Systems Analyst; James Murphy, D.V.M., Ph.D., Veterinary Pathologist; William Ruth, M. D., Physician; Diane Schweitzer, M. D., Physician; Eric Seldin, M. D., Oral Surgeon; John Stanbury, M. D., Physician; T. Phillip Sullivan, D.M.D., Dentist; Sherry Turkle, Post Doctoral Fellow in Psychiatry; Sally Zinno, M.P.H., Operations Manager; and Gerald Zuriff, Ph.D., Post Doctoral Fellow in Psychiatry.

Promotions included the following: Melvin H. Chalfen, M. D., to Assistant Medical Director in Charge of Environmental Medical Service; James G. Fox, D.V.M., Ph.D., to Director, Division of Laboratory Animal Medicine; Marie T. Jeon, to Administrative Coordinator, M.I.T. Health Plan; and Stephen L. Nigro, B. S., to Administrative Officer, Division of Laboratory Animal Medicine.

The following staff members resigned: Franklin Aldrich, Physician, Assistant Medical Director in Charge of Environmental Medical Service; Menelaos Aliapoulios, Surgeon; Harry Azadian, Surgeon; Lewis Braverman, Physician; Henry Brown, Surgeon; Donald Butterfield, Surgeon; Harold A. Carnes, Consultant in Dentistry; Carl Canzanelli, Surgeon; Lydia Dawes, Consultant in Psychiatry; Thomas Dwyer, Consultant in Psychiatry; H. Harris Funkenstein, Neurologist; Sylvester Kelly, Urologist; Melvin Krant, Physician; Walter Kunisch, Dentist; Phillip Porter, Pediatrician; David Richman, Neurologist; John Rowbotham, Surgeon; Kenneth Stampfer, Ophthalmologist; Elinor Spita, Supervisor of Nurses, M.I.T. Infirmary; Renee O'Sullivan, Surgeon; Andrew Thomson, Systems Analyst; and John Truman, Pediatrician.

Patricia Benedict, Physician,retired.

The appointments of the following staff members were changed: Charles Eades, M. D., Chief, Obstetrics-Gynecology; Edward Goodman, M. D., Ophthalmologist, Leave of Absence; Julius E. Goldblatt, M. D., Associate Surgeon-in-Chief; and John V. Pikula, M. D., Surgeon-in-Chief.

Employee Health Program

The Employee Health Program has seen a continuation of trends already established. The number of preemployment examinations has continued to fall, being 16.5 percent lower this year. The number of health surveys done at the patient's own request and for those invited to participate in health survey programs has increased by about 21 percent compared to one year ago.

Only two applicants for employment were found to have health problems serious enough to impair their ability to perform in the jobs applied for. This represents only 0.24 percent of the applications. Many were hired despite health problems which, although serious, would not interfere with job performance.

Including retired employees, there were 24 deaths recorded during the year. Heart disease (8) and cancer (7) again accounted for the large majority.

Dental Service

There were approximately 11,000 visits to the Dental Service. Eligibility for use of the Service has been widened to include all members of the M.I.T. community as well as Health Plan dependents over age 14. The range of services provided also has increased: endodontal (root canal), periodontal, and oral surgical services are now available, as well as the full range of general dental care.

Psychiatric Service

The following report was submitted by Dr. Merton J. Kahne. Data on the activity of the Service are available from Dr. Kahne.

The general disquiet with continued academic cutbacks, personnel attrition, and national political and economic troubles shared by most members of the M.I.T. community was overshadowed, among the psychiatric staff, by our sorrow at the death of Dr. Seeler, and Gay Warner who had been with us as Administrative Assistant for only a few months. Though with us all too briefly, Gay's warmth and vivaciousness was felt by all. Dr. Seeler was so much a part of our daily lives that it is impossible, even now, to grasp the fact that he is no longer there to guide us. For 20 years, his quiet smile and thoughtful counsel helped so many of us, and then in the short space of a week, he was gone. Both losses coming so suddenly and so unexpectedly leave us with a painful heaviness of heart.

Students across the country are depressed, concerned with promoting their careers, and above all -- not making waves. Like other campus services, we have witnessed a rather dispirited self-absorption among many students and much clinical depression. But we also have noted students' responsiveness to genuine interest and their continued concern with fashioning a more humane environment and meaningful lives.

The social strains occurring in the wake of the campus-wide fiscal retrenchment are reflected in the 27 percent rise in numbers of different persons seen in the clinic during the year and in the 15 percent rise in the number of visits. Although some of the increased utilization reflects the more immediate availability of staff through better scheduling, less turnover, and fewer hours lost through ill health, some increase is attributable to the further development of the Health Plan. Both the pattern of increased use of the Service and the types of problems engaged clearly point to the socioeconomic situation as the major source of our clientele's current difficulties. There was less marital discord among couples due to conflicts between career and familial commitments. There was more concern with finances and a marked increase in troubles associated with layoffs or threatened layoffs among employees and diminished availability of graduate and undergraduate financial assistance. Senior faculty and administrators showed the strain of attempting to meet increasingly complex and contradictory claims on their leadership skills. But the most oppressive aspect of the campus ambience was the awareness that work opportunities for young and old alike are being drastically reduced.

The number of persons hospitalized was essentially the same as last year, and Infirmary utilizations remained at about the same level. This year, for the first time in our history as a service, more non-students made use of our service than students.

Pressures continue for child diagnostic and parent counseling programs. Under Dr. Rochelle Friedman's careful guidance, there has been a sustained development of group therapy and couple counseling. In association with Dr. Lora Tessman, Ms. Holmes, and Ms. Heywood, Dr. Friedman has developed some interesting experiments with emotionally supportive health

care educational groups. Dr. Charlotte Schwartz and Myra Rodrigues, with the assistance of Carol Hulsizer and Cheryl Prevot, have a mutually supportive and sophisticated wives group. The number of people now available on a voluntary basis to help solve community members' problems is well over 100. And one of our earliest ventures in social health maintenance, the International Students Program, is now largely carried out by students themselves. As each of these programs becomes self-sustaining, the experience gained is applied to other areas of the community needing help.

The Employee Assistance Program is now at the point where implementation of a collaboratively administered program awaits administrative approval. The Lincoln Laboratory and Draper Laboratory Programs, initiated last year, have been further developed by Dr. Peter Jenney.

This year, Professor Gerald Zuriff of the Wheaton College Psychology Department joined our staff as Clinical Fellow. His excellent clinical skills augmented by a well developed appreciation of the problems of academic life have made him a welcome addition to our staff.

No review of the year's events would be complete without some reflection on the impact of the administrative decision to move the location of the Psychiatric Service to Building 12 to make way for expansion of other medical services. As far back as any member of the Medical Department can remember, the Psychiatric Service has been located both in the physical center of the Medical Department and at the second floor crossroads of the Institute's senior administration. The corridor consultations that took place there have so long been a familiar scene and a part of our practice that the idea of leaving the area was difficult for all of us. We are still accommodating to the transition process; it is hard to tell how our work will be reshaped by our changed location.

We are especially indebted to Ms. Hovey and Dr. Joseph Brenner who worked with Kenneth MacAskill, Building and Maintenance Supervisor, Earl Harvey, M.I.T. Architect, and Vicky Siriani, Interior Designer, on the myriad of details of planning the new space and arranging the move. Without their sustained energy, imagination, and concern, the move could not have been accomplished so quickly and effectively.

Social Work Service

Data on the case load of the Service are available from Jacqueline A. Buck who submitted the following report:

We cannot review the activities of the past year without coming face to face with our tragic and monumental loss of Dr. Seeler. It was Dr. Seeler who brought to the Institute, in 1963, the first social worker, Jean Murphy. Miss Murphy came here to determine whether or not there was a need or place for Social Work at M.I.T. Since that time, hundreds of clients have been seen, establishing social work as an added and viable entity among the range of services offered by the Medical Department to the Institute community.

Dr. Seeler remained extremely supportive of our work and effort. We appreciate his allowing us, through the years, the freedom to use our best professional judgment and to order our priorities in such a way as to best serve the interests and needs of our clients and their families. For the gift of his support and relationship, personally and professionally, we shall remain deeply grateful.

Despite Mrs. Rodrigues' serious illness, diminishing for a period of time the number of available staff hours, we managed to see, during this year, 238 new clients who had never used the Social Work Service. Thirty-two of these were Health Plan members/families. There were 1,311 visits to the Service, of which 211 were Health Plan visits.

The Foreign Student/Staff Wives' Discussion Group conducted by Mrs. Rodrigues, Mrs. Schwartz, and Mrs. Hulsizer was attended by 100 wives this year. Substantial additional time was invested in the planning and coordination of this valuable ongoing endeavor.

The effects of the economic crisis were again reflected in the lives of the people we have seen, and in the way in which this added dimension of stress exacerbates problems. Many people have been troubled by the possibility and/or eventuality of the loss of their job, with its resultant disruption to the well being of the family. Black employees particularly have felt vulnerable in the wake of threatened and real reductions in the work force. As we are so often privy to the overwhelming depression which accompanies the separation from and loss of work, the disabled worker also must deal with the necessity to live with the pain of diminished functioning as well. Work has meaning and ego-sustaining power in our society, which transcends the weekly paycheck or monthly benefits.

Student families have been under additional stress as the costs of living have escalated. Among this group, even well educated and qualified student wives have had great difficulty finding appropriate work to supplement family income. The unavailability of jobs combined with increased competition for existing jobs generally has meant that foreign wives with language difficulties and few specific skills transposable to our culture have remained jobless, and as a result, further isolated from the mainstream of activity with Americans and American life.

Scholarship aid was scarcer creating the need for students to borrow larger sums of money to meet necessary expenses, a source of anxiety for many students. Some parents of students have themselves been victims of unemployment and have had to incur large loan debts to support the entire nuclear family. Consequently, less help has been available to the student from family resources as previously planned.

As we have stated at other times, we try to concentrate our professional effort in areas of our own expertise where we feel we can be maximally helpful, namely marital distress; family problems; problems with children; problems of chronic, life-threatening, and terminal illness.

Mrs. Rodrigues remained active in the affairs of black staff and students. She served as a resource person for a black graduate student retreat, participated in a panel discussion on "Social Work and the Black Family" for the Black Science and Technology Conference, continued her work with the black faculty/staff and a bi-weekly employee committee, and served on the subcommittee working on concerns of minority students. In addition, she provided services to patients at the Clinical Research Center, and found time to supervise Peter Kelleher, a graduate student from Simmons College School of Social Work. Mr. Kelleher, who had been a member of M.I.T.'s original Upward Bound group and subsequently a staff worker, chose to do his first year graduate school field placement at M.I.T. with the Upward Bound Program, working directly with students and their families.

Infirmary

Following on the recommendation of a consultant, the Infirmary service was reorganized, with the establishment of a Unit Coordinator system. The Coordinator (Cherry Oman) and the Infirmary Supervisor of Nurses (Deborah Leone) have worked together to increase the efficiency of Infirmary operations.

There was very little change in the occupancy of the Infirmary; the number of admissions has been fairly constant for several years while utilization of the Department's ambulatory services has been steadily increasing. The commonest diagnoses among those admitted were respiratory

diseases (117), depression (42), gastroenteritis (32), and infectious mononucleosis (27). Seventy-eight patients were transferred from a general hospital for post-operative care.

The observation unit has continued to be very useful, 391 patients being admitted during the year. Of these, 80 were admitted to the Infirmary after no more than 24 hours of observation in the unit.

There were 615 minor surgical procedures performed, about the same as in the previous year. Athletic injuries were 367 in number, down 36 percent from last year. The dangerous trio of basketball (67), soccer (49), and football (41) continue to lead the list. Injuries while bicycling (39), however, displaced hockey injuries (35) from fourth position.

Clinical Laboratory, Electrocardiogram, X-Ray

The number of chest X-rays has been steadily decreasing during the past decade. This last year, 5,578 were done, representing a further 4 percent decrease from a year ago. There was, however, a 9 percent increase in other X-ray work. The total number of X-rays taken was 9,802, representing a modest increase. Electrocardiograms continue to be made in increasing numbers. There were 2,879 done, an increase of 7 percent over the year before.

There was an increase of 8 percent in the number of laboratory tests performed, with a total of 64,363. Of these, 12,497 were done at the Mount Auburn Hospital, representing a 5 percent decrease, since certain chemistry determinations are now being done in our laboratory rather than being sent out. The expansion of laboratory space to meet minimum requirements has been accomplished and has resulted in a real increase in efficiency and productivity of the laboratory.

Sanitation

Routine bacteriological monitoring of the M.I.T. food services and the swimming pool continues to be handled by the Massachusetts Dairy Laboratories. Fred E. Smith, our consultant Sanitary Engineer, reviews the bacteriological results and inspects the facilities regularly. There have been no major problems during the year.

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M.I.T. Health Plan

The following report was submitted by Laurence H. Bishoff:

This was a year of continued growth for the M.I.T. Health Plan. Membership grew by 36 percent, rising to 4,865 members from 3,570 members at the start of the year. Enrollment programs to increase membership followed the acquisition of the interim expansion space that had been assigned to the Department after the Plan's adoption as a permanent program at the Institute.

This space, located on the first floor of the main group about 100 yards east of the Homberg building, has been renovated and is now occupied by the psychiatry, social work, and business services. The relocation of these services will permit expansion of offices in the Homberg building to accommodate general surgery, internal medicine, diagnostic testing, medical records, nursing, and certain other medical specialty offices. The space should be adequate to handle departmental needs for two more years when an enrollment level of 7,000 members is expected.

The Plan has funded an additional position in internal medicine. Additional time in other specialties also has been acquired with program funds.

Utilization of outpatient services for the year increased by 35 percent over the previous year. This increase was almost exactly the same percentage as the increase in membership. There were six visits per member to the department during the year as there had been in the preceding 12 months.

With the increase in Plan revenues allocated to purchase departmental services, the program has become an important source of support for departmental operations. In the forthcoming year, \$470,000 is expected to be transferred to departmental accounts from Plan revenues in return for services to members.

Forecasted costs have been achieved in the past year. In addition to meeting departmental expenses, the Plan's continuation depends heavily on achieving forecasted levels of hospitalization that are comparable to other prepaid groups and less than the population at large. For the past year, actual hospitalization days were 355 days per 1,000 members compared to a forecasted 400 days in outside hospitals, and 158 days per 1,000 members compared to a projected 150 days per 1,000 members in the M.I.T. Infirmary. This lower level of hospitalization helped to offset the increase in hospital costs. Per diem costs in Plan hospitals which were \$186 only 18 months ago rose to \$260 in the last three months.

To handle administrative demands of an increased membership, Marie T. Jeon, formerly assistant administrative officer, has been appointed as administrative coordinator for the M.I.T. Health Plan. She provides leadership for an administrative staff to handle enrollment and claims matters. Growth in services also has led to the appointment of Sally Zinno as operations manager for departmental support activities and personnel.

This year, partly in anticipation of increased needs, and partly due to increased demand, our patient education program staff was augmented. Ms. Holmes, a member of the Plan, had begun efforts on a half-time basis a year earlier. This year the position was increased to a full-time job and shared with Ms. Holmes by Ms. Heywood. She provided staff support to the Department's consumer advisory group and effectively handled patient complaints, becoming a skillful patient advocate within the Department.

Ms. Holmes and Ms. Heywood initiated the development of programs including prenatal and postnatal education, parents discussion group, weight control, stop smoking programs, seminar on human sexuality, abortion counseling, and miscarriage groups. In addition, the office published a periodic newsletter to members, coordinated new member orientation programs, and arranged for the distribution of educational materials to patients. Currently under development is a slide/talk orientation program for new employees in cooperation with the M.I.T. Benefits Office.

Environmental Medical Service

The following report, submitted by Dr. Chalfen, includes a summary of detailed reports by Samuel Levin for the Radiation Protection Office and Richard Chamberlin for the Industrial Hygiene Office. In addition, the Radioactivity Center report is included.

The Institute's concern for people in work involving hazards of radiation and toxic materials was expressed by its creation of the Occupational Medical Service in the early 1940s and has continued in its support of the Environmental Medical Service. The Environmental Medical Service acts as an advisory body to a growing number of Institute committees concerned with

hazards. These committees, which examine and determine policy, are made up of faculty and of members of the Environmental Medical Service whose members advise the committee on technical matters and work in accord with policies of the committees. Membership of the physician-in-charge of Environmental Medical Service on these committees serves to keep him informed to fill the needs of Environmental Medical Service and to advise the Medical Director of new hazards in the M. I. T. community which may require medical advice and treatment.

Committees presently participating are the Laboratory Hazards Committee, Radiation Protection Committee, Reactor Safeguard Committee, Committee on Radiation Exposure to Human Subjects, Committee on the Use of Humans as Experimental Subjects, Assessment of Biohazards Committee, Safety Committee, and Animal Care Committee.

The Biohazards Committee, appointed in January, considers safe practice in research in oncogenic viruses and recombinant DNA molecules. A new member of Environmental Medical Service is now being sought to develop a registry of such agents and work, to advise safe practices in combination with the Industrial Hygiene Office and Radiation Protection Office, and to be knowledgeable in the literature and relevant Federal guidelines.

This committee and the Environmental Medical Service face a difficult task as much of the work is pioneering, controversial, and susceptible to political and legal input. For those who are interested, there have been many articles published in Science and other publications during the past two or more years. During these coming years, Environmental Medical Service will spend much time and thought on this issue and also on the subject of the rapidly increasing number of chemicals which are suspected of being actual or potential carcinogens.

The increase in the number of laboratories using radioisotopes and thus requiring Radiation Protection Office (R. P. O.) surveys continues. A new staff member in R. P. O. will work with lasers, particle accelerators and sources of non-ionizing radiation. The work of the Industrial Hygiene Office (I. H. O.) also has increased. I. H. O. members have devoted time in advising Draper Laboratory about industrial hygiene in their new building which will be occupied in fall, 1976.

Radiation Protection Office (R. P. O.)

Activities of the R. P. O. included continuation of monitoring procedures at the assembly of the new core for MITR-II and the associated start-up procedures. Power is now up to 2.5 mW and will increase further as the year goes on.

Radiation Protection Office laboratory surveys increased from 4,850 to 5,100. There are now 350 laboratories and there were 310 a year ago.

Use of protein iodination procedures with radio-iodine continued to increase, and contributed to an increase in the number of persons measured with an in vivo counting system from 180 to 210. Stack discharge monitoring procedures also continued; 2,100 stack samples were collected and analyzed. The R. P. O. and the I. H. O. are collaborating to determine the most efficient method for selectively trapping gaseous radio-iodine. Advances in reducing this discharge have already been made.

R. P. O. also has aided in special projects at the Lincoln Laboratory, and collaborated with the M. I. T. High Voltage Laboratory in the installation of a Waste Treatment Research Facility at Deer Island to disinfect sewage sludge by means of electron-beam irradiation. The Office also provided advisory services for Lincoln Laboratory and Draper Laboratory for laser-beam use outside of buildings.

The Bates Linear Accelerator is now operating on a typical schedule of 120 hours a week from 8 a.m. Monday to 8 a.m. Saturday. R.P.O. personnel are present during those times and during maintenance of equipment or areas where radiation is present. This round-the-clock coverage requires four technical persons, one added this past year. With the increase in beam time and average beam intensity, more visiting scientists have used the facilities, requiring increased R.P.O. services. A sophisticated personnel radiation exposure monitoring system is in effect and provides daily readouts of visitor badges and monthly readouts of L.I.N.A.C. personnel badges.

The laser eye examination program involves 380 people. No laser associated conditions were detected.

Industrial Hygiene Office (I.H.O.)

The carcinogen monitoring program continues. People in this program work with OSHA designated carcinogens, aflotoxins, and animals involved in studies using carcinogens.

I.H.O. activities included laboratory hood surveillance, a respirator program, a hearing protection program, and laboratory analysis of samples of blood, urine, and air for various metals, including beryllium. The 10-year-old atomic absorption unit continues to be used extensively, but is near replacement condition.

During the year, I.H.O. helped Draper Laboratory move to a new building, which required about 1.5 person days per week. It is estimated that they will need about one person day per week in the coming year. Lincoln Laboratory and L.I.N.A.C. also have been advised regularly.

Several special projects have needed I.H.O. help. These include surveying and labeling of 58 new hoods in Building 66 (Chemical Engineering), design of a special centrifuge for biological materials in Building E17, iodine filtration study, and work with the planning of a new animal care facility.

Radioactivity Center

The Radioactivity Center work continues essentially as outlined in last year's report in the study of human beings exposed to alpha emitters, primarily radium and mesothorium. Of much interest has been the study of persons treated with intravenous radium chloride at a major medical clinic in the 1920s. The patients have been identified through the cooperation of this major medical clinic and by Professor Robley Evans and the efficient Deputy Director of the Radioactivity Center, Mary Margaret Shanahan. More detailed metabolic studies of radium turnover have been possible with 10-day admissions of patients to the M.I.T. Clinical Research Center and by the personnel of the Center of Human Radiobiology at the Argonne National Laboratory, the parent of the Radioactivity Center.

Division of Laboratory Animal Medicine (D.L.A.M.)

The following report was submitted by Dr. James G. Fox:

The 1975-76 period has continued in a pattern of growth for the newly created Division of Laboratory Animal Medicine. A key factor in establishing the fundamentals of the animal care program at M.I.T. was the implementation of centralized management of all animal

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facilities at M. I. T. during the last year. The daily census of animals, involving 15 species, now exceeds 13,000, a growth of 23 percent from that of a year ago.

Space in existing animal facilities has been utilized to meet current needs, even though compromises had to be made in housing and management due to overcrowding and inadequate design. The American Association for Accreditation of Laboratory Animal Care committee (recognized by NIH funding agencies) has placed M. I. T. on probationary accreditation with 11 months to correct existing deficiencies. Because of the urgent need for progress in this area, staff members of D. L. A. M., the Environmental Medical Service, the Planning Office, and Physical Plant have developed plans for a new 13,000 square foot animal facility with animal holding space, containment areas, diagnostic laboratories, and centralized administrative support areas. The completion date for the new structure is scheduled for May 1977. The facility will initially house animals relocated during renovation of the existing animal facilities. Grants to offset the costs of this renovation are actively being sought.

The lack of proper diagnostic laboratory facilities and personnel has been partially alleviated by the newly formed animal diagnostic laboratory. Dr. James Murphy has been appointed to help direct the laboratory.

The disease surveillance program is a coordinated effort by the staff of the Division of Laboratory Animal Medicine to select dealers who supply high quality healthy animals, quarantine newly acquired animals (where the present facilities allow), monitor and screen for possible disease conditions before release of quarantine animals to the investigator, and survey the health status of those animals housed within the various facilities. Costs for this resource are being paid for in part by an NIH Animal Diagnostic Grant.

The staff of D. L. A. M. is researching spontaneous or acquired laboratory animal disease entities which may adversely affect biomedical research with animals. Also, for the first time at M. I. T., a course in animal experimentation and technique will be offered to both graduate and undergraduate students.

The current and anticipated future costs of research involving animals in addition to the limited availability of certain species of animals makes it imperative that the available animal resources at M. I. T. be afforded the most intensive care possible to avoid losses due to disease and environmental conditions. Our efforts in service, teaching, and research are directed to achieve these goals.

MELVIN H. RODMAN

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*

Year	Number of students	Year	Number of students	Year	Number of students
1865-66	72	1903-04	1,528	1941-42	3,055
1866-67	137	1904-05	1,561	1942-43	3,048
1867-68	167	1905-06	1,466	1943-44	1,579
1868-69	172	1906-07	1,397	1944-45	1,198
1869-70	206	1907-08	1,415	1945-46	1,538
1870-71	224	1908-09	1,461	1946-47	5,172
1871-72	261	1909-10	1,479	1947-48	5,662
1872-73	348	1910-11	1,506	1948-49	5,433
1873-74	276	1911-12	1,559	1949-50	5,458
1874-75	248	1912-13	1,611	1950-51	5,171
1875-76	255	1913-14	1,685	1951-52	4,874
1876-77	215	1914-15	1,816	1952-53	5,074
1877-78	194	1915-16	1,900	1953-54	5,183
1878-79	188	1916-17	1,957	1954-55	5,348
1879-80	203	1917-18	1,698	1955-56	5,648
1880-81	253	1918-19	1,819	1956-57	6,000
1881-82	302	1919-20	3,078	1957-58	6,179
1882-83	368	1920-21	3,436	1958-59	6,259
1883-84	443	1921-22	3,505	1959-60	6,270
1884-85	579	1922-23	3,180	1960-61	6,289
1885-86	609	1923-24	2,949	1961-62	6,454
1886-87	637	1924-25	2,938	1962-63	6,695
1887-88	720	1925-26	2,813	1963-64	6,925
1888-89	827	1926-27	2,671	1964-65	7,151
1889-90	909	1927-28	2,712	1965-66	7,408
1890-91	937	1928-29	2,868	1966-67	7,567
1891-92	1,011	1929-30	3,066	1967-68	7,730
1892-93	1,060	1930-31	3,209	1968-69	7,764
1893-94	1,157	1931-32	3,188	1969-70	8,024
1894-95	1,183	1932-33	2,831	1970-71	7,799
1895-96	1,187	1933-34	2,606	1971-72	7,717
1896-97	1,198	1934-35	2,507	1972-73	7,850
1897-98	1,198	1935-36	2,540	1973-74	7,888
1898-99	1,171	1936-37	2,793	1974-75	8,050
1899-00	1,178	1937-38	2,966	1975-76	8,482
1900-01	1,277	1938-39	3,093		
1901-02	1,415	1939-40	3,100		
1902-03	1,608	1940-41	3,138		

*From 1943 to 1946 Army and Navy students are omitted (see Table 3-B in reports for 1943 to 1946).

Table I-A Student Registration in the Summer Session since 1948

Year	*In Regular Subjects	+In Other Subjects	Year	*In Regular Subjects	+In Other Subjects
1948	2,146	-	1964	1,882	1,492
1949	1,875	171	1965	2,090	1,568
1950	1,852	259	1966	2,054	1,787
1951	1,861	813	1967	2,218	1,829
1952	1,689	832	1968	2,490	1,739
1953	1,672	1,289	1969	2,241	1,719
1954	1,675	1,398	1970	2,185	1,666
1955	1,619	1,653	1971	2,197	1,109
1956	1,553	2,497	1972	2,121	1,235
1957	1,548	1,757	1973	2,205	1,367
1958	1,650	1,752	1974	2,153	1,701
1959	1,635	1,510	1975	2,238	1,430
1960	1,600	1,696			
1961	1,668	1,412			
1962	1,748	1,763			
1963	1,808	1,397			

* 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

	Professors	Administration	also Professors	Institute Professors	Emeriti-Part Time	Associate Professors	Professors	Assistant Professors	Sr. Lecturers & Prof. Emeriti	Sr. Lecturers	Lecturers	Sr. Research Scientists	Instructors	Technical Instructors	Instructors	Research Associates	Technical Assistants	Research Assistants	Teaching Assistants	Instructor Grad	Total	Visiting Professors	Others ¹
Institute Professors	9	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	4	2
School of Architecture and Planning																							
Architecture	14	1	-	-	-	14	9	3	3	5	5	-	4	5	4	4	1	12	20	2	94	3	5
Urban Studies and Planning	8	2	-	-	-	14	12	-	-	6	6	-	-	-	1	1	-	8	2	6	59	3	2
Total	22	3	-	-	-	28	21	3	3	11	11	-	4	5	5	5	1	20	22	8	154	6	7
School of Engineering																							
Aeronautics and Astronautics	21	3	-	-	-	6	5	2	-	8	8	-	2	2	10	10	-	105	3	-	165	1	3
Chemical Engineering	10	1	-	-	-	3	8	1	-	2	2	-	2	2	12	12	-	35	17	4	96	9	4
Civil Engineering	19	1	-	-	-	12	16	-	2	2	1	-	-	-	9	9	-	111	19	-	192	2	11
Electrical Engineering and Computer Science	49	5	-	-	-	22	26	3	1	17	-	-	-	-	13	13	-	200	103	13	452	4	13
Materials Science and Engineering	19	2	-	-	-	6	4	-	-	1	-	-	4	4	14	14	-	112	16	1	179	5	10
Mechanical Engineering	24	2	-	-	-	12	8	2	4	11	-	-	2	2	12	12	-	155	2	5	239	3	12
Nuclear Engineering	14	1	-	-	-	5	2	-	-	-	-	-	-	-	4	4	-	60	26	-	112	2	2
Ocean Engineering	10	2	-	-	-	7	6	-	-	1	-	-	-	-	4	4	-	40	10	-	80	5	5
School Professors	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	2	-
Total	171	17	-	-	-	73	75	8	7	42	1	1	10	10	78	78	-	818	196	23	1,520	33	60
School of Humanities and Social Science																							
Educational Programs	2	-	-	-	-	2	2	-	-	-	-	-	-	-	1	1	1	-	-	-	8	1	13
Economics	13	1	-	-	-	3	3	1	-	-	-	-	-	-	-	-	-	11	23	-	56	2	4
Foreign Literatures and Linguistics	8	1	-	-	-	3	3	1	-	9	-	-	5	-	-	-	-	15	3	-	48	-	8
Humanities	16	2	-	-	-	13	19	2	-	11	-	-	6	2	1	13	-	-	-	-	85	5	2
Philosophy	5	1	-	-	-	1	6	-	-	-	-	-	1	-	-	-	-	1	5	-	20	-	-
Political Science	14	3	-	-	-	3	7	-	-	2	-	-	-	-	-	-	-	16	11	-	56	-	3
Psychology	6	1	-	-	-	3	2	-	-	-	-	-	3	3	8	-	-	2	-	-	26	1	15
Total	64	9	-	-	-	28	42	4	-	22	-	14	5	10	14	45	42	-	-	-	299	9	45
Alfred P. Sloan School of Management																							
Management	27	2	-	-	-	9	23	-	9	5	-	-	-	-	9	1	36	30	-	-	151	12	17

School of Science	16	3	-	10	8	-	-	-	-	2	1	49	36	16	15	-	156	4	51
Biology	21	2	-	3	11	-	-	2	-	1	2	56	12	103	56	-	269	2	33
Chemistry	11	1	-	8	6	1	-	-	1	-	-	11	-	66	11	1	117	-	7
Earth and Planetary Sciences	33	2	-	5	8	-	-	5	-	24	-	3	3	14	57	-	154	3	11
Mathematics	6	2	-	1	2	1	-	1	-	-	-	7	-	46	2	-	68	2	4
Meteorology	13	3	-	9	7	-	2	11	2	4	-	34	23	58	7	-	173	20	33
Nutrition and Food Science	48	3	-	14	20	1	-	-	9	3	5	-	-	144	41	-	288	6	11
Physics	148	16	-	50	62	3	2	19	12	34	8	160	74	447	189	1	1,225	37	150
Total																			
Administration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aerospace Studies	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	6	1	17
Arteriosclerosis	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	6
Athletic	-	1	-	8	2	-	-	2	-	9	-	-	-	-	-	-	22	-	18
Center for Advanced Engineering Study	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	2
Center for Advanced Visual Study	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12
Center for Cancer Research	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15
Center for International Studies	-	-	-	-	-	-	-	-	-	-	-	16	-	-	-	-	16	-	9
Center for Materials Science and Engineering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Center for Policy Alternatives	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10	-	9
Center for Space Research	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Center for Transportation Studies	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	3
Division for Study and Research in Education	2	1	-	1	-	-	-	7	-	-	-	-	-	-	-	-	11	1	2
Electronic Systems Laboratory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Energy Laboratory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Harvard-MIT Health Sciences and Technology	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	5
Laboratory of Architecture and Planning	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	3	-	3
Laboratory for Nuclear Science	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
Libraries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	61
Medical	1	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	4	-	123
Military Science	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	6	1	2
National Magnet Library	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Naval Science	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	7	1	-
Operations Research	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Project Mac	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Research Laboratory of Electronics	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	6	-	49
Sea Grant Program	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Student Activities	-	-	-	-	-	-	-	-	-	-	1	-	6	-	-	-	7	-	3
Total	3	4	-	10	2	-	-	9	2	9	20	37	6	-	-	-	102	4	366
Grand Total	444	51	4	198	225	18	19	108	15	62	48	299	96	1,366	479	32	3,464	1105	647
Faculty Ex-Officio																			

The total Faculty is 979

1 Includes Guests,visiting Engineers,visiting Lecturers,visiting Instructors,visiting Scientists,visiting Social Scientists,Research Affiliates, Post-doctoral Associates,Fellows,Administrative Officers,Administrative Assistants,visiting Architects,Executive Officers,Consulting Professors,Special Assistants,visiting Scholars,Coaches,Editors,Librarians,Medical Doctors,Honorary Lecturer,Facilities Officer, and Housemaster.

2 Total Teaching Staff is 1688

3 Not included in preceding total

4 Visiting Professors include 44 Professors,22 Associate Professors,6 Assistant Professors

Table III Classification of Students since 1973

Course	1973-74				1974-75				1975-76				Course Number			
	2	3	4	G Total	2	3	4	G Total	2	3	4	G Total				
School of Architecture and Planning																
Architecture, IV	43	42	51	144	280	53	46	45	163	307	37	53	54	184	328	IV
Architecture, IV-B	-	2	3	-	5	1	3	2	-	3	1	1	1	-	3	IV-B
Urban Studies and Planning, XI	10	23	23	147	203	9	20	25	140	194	5	10	33	127	175	XI
Total	53	67	77	291	488	63	66	72	303	504	43	64	88	311	506	Total
School of Engineering																
Aeronautics and Astronautics, XVI	19	23	16	152	210	18	12	21	155	206	26	17	13	191	247	XVI
Aeronautics and Astronautics, XVI-B (Cooperative)	-	2	-	-	2	1	4	1	-	6	-	4	3	-	7	XVI-B
Chemical Engineering, X	29	34	33	148	244	44	37	31	149	261	78	57	40	163	338	X
Chemical Engineering, X-C	2	3	6	-	11	3	2	7	-	12	1	3	5	-	9	X-C
Civil Engineering, I	37	48	48	244	377	23	52	54	264	393	41	49	58	258	406	I
Electrical Engineering and Computer Science, VI	130	122	97	464	1,101	105	132	112	489	1,125	160	115	134	484	1,147	VI
Program 1-Electrical Science and Engineering	85	109	94	-	-	70	89	128	-	-	79	61	114	-	-	-
Program 3-Computer Science and Engineering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electrical Engineering and Computer Science, VI-A (Cooperative)	2	35	36	27	100	1	57	43	27	128	3	32	58	37	130	VI-A
Materials Science and Engineering, III	9	10	16	130	165	8	21	12	138	179	13	9	21	143	186	III
Materials Science and Engineering, III-A	-	-	1	-	1	-	-	1	-	1	1	-	-	-	1	III-A
Materials Science and Engineering, III-B	-	-	-	-	-	-	-	-	-	-	1	2	1	-	4	III-B
Mechanical Engineering, II	61	54	38	237	390	57	67	43	231	398	56	66	66	216	404	II
Mechanical Engineering, II-A	8	6	12	-	26	3	8	10	-	21	7	14	6	-	27	II-A
Mechanical Engineering, II-B (Cooperative)	1	-	1	-	2	-	7	4	-	11	4	4	7	-	15	II-B
Mechanical Engineering, II-T-Textile Technology	-	-	-	6	6	-	-	-	4	4	-	-	-	5	5	II-T
Nuclear Engineering, XXII	-	-	-	129	129	-	-	-	144	144	17	3	-	184	204	XXII
Ocean Engineering, XIII	16	11	10	97	134	11	15	10	97	133	10	9	12	100	131	XIII
Ocean Engineering, XIII-C (Cooperative)	3	2	-	5	5	-	4	2	-	6	1	2	1	-	4	XIII-C
Ocean Engineering, XIII-W (Woods Hole)	-	-	-	9	9	-	-	-	12	12	-	-	-	10	10	XIII-W
Naval Construction and Engineering, XIII-A	-	-	-	59	59	-	-	-	63	63	-	-	-	68	68	XIII-A
Shipping and Shipbuilding Management, XIII-B	-	-	-	2	2	-	-	-	7	7	-	-	-	6	6	XIII-B
Center for Advanced Engineering Study, EN	-	-	-	47	47	-	-	-	66	66	-	-	-	82	82	EN
Total	402	459	408	1,751	3,020	344	507	479	1,846	3,176	498	447	539	1,947	3,431	Total

School of Humanities and Social Science

Economics, XIV	15	20	28	121	184	21	17	26	118	182	14	27	22	116	179	XIV
Foreign Literatures and Linguistics, XXIII	-	-	-	37	37	-	-	-	38	38	-	-	-	34	34	XXIII
Humanities and Engineering, XXI-A	-	1	5	-	6	1	1	2	-	4	-	1	4	-	5	XXI-A
Humanities and Science, XXI-B	8	14	39	-	61	3	15	21	-	39	6	9	25	-	40	XXI-B
Philosophy, XXIV	4	3	2	20	29	-	1	-	21	22	3	-	2	17	22	XXIV
Political Science, XVII	6	7	22	99	134	2	8	5	102	117	7	4	9	90	110	XVII
Psychology, IX	-	-	-	28	28	-	-	-	30	30	-	-	-	29	29	IX
Total	33	45	96	305	479	27	42	54	309	432	30	41	62	286	419	Total

Alfred P. Sloan School of Management

Management, XV	12	46	67	386	511	25	35	55	384	499	20	35	52	305	412	XV
Management Fellows, XV-A	-	-	-	-	-	-	-	-	-	-	-	-	-	68	68	XV-A
Management-Operations Research, XV-B	-	-	-	-	-	-	-	-	-	-	-	-	-	15	15	XV-B
Total	12	46	67	386	511	25	35	55	384	499	20	35	52	388	495	Total

School of Science

Biology, VII	72	110	105	143	430	56	91	99	139	385	57	58	81	132	328	VII
Biology, VII-A	4	12	28	-	44	4	8	13	-	25	8	8	20	-	36	VII-A
Biology, VII-B	9	15	14	-	38	23	26	19	-	68	30	45	26	-	101	VII-B
Biology, VII-W(Woods Hole)	-	-	-	10	10	-	-	-	14	14	-	-	-	14	14	VII-W
Chemistry, V	62	56	41	186	345	58	61	50	170	339	64	52	56	171	343	V
Earth and Planetary Sciences, XII	19	25	25	88	157	17	28	25	89	159	18	21	29	81	149	XII
Earth and Planetary Sciences, XII-W(Woods Hole)	-	-	-	29	29	-	-	-	32	32	-	-	-	38	38	XII-W
Earth and Planetary Sciences, XII-W(Woods Hole)	2	5	10	-	17	3	4	10	-	17	2	6	7	12	27	XXV
Interdisciplinary Science Program, XXV	74	95	114	112	395	53	77	90	125	345	65	68	86	138	357	XVIII
Mathematics, XVIII	-	-	-	39	39	-	-	-	40	40	-	-	-	51	51	XIX
Meteorology, XIX	-	-	-	17	17	-	-	-	14	14	-	-	-	12	12	XIX-W
Meteorology, XIX-W(Woods Hole)	-	-	-	124	124	-	-	-	153	153	-	-	-	172	172	XX
Nutrition and Food Science, XX	-	-	-	248	524	91	111	93	253	548	89	95	122	253	559	VIII
Physics, VIII	108	89	79	248	524	91	111	93	253	548	89	95	122	253	559	VIII
Health Sciences and Technology, HST	-	-	-	46	46	-	-	-	43	43	-	-	-	43	43	HST
Total	350	407	416	1,042	2,215	305	406	399	1,072	2,182	333	353	427	1,117	2,230	Total

Undesignated	280			280	216	216			216	216	232				232	Undes.
First Year	895			895	1,041	1,041			1,041	1,169	1,169				1,169	First Year

Grand Total	895	1,130	1,024	1,064	3,775	7,888	1,041	980	1,056	1,059	1,156	940	1,168	4,049	8,482	Grand Total
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(not included in above figures)

Non-Institute Students from Harvard	2	4	10	190	206	3	2	9	168	182	1	1	2	209	213	NIH
Non-Institute Students from Wellesley	53	51	100	-	204	44	77	106	3	230	59	60	119	2	240	NIW
Non-Institute Students from Boston University	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	NI

- 1 These totals include 5 students in third year and 1 in fourth year on Foreign Study; 1 student in second year and 3 in third year on Domestic Study
- 2 These totals include 1 student in second year, 5 in third year and 2 in fourth year on Foreign Study; 2 in third year on Domestic Study
- 3 These 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

Table III-A Women Students by Schools, Courses and Years, 1975-76¹

Course	2	3	4	Graduate		Total
				Regular	Special	
School of Architecture and Planning						
Architecture,IV	9	10	8	48	13	88
Urban Studies and Planning,XI	4	2	9	41	5	61
Total	13	12	17	89	18	149
School of Engineering						
Aeronautics and Astronautics,XVI	4	5	-	7	-	16
Aeronautics and Astronautics,XVI-B(Cooperative)	-	-	1	-	-	1
Chemical Engineering,X	19	13	3	13	-	48
Chemical Engineering,X-C	1	1	1	-	-	3
Civil Engineering,I	11	4	9	22	5	51
Civil Engineering,IR	-	-	-	1	-	1
Electrical Engineering and Computer Science,VI						
Program 1-Electrical Science and Engineering	11	4	3			
Program 3-Computer Science and Engineering	5	3	5	15	8	54
Electrical Engineering and Computer Science,VI-A (Cooperative)	1	1	3	4	-	9
Materials Science and Engineering,III	6	2	2	15	2	27
Materials Science and Engineering,III-A	1	-	-	-	-	1
Materials Science and Engineering,III-B(Cooperative)	1	2	-	-	-	3
Mechanical Engineering,II	12	4	5	10	-	31
Mechanical Engineering,II-A	-	3	1	-	-	4
Mechanical Engineering,II-B(Cooperative)	1	-	-	-	-	1
Ocean Engineering,XIII	2	-	3	-	-	5
Ocean Engineering,XIII-C(Cooperative)	-	1	-	-	-	1
Nuclear Engineering,XXII	-	1	-	4	-	5
Center for Advanced Engineering Study,EN	-	-	-	-	1	1
Total	75	44	36	91	16	262
School of Humanities and Social Science						
Economics,XIV	3	3	4	13	2	25
Foreign Literatures and Linguistics,XXIII	-	-	-	10	1	11
Humanities and Engineering,XXI-A	-	-	-	-	-	-
Humanities and Science,XXI-B	1	3	5	-	-	9
Philosophy,XXIV	-	-	-	4	-	4
Political Science,XVII	2	1	-	22	4	29
Psychology,IX	-	-	-	11	1	12
Total	6	7	9	60	8	90

Alfred P. Sloan School of Management

Management ²	-	-	-	-	-	-	-	89	65	154	10	10	10	10	19	7
School of Science																
Biology	-	1	10	17	21	38	105	93	285	25	11	16	14	10		
Chemistry	7	19	59	146	180	342	427	262	1,442	55	52	39	32	26		
Earth and Planetary Sciences ⁴	1	7	10	22	20	71	84	53	268	8	3	10	13	8		
Mathematics	-	-	6	25	35	70	211	136	483	22	31	22	18	18		
Meteorology	-	-	-	-	-	14	45	25	84	5	1	7	2	3		
Nutrition and Food Science	-	-	-	-	4	28	66	72	170	7	18	15	9	14		
Oceanography ⁵	-	-	-	-	-	-	11	-	11	-	-	-	-	-		
Physics	-	2	6	48	159	283	390	232	1,120	43	38	34	32	31		
Total	8	29	91	258	419	846	1,339	873	3,863	165	154	143	120	110		
Awarded jointly with Woods Hole Oceanographic Institution																
Biology	-	-	-	-	-	-	-	3	3	-	-	-	2	1		
Earth and Planetary Sciences	-	-	-	-	-	-	4	21	25	2	6	2	6	5		
Meteorology	-	-	-	-	-	-	1	10	11	2	-	-	3	1		
Ocean Engineering	-	-	-	-	-	-	-	2	2	-	-	-	1	1		
Total	-	-	-	-	-	-	5	36	41	4	6	2	12	8		
Grand Total	8	29	91	258	447	979	2,504	1,871	6,187	336	329	302	314	224		

* Includes only February and June degrees

+ Previously included in Industrial Economics

1 Changed from Industrial Economics to Economics 1966

2 Changed from Industrial Management to Management February 1967

3 Includes Ceramics, Metallurgy and Materials Science changed to Materials Science and Engineering 1975

4 Changed from Geology and Geophysics to Earth and Planetary Sciences 1970

5 Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology

6 Changed from City and Regional Planning to Urban Studies and Planning September 1969

7 Prior to 1960 Aeronautical Engineering

8 Changed from Naval Architecture and Marine Engineering to Ocean Engineering September 1971

9 Changed from Electrical Engineering and Computer Science 1975

Table III-B Special Students by Schools, Courses and Years, 1975-76¹

Course	Year				Total	
	2	3	4	G		
School of Architecture and Planning						
Architecture(IV)	-	-	-	26	26	
Urban Studies and Planning(XI)	-	-	-	24	24	
Total	-	-	-	50	50	
School of Engineering						
Aeronautics and Astronautics(XVI)	-	-	-	29	29	
Chemical Engineering(X)	1	-	-	5	6	
Civil Engineering(I)	-	-	-	31	31	
Electrical Engineering and Computer Science (VI,VI-1,VI-3)	1	4	1	51	57	
Materials Science and Engineering(III)	-	-	-	7	7	
Mechanical Engineering(II)	1	-	-	7	8	
Ocean Engineering(XIII)	1	-	-	9	10	
Nuclear Engineering(XXII)	-	-	-	2	2	
Center for Advanced Engineering Study(EN)	-	-	-	82	82	
Total	4	4	1	223	232	
School of Humanities and Social Science						
Economics(XIV)	-	-	-	7	7	
Foreign Literatures and Linguistics(XXIII)	-	-	-	2	2	
Humanities and Engineering or Science(XXI-A, XXI-B)	-	1	-	-	1	
Philosophy(XXIV)	-	-	-	-	-	
Political Science(XVII)	-	-	-	6	6	
Psychology(IX)	-	-	-	1	1	
Total	-	1	-	16	17	
Alfred P. Sloan School of Management						
Management(XV, XV-A)	-	1	1	52	54	
School of Science						
Biology(VII,VII-A,VII-B)	1	-	-	22	23	
Chemistry(V)	-	-	-	2	2	
Earth and Planetary Sciences(XII)	-	-	-	3	3	
Interdisciplinary Science Program(XXV)	-	-	-	1	1	
Mathematics(XVIII)	1	-	-	6	7	
Meteorology(XIX)	-	-	-	4	4	
Nutrition and Food Science(XX)	-	-	-	16	16	
Physics(VIII)	-	3	-	8	11	
Health Sciences and Technology(HST)	-	-	-	43	43	
Total	2	3	-	105	110	
Undesignated	58				58	
First Year	-				-	
Grand Total	-	64	9	2	446	521

¹ Included also in Table III

Table IV Continued, Former, and New Students

	1971-72	1972-73	1973-74	1974-75	1975-76
Continued Students					
Undergraduate and graduate students registered at the end of the last academic year (including special students)	5,332	5,337	5,426	5,513	5,747
Non-continued Students					
Former undergraduates and graduate students who previously attended the Institute but were not registered at the end of the last academic year (including special students)	291	273	306	249	227
Undergraduate students who enrolled for the first time since secondary school (excluding special students)	979	1,041	893	1,033	1,156
Undergraduate students who enrolled for the first time at the Institute and who transferred from another collegiate institution (excluding special students)	90	104	85	99	130
Graduate students who enrolled for the first time at the Institute (excluding special students)	786	883	884	849	935
Special undergraduate and graduate students with no previous Institute registration	239	212	294	307	287
Total	7,717	7,850	7,888	8,050	8,482

Table V Regular Students from Other Colleges and Graduates of M.I.T.
Classified by Schools and Courses 1975-76

	Entered with no previous degree	Entered with Bachelor's degree from other colleges	Entered Graduate School with Bachelor's degree from M.I.T.
School of Architecture and Planning			
Architecture(IV,IV-B)	19	125	33
Urban Studies and Planning (XI)	3	91	12
Total	22	216	45
School of Engineering			
Aeronautics and Astronautics(XVI, XVI-B)	6	124	38
Chemical Engineering(X,X-C)	13	127	31
Civil Engineering, (I)	17	183	44
Electrical Engineering and Computer Science(VI,VI-1,VI-3,VI-A)	75	254	216
Materials Science and Engineering(III, III-A,III-B)	4	104	32
Mechanical Engineering (II,II-A,II-B, II-T)	24	162	52
Nuclear Engineering(XXII)	2	161	21
Ocean Engineering(XIII,XIII-A, XIII-B,XIII-C,XIII-W)	6	157	18
Total	147	1272	452
School of Humanities and Social Science			
Economics(XIV)	4	99	10
Foreign Literatures and Linguistics (XXIII)	-	28	4
Humanities and Engineering or Science(XXI-A,XXI-B)	4	-	-
Philosophy(XXIV)	-	17	-
Political Science(XVII)	-	74	10
Psychology(IX)	-	25	3
Total	8	243	27
Alfred P. Sloan School of Management			
Management(XV,XV-A,XV-B)	8	292	44
School of Science			
Biology(VII,VII-A,VII-B,VII-W)	22	108	16
Chemistry(V)	14	164	5
Earth and Planetary Sciences(XII, XII-W)	3	89	27
Interdisciplinary Science Program (XXV)	1	7	4
Mathematics(XVIII)	29	117	15
Meteorology(XIX,XIX-W)	-	52	7
Nutrition and Food Science(XX)	-	116	40
Physics(VIII)	33	159	86
Total	102	812	200
Undesignated	2	-	
First Year	2		
Grand Total	293	2835	768

Table VI List of Colleges and Universities with Number of Graduates
Entering the Institute as Regular Students, 1975-1976 ¹

Alabama, University of	2	Colorado State University	1
American College	1	Columbia University	12
Amherst College	1	Connecticut, University of	2
Antioch College	3	Cooper Union, The	6
Arizona, University of	2	Cornell University	26
Arizona, State University	3	Creighton University	1
Auburn University	3		
Augustana College	1	Dartmouth College	6
		Dayton, University of	1
Barnard College	2	Denver, University of	1
Barrington College	1	Detroit, University of	2
Bates College	1	Detroit Institute of Technology	1
Berea College	1	Douglass College	1
Boston Architectural Center	2	Drexel University	4
Boston College	2	Duke University	3
Boston University	6		
Bowdoin College	2	Emory University	3
Brandeis University	6	Evansville, University of	1
Brigham Young University	1		
Brooklyn College	1	Florida, University of	3
Brown University	13	Florida Atlantic University	1
Bryn Mawr College	2	Florida State University	2
California, University of, Berkeley	23	George Washington University	3
California, University of, Davis	2	Georgia Institute of Technology	4
California, University of, Irvine	3	Goddard College	1
California, University of, Los Angeles	1	Goucher College	1
California, University of, San Diego	3		
California, University of, Santa Barbara	3	Hampshire College	2
California, University of, Santa Cruz	1	Hampton Institute	1
California Institute of Technology	5	Harvard University	17
California State University at Fullerton	1	Harvey Mudd College	1
California State University at San Jose	1	Haverford College	1
Canisius College	1	Hofstra University	1
Capital University	1	Houston, University of	1
Carleton College	1	Howard University	1
Carnegie-Mellon University	7	Hunter College	1
Case Western Reserve University	4		
Catholic University of America	2	Idaho, University of	1
Chicago, University of	4	Illinois, University of, Chicago Circle	1
Cincinnati, University of	2	Illinois, University of, Urbana-Champaign	5
City College, The	5	Illinois Institute of Technology	2
City University of New York	1	Iowa State University of Science and Technology	6
Clark College	2		
Clarkson College of Technology	2		
Cleveland State University	1	John Carroll University	1
Coe College	1	Johns Hopkins University	2
Colby College	4	Juniata College	1
Colgate University	1		
Colorado, University of	5	Kansas, University of	3
Colorado School of Mines	1	Kansas State University	1

Table VI continued

Kentucky, University of	1	Ohio University	1
Kenyon College	1	Oklahoma, University of	5
Kirkland College	1	Oklahoma State University	3
		Old Dominion University	1
Lehigh University	3	Oregon State University	3
Lewis and Clark College	1		
Long Island University	1	Pacific, University of the	1
Louisiana State University and Agricultural and Mechanical College	3	Pennsylvania, University of	16
Lowell Technological Institute	3	Pennsylvania State University	8
Loyola University of Los Angeles	1	Pittsburgh, University of	3
Lycoming College	1	Polytechnic Institute of Brooklyn	1
		Pomona College	1
		Princeton University	11
Maine, University of	1	Principia College	2
Marquette University	1	Purdue University	4
Maryland, University of	6		
Massachusetts, University of, Amherst	3	Radcliffe College	2
Massachusetts, University of, Boston	7	Reed College	1
Massachusetts College of Pharmacy	1	Rensselaer Polytechnic Institute	10
Massachusetts Institute of Technology	197	Rhode Island, University of	3
McNeese State University	1	Rhode Island School of Design	1
Miami, University of, Florida	1	Rice University	3
Michigan, University of, Ann Arbor	19	Ripon College	1
Michigan State University	6	Rochester, University of	2
Middlebury College	2	Rochester Institute of Technology	2
Minnesota, University of	7	Rutgers, The State University	6
Mount Holyoke College	1		
		St. Catherine, College of	1
Nevada, University of	1	St. Joseph College, Maryland	1
New Hampshire, University of	2	St. Mary's College, California	1
New Mexico, University of	4	St. Mary's University	1
New York, State University of, Albany	6	Salem State College	2
New York, State University of, Buffalo	3	Seattle University	1
New York, State University of, Downstate Medical Center	1	Simmons College	2
New York, State University of, Maritime College	1	Smith College	2
New York, State University of, Stony Brook	5	Southeastern Massachusetts University	1
New York University	8	Southern California, University of	4
North Carolina, University of, Chapel Hill	4	Southern Methodist University	1
North Carolina State University, Raleigh	2	Stanford University	10
North Dakota, University of	1	Stevens Institute of Technology	2
Northeastern University	23	Swarthmore College	4
Northwestern University	3	Sweet Briar College	1
Notre Dame, University of	5	Syracuse University	4
Oakland University	2	Teacher's College, Columbia University	1
Oberlin College	2	Tennessee, University of, Knoxville	1
Ohio State University	1	Tennessee Technological University	1
		Texas, University of, Austin	5
		Texas A & M University	3
		Texas Christian University	1
		Thomas Jefferson University	1
		Tri State College	1

Table VI continued

Trinity College, New York	1	Cairo University (United Arab Republic)	3
Tufts University	10	Cambridge University (England)	5
		Capetown, University of (South Africa)	1
Union College, New York	1	Chung Cheng Institute of Technology	
U. S. Coast Guard Academy	3	(Republic of China)	1
U. S. Merchant Marine Academy	1	Chung-Yuan College of Science and	
U. S. Military Academy	17	Engineering (Republic of China)	2
U. S. Naval Academy	14	College of Chinese Culture (Republic of	
Utah, University of	4	China)	1
Vanderbilt University	1	Dalhousie University (Canada)	1
Vassar College	2	Daneshgah Isfahan (Iran)	1
Villanova University	1	Daneshgah Melli (Iran)	1
Virginia, University of	5	Daneshgah Pahlavi (Iran)	4
Virginia Polytechnic Institute and		Daneshgah Sanati Arya-Mehr (Iran)	7
State University	1	Daneshgah Tehran (Iran)	10
		Daneshkadeh Naft Aran (Iran)	1
Washington, University of	10	Dublin, University of, Trinity College	
Wayne State University	3	(Ireland)	1
Webb Institute of Naval Architecture	2		
Wellesley College	1	East China College of Chemical Technology	
West Virginia University	1	(Republic of China)	1
William and Mary, College of	1	Ecole Centrale de Lyon (France)	1
Williams College	2	Ecole Centrale des Arts et Manufactures	
Wisconsin, University of, Eau Claire	1	(France)	6
Wisconsin, University of, Madison	6	Ecole Nationale des Ponts et Chaussees	
Wisconsin, University of, Milwaukee	2	(France)	4
Worcester Polytechnic Institute	6	Ecole Nationale Superieure de Chimie	
		(France)	1
Yale University	11	Ecole Nationale Superieure de l'Aeronautique	
		(France)	1
	872	Ecole Nationale Superieure de Mines de Paris	
		(France)	2
		Ecole Nationale Superieure des Industries	
		(France)	1
Abadan Institute of Technology (Iran)	1	Ecole Nationale Superieure des	
Ahmadu Billo University (West Africa)	2	Telecommunications (France)	1
Akita Daigaku (Japan)	1	Ecole Polytechnique (France)	1
Alberta, University of (Canada)	1	Eidgenossische Technische Hochschule	
Arhus Universitet (Denmark)	2	Zurich (Switzerland)	1
Arya-Mehr Industrial (Iran)	1	Engineering and Technology, University of	
Asian Institute of Technology (Pakistan)	1	(Pakistan)	1
Auckland, University of (New Zealand)	1	Escuela de Ingenieria Aeronautica	
Australian National University		(Argentina)	1
(Australia)	1	Escuela Ingenieria Naval (Chile)	1
		Escuela Politecnica National (Ecuador)	1
Baroda, University of (India)	1	Escuela Tecnica de Ingenieros Aeronauticos	
Birla Institute of Science and		(Spain)	1
Technology (India)	1	Escuela Tecnica Superior de Ingenieros	
Bristol, University of (England)	2	Navales (Spain)	1
British Columbia, University of		Ethnikon Metsovion Polytechneion Athinia	
(Canada)	3	(Greece)	3

Table VI continued

Farnborough College of Technology (England)	1	Mahaitayalai Chiengmai (Thailand)	1
		Manitoba, University of (Canada)	1
		McGill University (Canada)	5
Ha'Technion-Machan Technologi Li Israel (Israel)	6	McMaster University (Canada)	1
Ha'Universita Ha'Ivrith Birushalayim (Israel)	2	Melbourne, University of (Australia)	1
Hitotsubashi Daigaku (Japan)	2	Montreal, University of (Canada)	1
		Moscow State University (U. S. S. R.)	1
		Mysore, University of (India)	1
Ibadan, University of (Nigeria)	1	National Cheng-Kung University (Republic of China)	1
Imperial College of Science and Technology (England)	1	National Taiwan University (Republic of China)	8
Indian Institute of Science, Bangalore (India)	1	Newcastle Upon The Tyne, University of (England)	3
Indian Institute of Technology, Bombay (India)	2		
Indian Institute of Technology, Kanpur (India)	3	Osaka Daigaku (Japan)	1
Institut National des Sciences et Techniques Nucleaires (France)	1	Oxford University (England)	2
Instituto catolico de Artes e Industrias (Spain)	1	Panepistimion Patron (Greece)	1
Instituto Militar de Engenharia (Brazil)	1	Panjab University (Pakistan)	1
Instituto Politecnico Nacional (Mexico)	2	Phillips-Universitat Marburg/Lahn (West Germany)	1
Instituto Tecnologico y de Estudios Superiors de Monterrey (Mexico)	2	Politecnico di Milano (Italy)	1
Instituto Tecnologico y de Estudios Superiores de Occidente (Mexico)	1	Pontificia Universidade Catolica do Rio de Janeiro (Brazil)	1
Institutul Politehnic "Gheroghe Gheorghiu-Dej" Bucuresti (Romania)	1	Puerto Rico, University of, Mayaguez (Puerto Rico)	5
Jami'at Al-Riyalh (Arabia)	1	Queens College (England)	1
Junta de Engenharia Nuclear (Spain)	3	Queen's University at Kingston (Canada)	3
		Queensland, University of (Australia)	1
		Ravensharo (India)	1
Kabul Pohantoon (Afghanistan)	1	Rheinische Friedrich-Wilhelms-Universitat (West Germany)	1
Karachi, University of (Pakistan)	1	Rijksuniversiteit te Utrecht (Netherlands)	1
Keio Gijuku Daigaku (Japan)	2	Royal Academy of Fine Arts (Belgium)	1
Kievskij Ordena Trudovogo Krasnogo Znameni Institut (U. S. S. R.)	1	Royal Military College (Canada)	1
Kijksuniversiteit te Gent (Belgium)	1		
Kyota Daigaku (Japan)	1	Saskatchewan, University of (Canada)	2
		Scholi Naftikon Dokimon (Greece)	1
Lagos, University of (Nigeria)	1	School of Architecture, Ahmedabad (India)	2
Leningradskij (U. S. S. R.)	1	Seoul Dai Hak Kyo (Republic of Korea)	2
London, University of (England)	1	Sheffield, University of (England)	1
London School of Economics and Political Science (England)	3	Southwest London College (England)	1
Loughborough University of Technology (England)	1	Tatung Institute of Technology (Republic of China)	1
Lucknow, University of (India)	1	Technische Universitat (West Germany)	1
Ludwig-Maximilians-Universitat Munchen (West Germany)	1	Technische Universitat Munchen (West Germany)	1

Table VI continued

Tokyo Daigaku (Japan)	12	Victoria, Univeristy of (Canada)	1
Toronto, University of (Canada)	4	Waseda Daigaku (Japan)	2
Universidad Autonoma de Morelos (Mexico)	1	West Indies, University of (Trinidad)	1
Universidad Catolica Andres Bello (Venezuela)	1	Witwatersrand, University of (South Africa)	2
Universidad Catolica de Chile (Chile)	1	<u>Yokohama Koburitsu Daigaku (Japan)</u>	<u>1</u>
Universidad Central de Venezuela (Venezuela)	2		260
Universidad Complutense de Madrid (Spain)	2	<u>Grand Total</u>	<u>1,132</u>
Universidad de Barcelona (Spain)	1		
Universidad de Chile (Chile)	1		
Universidad de la Republica (Uruguay)	1		
Universidad de Los Andes (Venezuela)	1		
Universidad del Valle (Colombia)	1		
Universidad Iberoamericana (Mexico)	2		
Universidad Metropolitana (Venezuela)	1		
Universidad Nacional Autonoma de Mexico (Mexico)	4		
Universidad Nacional de Cordoba (Argentina)	1		
Universidad nacional mayor de San Marcos (Peru)	1		
Universidad Simon Bolivar (Venezuela)	1		
Universidad de Brasil (Brazil)	1		
Universidade de Sao Paulo (Brazil)	2		
Universidade Federal de Pernambuco (Brazil)	1		
Universidade Federal do Rio de Janeiro (Brazil)	1		
Universidade Technica de Lisboa (Portugal)	2		
Universita Degli Studi de Napoli (Italy)	1		
Universita Degli Studi di Roma (Italy)	1		
Universitat Salzburg (Austria)	1		
Universitat Tel-Aviv (Israel)	2		
Universite de Geneva (Switzerland)	2		
Universite de L'Etat A Liege (Belgium)	1		
Universite de Paris VI (France)	1		
Universite de Paris VII (France)	2		
Universite libre de Bruxelles (Belgium)	1		
Universitet I Oslo (Norway)	1		
University College (England)	1		
University of Engineering and Technology (Pakistan)	1		

1 Graduates of 206 Colleges and Universities in the United States and 152 Foreign Colleges entered the Institute.

Table VII Geographic Distribution of Students, 1975-1976

	Under-grad.	Grad.		Under-grad.	Grad.		Under-grad.	Grad.
United States			U.S.Territories and Dependencies			Kenya	2	1
Alabama	17	19				Korea	19	29
Alaska	7	2	Puerto Rico	26	19	Laos	1	-
Arizona	29	9	Virgin Islands	2	-	Lebanon	3	9
Arkansas	10	1				Libya	-	1
California	196	173	U.S.Citizens			Luxembourg	1	1
Colorado	37	21	Foreign Address	54	48			
Connecticut	146	75	Total U.S.	4,099	2,902	Malaysia	14	14
Delaware	19	14				Mexico	6	36
District of Columbia	23	24	Foreign Countries*			Morroco	-	1
Florida	79	63	Afghanistan	-	1	Mozambique	-	1
Georgia	27	17	Algeria	-	2	Netherlands	1	6
Hawaii	25	11	Argentina	5	8	New Zealand	1	3
Idaho	8	3	Australia	3	9	Niger	-	1
Illinois	158	79	Austria	1	3	Nigeria	3	18
Indiana	35	15	Bahama Islands	1	-	Norway	1	11
Iowa	25	14	Bangladesh	2	2	Pakistan	16	17
Kansas	32	12	Barbados	1	-	Panama	-	1
Kentucky	21	6	Belgium	-	11	Peru	1	12
Louisiana	22	18	Bermuda	-	1	Phillipines	1	2
Maine	34	13	Bolivia	1	-	Poland	2	1
Maryland	126	63	Brazil	2	47	Portugal	1	10
Massachusetts	632	1,051	Bulgaria	-	1	Rumania	-	4
Michigan	101	58	Cambodia	1	-	Saudi Arabia	1	5
Minnesota	39	19	Canada	42	80	Singapore	1	-
Mississippi	5	2	Ceylon	1	-	South Africa, Republic of	1	4
Missouri	53	19	Chile	1	16	Spain	1	24
Montana	6	1	China, Republic of	22	103	Sri Lanka	2	1
Nebraska	10	9	Colombia	7	11	Sweden	-	5
Nevada	6	1	Costa Rica	2	1	Switzerland	1	6
New Hampshire	33	33	Cuba	1	3	Tanzania	2	1
New Jersey	263	138	Curacao	1	-	Thailand	5	12
New Mexico	10	12	Cyprus	3	2	Trinidad	4	2
New York	866	346	Czechoslovakia	-	2	Turkey	4	11
North Carolina	47	20	Denmark	1	8	Uganda	-	1
North Dakota	1	1	Ecuador	-	1	Union of Soviet Socialist Republics	-	3
Ohio	156	68	England	1	19	United Arab Republic (Egypt)	1	8
Oklahoma	18	14	Ethiopia	1	3	United Kingdom	7	23
Oregon	30	14	France	-	43	Uruguay	2	1
Pennsylvania	261	132	Germany	2	14	Venezuela	5	25
Rhode Island	20	30	Ghana	12	10	Vietnam	2	4
South Carolina	15	10	Greece	9	46	Yugoslavia	3	4
South Dakota	8	3	Guatemala	-	1	Zaire, Republic of	-	1
Tennessee	27	12	Guyana	1	-	Zambia	-	2
Texas	117	39	Honduras	1	-	Stateless	10	8
Utah	3	12	Hong Kong	38	66	Total Foreign	334	1,147
Vermont	16	8	Hungary	2	-	Grand Total	4,433	4,049
Virginia	78	59	Iceland	-	1			
Washington	65	29	India	8	80			
West Virginia	3	5	Indonesia	1	2			
Wisconsin	47	38	Iran	16	79			
Wyoming	5	-	Iraq	-	1			
			Ireland	2	5			
			Israel	3	26			
			Italy	4	19			
			Ivory Coast	-	1			
			Jamaica	1	7			
			Japan	9	78			
			Jordan	-	4			

* Country of Citizenship

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.

	Total by decade										Grand Total	Calendar year since 1972 (included in decade total)						
	1868-70	1871-80	1881-90	1891-1900	1901-10	1911-20	1921-30	1931-40	1941-50	1951-60		1961-70	1971-	1972	1973	1974	1975	1976*
School of Architecture and Planning¹																		
Architecture	-	12	24	162	188	233	223	23	-	-	-	-	-	-	-	-	-	
Undesignated	-	-	-	-	-	-	-	-	-	2	16	-	6	1	3	4	2	
Architectural Engineering ²	-	-	-	-	-	108	64	-	-	-	-	-	-	-	-	-	-	
Art and Design	-	-	-	-	-	-	-	-	-	26	274	300	43	51	53	37	44	
Urban Studies	-	-	-	-	-	-	-	-	-	-	100	100	23	10	20	21	17	
Undesignated	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	
Total	-	12	24	162	188	233	331	87	-	28	391	1,456	72	62	76	62	63	
School of Engineering																		
Aeronautics and Astronautics ¹¹	-	-	-	-	-	-	68	287	526	395	556	150	47	13	17	21	13	
Undesignated	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	
Building Engineering and Construction	-	-	-	-	-	32	99	114	131	-	-	-	-	-	-	-	-	
Chemical Engineering	-	-	-	91	123	372	571	434	740	726	421	168	20	26	29	36	35	
Undesignated	-	-	-	-	-	-	-	-	-	3	41	-	44	8	5	10	7	
Chemical Engineering Practice	-	-	-	-	-	99	90	95	108	1	-	-	-	-	-	-	-	
Civil Engineering	12	84	86	256	407	504	653	284	272	457	252	253	35	33	55	49	56	
Undesignated	-	-	-	-	-	-	-	-	-	7	19	26	4	3	2	2	-	
Computer Science and Engineering	-	-	-	-	-	-	-	-	-	-	80	80	-	-	-	-	10	
Electrical Engineering	-	-	72	335	349	468	1,000	719	1,218	1,518	1,941	1,203	221	224	213	216	120	
Undesignated	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	
Electrochemical Engineering ³	-	-	-	-	28	84	133	56	-	-	-	-	301	-	-	-	-	
General Engineering	-	-	-	-	6	226	222	230	133	-	-	-	817	-	-	-	-	
Materials Science and Engineering ⁴	-	-	-	-	-	52	194	311	186	81	186	81	824	13	10	16	10	
Undesignated	-	-	-	-	-	-	-	-	-	1	17	17	18	7	4	2	-	
Mechanical Engineering	5	40	147	329	502	623	797	602	1,164	1,049	563	266	39	37	40	52	55	
Undesignated	-	-	-	-	-	-	-	-	-	12	78	90	13	14	13	10	10	
Military Engineering	-	-	-	-	-	1	4	-	-	-	-	5	-	-	-	-	-	
Mining Engineering and Metallurgy	8	44	64	74	250	129	174	137	-	-	-	880	-	-	-	-	-	
Naval Architecture and Marine Engineering	-	-	-	43	133	69 ⁴	100	173	234	139	69	32	992	3	5	7	5	
Ocean Engineering	-	-	-	-	-	-	-	-	-	-	28	28	1	4	2	14	7	
Sanitary Engineering	-	-	-	29	54	123	34	20	4	-	-	264	-	-	-	-	-	
Total	25	168	369	1,157	1,846	2,378	3,888	3,179	4,791	4,967	4,012	2,418	29,198	412	384	417	437	398

School of Humanities and Social Science																			
Economics	-	-	-	-	-	-	-	-	-	-	-	129	152	281	40	24	24	24	17
Economics, Politics and Engineering or Science	-	-	-	-	-	-	-	-	61	152	100	-	-	313	-	-	-	-	-
Humanities and Engineering or Science ⁵	-	-	-	-	-	-	-	-	-	49	412	249	710	63	43	35	25	20	20
Philosophy	-	-	-	-	-	-	-	-	-	-	-	19	-	19	4	8	4	-	3
Political Science ⁹	-	-	-	-	-	-	-	-	-	-	-	114	91	205	17	16	18	9	7
Total	-	-	-	-	-	-	-	-	61	201	755	511	1,528	124	91	81	58	47	47
Alfred P. Sloan School of Management ⁶																			
Business and Engineering Administration Management/ ¹⁰	-	-	-	-	-	-	142	872	641	909	732	-	-	3,296	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	172	565	382	-	1,119	74	65	57	59	52
Total	-	-	-	-	-	-	142	872	641	909	904	565	382	4,415	74	65	57	59	52
School of Science																			
Biology ²	-	3	11	25	27	49	57	129	74	116	16	-	-	507	-	-	-	-	-
Undesignated	-	-	-	-	-	-	-	-	-	-	-	-	225	225	39	41	49	47	36
Chemistry	2	27	80	154	151	111	141	166	232	207	307	290	1,868	45	45	51	52	60	60
Earth and Planetary Sciences ⁸	-	-	-	8	6	3	36	22	32	141	109	132	489	17	27	20	23	28	28
Undesignated	-	-	-	-	-	-	-	-	-	-	7	20	-	27	3	-	-	-	-
Food Technology and Biochemical Engineering-General Science or General Course	2	11	17	49	20	26	17	73	58	62	-	-	-	108	-	-	-	-	-
Interdisciplinary Science Program	-	-	-	-	-	-	-	-	-	-	-	56	56	17	11	11	8	9	9
Life Sciences ⁷	-	-	-	-	-	-	-	-	-	-	291	514	805	60	100	102	102	100	100
Mathematics	-	-	-	-	-	-	19	48	72	220	831	594	1,784	88	122	117	107	81	81
Meteorology	-	-	-	-	-	-	-	-	56	38	-	-	-	94	-	-	-	-	-
Physics	-	5	6	24	19	21	49	170	306	617	1,079	589	2,885	106	104	75	85	97	97
Total	4	46	114	260	223	210	319	608	865	1,463	2,651	2,420	9,183	375	450	425	424	411	411
Grand Total	29	226	507	1,579	2,257	2,963	5,410	4,515	6,626	7,535	8,011	6,122	45,780	1,057	1,052	1,038	1,040	971	971

* Included only February and June degrees

+ Two received the degree in Naval Architecture, Course XIII-B, in 1916 and three in 1917

1 See also Table XI

2 Prior to 1923 degrees were awarded in Architecture

3 Prior to 1909 this course was designated as Option 3 (Electrochemistry) or Physics

4 Prior 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

5 Prior to 1958 these degrees were included in General Engineering and General Science or General Course

6 Changed to Alfred P. Sloan School of Management after 1963

7 Changed to Life Sciences beginning January 1962

8 Changed from Geology and Geophysics to Earth Sciences in February 1961, changed from Earth Sciences to Earth and Planetary Sciences in February 1970

9 Prior to September 1965, these degrees were included in Economics, Politics and Engineering or Science

10 Prior to 1959, Business and Engineering Administration, changed from Industrial Management to Management in February 1967

School of Humanities and Social Science

Economics ⁷	-	-	-	-	-	-	-	-	19	12	31	5	1	3	1	1
Economics and Engineering or Science ¹⁰	-	-	-	-	12	16	19	10	10	-	57	-	-	-	-	-
Linguistics	-	-	-	-	-	-	-	-	1	7	8	-	1	2	3	-
Philosophy	-	-	-	-	-	-	-	2	2	6	8	1	1	2	2	-
Political Science ⁷	-	-	-	-	-	-	-	-	25	49	74	2	8	8	12	10
Psychology ⁴	-	-	-	-	-	-	-	-	7	5	12	2	2	1	-	-
Total	-	-	-	-	12	16	19	64	79	190	10	14	15	18	11	

Alfred P. Sloan School of Management⁵

Management ⁸	-	-	-	4	60	122	581	1,274	1,028	3,069	144	195	183	184	146	
School of Science	-	-	-	-	-	-	-	17	11	28	4	1	3	1	1	
Biochemical Engineering	-	-	-	-	-	-	3	6	3	12	2	1	-	1	2	
Biochemistry	-	-	-	-	-	-	29	12	32	130	4	10	4	5	2	
Biology	1	1	10	1	19	25	2	3	1	6	-	1	-	-	-	
Biophysics	-	-	-	-	-	-	46	97	43	356	6	5	6	11	3	
Chemistry	2	3	7	22	51	53	7	7	52	59	12	11	7	8	8	
Earth and Planetary Sciences	-	-	-	-	-	-	44	3	-	59	-	-	-	-	-	
Food Technology	-	-	-	-	-	-	-	57	24	81	7	4	3	2	3	
Food Science and Technology	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	
General Science	-	-	-	-	-	-	-	-	-	179	-	-	-	-	-	
Geology and Geophysics ⁹	-	-	2	5	15	17	48	71	4	4	-	-	-	-	4	
Interdisciplinary Science Program	-	-	-	-	-	-	96	73	35	285	6	7	-	6	8	
Mathematics	-	-	2	9	25	45	118	87	47	386	9	14	7	7	5	
Meteorology ⁶	-	-	-	-	35	99	-	23	-	23	-	-	-	-	-	
Nutrition	-	-	-	-	-	-	-	7	25	77	4	10	7	10	11	
Nutritional Biochemistry and Metabolism	-	-	-	-	-	-	-	28	17	45	4	1	3	3	-	
Oceanography	-	-	-	-	-	-	-	-	-	456	11	19	10	15	7	
Physics	-	3	2	2	16	40	121	138	84	456	11	19	10	15	7	
Total	2	8	12	41	79	185	514	647	398	2,187	69	84	50	69	54	

Operations Research	-	-	-	-	-	-	-	2	50	52	9	5	13	8	7	
Without Course Specification	-	-	-	5	308	263	357	299	223	1,578	48	37	29	37	16	
Grand Total	• 2	21	121	274	1,544	2,083	5,286	7,061	4,307	23,647	713	778	733	754	621	

* Includes only February and June degrees

1 See also Table XI

2 Prior to 1923 degrees were awarded in Architecture

3 Prior to 1959 included in Chemical Engineering

4 Prior to September 1964 included in Economics, Politics and Engineering or Science

5 Considered Engineering until 1950

6 Considered Engineering until 1956

7 Prior to September 1965 these degrees were included in Economics, Politics and Engineering or Science

8 Prior to February 1967 Industrial Management

9 Changed to Earth and Planetary Sciences beginning February 1970

10 Includes six degrees in Political Science awarded 1965

11 Prior to 1960 Aeronautical Engineering

12 Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975

Table XI Number of Degrees of Bachelor and Master in Architecture and Bachelor and Master in City Planning

	Total by decades										Grand Total	Calendar year since 1972 (included in decade total)				
	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1972	1973	1974	1975		1976*				
Bachelor in Architecture ²	-	146	126	257	211	25	765	4	-	-	-	-	-			
Bachelor in City Planning ¹	-	14	13	4	-	-	31	-	-	-	-	-	-			
Master in Architecture ³	63	81	78	191	214	21	648	1	-	-	-	-	-			
Master of Architecture	-	-	-	-	-	122	122	22	23	19	27	31				
Master of Architecture in Advanced Studies	-	-	-	-	-	96	96	22	18	21	18	17				
Master in City Planning	-	18	82	114	152	169	535	25	29	25	39	27				
Grand Total	63	259	299	566	577	433	2,197	74	70	65	84	75				

* Includes only February and June degrees

1 From 1935 to 1944, Bachelor of Architecture in City Planning

2 Degrees of Bachelor in Architecture changed to degree of Master of Architecture in 1972

3 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

	Total by decade					Grand Total	Calendar year since 1972 (included in decade total)				
	1949-60	1961-70	1971-	1971-	1971-		1972	1973	1974	1975	1976*
Engineer in Aeronautics and Astronautics ¹	35	58	19	112	3	2	4	2	4	2	
Building Engineer ³	5	2	-	7	-	-	-	-	-	-	
Chemical Engineer	17	31	41	89	6	12	7	5	5	5	
Civil Engineer	21	78	54	153	23	10	5	4	4	5	
Electrical Engineer	132	444	251	827	48	42	44	32	35	35	
Environmental Engineer	-	-	7	7	-	1	2	2	2	2	
Marine Mechanical Engineer	7	2	1	10	1	-	-	-	-	-	
Materials Engineer	-	7	3	10	-	-	-	-	1	1	
Mechanical Engineer	102	166	76	344	14	18	15	10	10	4	
Metallurgical Engineer	24	18	6	48	2	2	1	-	-	-	
Meteorologist ⁴	2	-	-	2	-	-	-	-	-	-	
Naval Architect	11	21	17	49	1	1	1	8	3	3	
Naval Engineer	334	246	20	600	-	-	-	1	1	-	
Nuclear Engineer	-	37	27	64	3	5	7	4	4	4	
Ocean Engineer	-	4	109	113	21	25	23	14	14	23	
Sanitary Engineer ³	9	3	-	12	-	-	-	-	-	-	
Total	699	1,117	631	2,447	123	118	109	85	85	84	
Awarded jointly with Woods Hole Oceanographic Institution											
Ocean Engineer	-	-	11	11	4	2	-	4	-	-	
Grand Total	699	1,117	633	2,458	127	120	109	89	89	84	

* Includes only February and June degrees

1 Prior to 1960 Aeronautical Engineer

2 Degree discontinued after 1955

3 Degrees discontinued after 1964

Table XIII Number of Degrees of Doctor of Philosophy Awarded

	Total by decade										Grand Total	Calendar year since 1972 (included in decade total)					
	1907-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-									
School of Architecture																	
Architecture	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
Urban Studies and Planning ⁶	-	-	-	-	-	-	24	30	54	5	5	6	8	6	2	-	-
Total	-	-	-	-	-	-	24	31	55	5	5	6	8	7	2	-	-
School of Engineering																	
Aeronautics and Astronautics ⁷	-	-	-	-	-	6	57	61	124	10	10	13	11	12	6	-	-
Chemical Engineering	-	-	-	-	-	-	31	25	56	1	1	7	6	3	2	-	-
Civil Engineering	-	-	-	-	-	1	72	79	152	15	15	16	11	16	7	-	-
Electrical Engineering and Computer Science ⁹	-	-	-	-	1	9	248	211	469	32	40	30	30	44	16	-	-
Materials Science and Engineering ⁵	-	-	-	-	-	6	103	78	187	14	14	14	10	9	7	-	-
Mechanical Engineering	-	-	-	-	-	4	95	88	187	15	8	8	16	16	15	-	-
Nuclear Engineering ⁸	-	-	-	-	-	5	90	53	148	10	7	6	6	9	13	-	-
Ocean Engineering	-	-	-	-	-	-	15	15	30	5	3	2	2	-	2	-	-
Sanitary Engineering	-	-	-	-	-	2	3	-	5	-	-	-	-	-	-	-	-
Total	-	-	-	-	1	33	714	610	1,358	102	108	92	109	68	-	-	-
School of Humanities and Social Science																	
Economics ¹	-	-	-	-	19	96	195	112	422	25	20	19	18	12	-	-	-
Group Psychology	-	-	-	-	8	1	-	-	9	-	-	-	-	-	-	-	-
Linguistics	-	-	-	-	-	-	35	42	77	9	6	11	7	4	-	-	-
Philosophy	-	-	-	-	-	-	8	15	23	3	4	3	3	1	-	-	-
Political Science	-	-	-	-	-	-	71	59	130	7	10	12	12	6	-	-	-
Psychology	-	-	-	-	-	3 ⁺	24	28	55	6	5	2	2	7	6	-	-
Total	-	-	-	-	27	100	333	256	716	50	45	47	47	29	-	-	-

Alfred P. Sloan School of Management

Management,XV	6	3	6	65	10	90
Management Fellows,XV-A	-	-	-	6	3	9
Management-Operations Research,XV-B	-	-	-	3	-	3
Total	6	3	6	74	13	102
School of Science						
Biology,VII	14	17	17	38	9	95
Biology,VII-A	3	3	4	-	-	10
Biology,VII-B	13	13	8	-	-	34
Biology,VII-W(Woods Hole)	-	-	-	3	-	3
Chemistry,V	14	9	7	25	1	56
Earth and Planetary Sciences,XII	8	5	5	12	1	31
Earth and Planetary Sciences,XII-W(Woods Hole)	-	-	-	6	-	6
Interdisciplinary Science Program,XXV	-	-	-	6	-	6
Mathematics,XVIII	10	13	16	11	1	51
Meteorology,XIX	-	-	-	5	-	5
Nutrition and Food Science,XX	-	-	-	49	6	55
Physics,VIII	11	7	9	18	2	47
Health Sciences and Technology,HST	-	-	-	-	8	8
Total	73	67	66	173	28	407
Undesignated	68	-	-	-	-	68
First Year	177					177
Grand Total	177	241	133	134	487	83

1 Also included in Table III

Total undergraduate women 685, 29 special undergraduate women are included, 27 of whom are registered as second year undesignated.

Table XIV Number of Degrees of Doctor of Science Awarded

	Total by decade										Calendar year since 1972 (included in decade total)				
	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-	Grand Total	1972	1973	1974	1975	1976*		
School of Engineering															
Aeronautics and Astronautics ¹	2	4	5	18	31	76	30	166	6	6	4	4	5		
Chemical Engineering	-	23	78	114	117	151	52	535	12	9	8	7	6		
Civil Engineering	-	2	12	23	46	75	29	187	6	3	7	3	2		
Electrical Engineering and Computer Science ⁵	3	12	30	34	141	124	47	391	13	7	8	8	5		
Electrochemical Engineering	-	1	1	-	-	-	-	2	-	-	-	-	-		
Materials Science and Engineering ⁶	-	14	32	86	194	201	58	585	13	11	6	8	11		
Mechanical Engineering	-	4	13	35	125	145	51	373	10	6	10	9	8		
Mineral Engineering	1	-	4	-	-	-	-	5	-	-	-	-	-		
Nuclear Engineering	-	-	-	-	9	55	30	94	11	6	2	2	5		
Ocean Engineering ⁴	-	1	-	-	2	6	9	18	2	-	1	4	-		
Petroleum Engineering	-	-	1	-	-	-	-	1	-	-	-	-	-		
Sanitary Engineering	-	-	2	3	18	2	-	25	-	-	-	-	-		
Total	6	61	178	313	683	835	306	2,382	73	48	46	45	42		
School of Science															
Chemistry	-	2	5	4	3	1	2	17	-	-	-	-	1		
Earth and Planetary Sciences ²	1	2	4	5	2	3	4	21	2	-	-	2	-		
Mathematics	-	2	3	-	1	1	2	9	1	-	-	-	-		
Meteorology	-	-	6	25	17	6	4	58	1	-	-	2	1		
Nutrition and Food Science	-	-	-	3	10	17	14	44	2	3	3	-	1		
Oceanography ³	-	-	-	-	-	1	-	1	-	-	-	-	-		
Physics	-	5	18	14	7	7	8	59	-	1	1	2	2		
Total	1	11	36	51	40	36	34	209	6	4	4	6	5		
Awarded jointly with Woods Hole Oceanographic Institution															
Meteorology	-	-	-	-	-	-	4	4	1	1	1	-	-		
Grand Total	7	72	214	364	723	871	344	2,595	80	53	51	51	47		

* Includes only February and June degrees

- 1 Prior to 1960 Aeronautical Engineering
- 2 Changed from Geology and Geophysics to Earth and Planetary Sciences 1970
- 3 Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology
- 4 Changed from Naval Architecture and Marine Engineering to Ocean Engineering 1970
- 5 Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975
- 6 Changed from Metallurgy and Materials Science to Materials Science and Engineering 1975

Table XV Summary of Degrees Awarded
(1868-1976)

Bachelor in Architecture (discontinued 1972)	765
Bachelor in City Planning (discontinued 1954)	31
Bachelor of Science	45,780
Master in Architecture (discontinued 1972)	648
Master in City Planning	535
Master in Public Health (discontinued 1944)	104
Master of Architecture	122
Master of Architecture in Advanced Studies	96
Master of Science	23,647
Advanced Engineering	2,447
Advanced Engineering awarded jointly with Woods Hole Oceanographic Institution	11
Doctor of Engineering (discontinued 1918)*	4
Doctor of Philosophy	6,146
Doctor of Philosophy awarded jointly with Woods Hole Oceanographic Institution	41
Doctor of Public Health (discontinued 1944)*	9
Doctor of Science	2,591
Doctor of Science awarded jointly with Woods Hole Oceanographic Institution	4
	<hr/>
	82,981

* See 1959 Report of the Registrar for details

WARREN D. WELLS

Office of the President and the Chancellor

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 at M.I.T. reports to the President through Professor Roy Lamson, Special Assistant to the President for the Arts. The Director of Information Processing Services reports directly to the Chancellor. The Institute Information Services and the M.I.T. Press report to Constantine B. Simonides, Vice President in the Office of the President and the Chancellor.

Council for the Arts

The Council's third full operating year, 1975-76, 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 Annette Anderson, Assistant Director--worked with the members of the Council to extend the support and expand the range of artistic activities at the Institute.

The Program and Information Committee, chaired by Dr. Leo Beranek, made 17 grants totaling \$32,158 to a wide variety of programs in the arts at M.I.T. Grant recipients included the Folk Dance Club for the purchase of tapes to record their collection; WTBS for the purchase of a portable recording unit; Hayden Gallery for the purchase and installation of video security equipment; the Center for Advanced Visual Studies for materials for Center artists to create works included in the Boston Celebrations II show at the Institute for Contemporary Art in Boston; and Course XXI for a series of speakers during the year. Additional grants supported two I.A.P. projects: a workshop in color television production, and a seminar entitled Vision, Art and Science. The grants also provided sets and staging for the Shakespeare Ensemble; assisted the Music Section in purchasing chamber music scores; gave seed support for a new literary magazine, Rune; and provided support for a joint exhibition by Hayden Gallery and the Institute of Contemporary Art of Claes Oldenburg's sculpture and drawings.

During the year, the Museum and Acquisitions Committee, under the chairmanship of Ida Rubin, worked closely with M.I.T.'s Committee on the Visual Arts. In October, the Institute received, through the joint effort of the two committees, five sculptures by the late Jacques Lipchitz on extended loan from Mrs. Yulla Lipchitz, the sculptor's widow. The collection was augmented by a sixth sculpture, loaned by Mr. and Mrs. Ralph Pomerance of Connecticut. (Mrs. Pomerance is a Council Member and also serves on the Museum and Acquisitions Committee.) Five of the large sculptures are in Hayden Courtyard, and the sixth is in Hayden Library.

In December, a major sculpture by Louise Nevelson, one of America's most celebrated contemporary artists, was installed adjacent to M.I.T.'s new Ralph Landau Building,

designed by Council member I. M. Pei. The sculpture, a large black steel construction entitled Transparent Horizon, measures 20 feet high and 21 feet long, weighs approximately 10 tons, and is composed of abandoned metal scraps as well as deliberately fabricated shapes. The Nevelson project was initiated in 1974, and continued with the joint cooperation of the Council's Museum and Acquisitions Committee, the Committee on the Visual Arts, the Planning Office, and the Physical Plant.

The Committee on the Visual Arts and Mrs. Vera List, also a member of the Council's Museum and Acquisitions Committee, arranged for the extended loan to M.I.T. of Larry Bell's plate glass The Iceberg and its Shadow. The work, which is part of the Albert and Vera List Family Collection, will be shown in Hayden Gallery during January and February of 1977.

Five new members were nominated by the Membership Committee and were appointed to the Council by President Jerome B. Wiesner for three-year terms. They are John C. Kern, Class of 1950, of Hinsdale, Illinois; Katie Louchheim of Washington, D.C.; Philip Morrison, M.I.T. Institute Professor of Physics, Cambridge; Dorothy Rautbord of Palm Beach, Florida; and Robert P. Rudy, Class of 1937, of New York City. Total Council membership at the end of the year was 72.

In addition to work done through the standing committees, the Council continued publication of both the Newsletter (circulation 8,000) and the monthly calendar of arts events at M.I.T. (circulation 1,000).

The Symphony Orchestra performed for the first time in Washington, D.C., on April 19 at the John F. Kennedy Center for the Performing Arts under the joint sponsorship of the Council for the Arts and the M.I.T. Club of Washington. Professor Marcus Thompson, the music faculty's distinguished violist, was the featured soloist in a program chosen by conductor David M. Epstein. Paul Hume, music critic of The Washington Post, wrote, "The M.I.T. Symphony Orchestra came to town last night, and its students of architecture, biology, computer science, earth and planetary science, physics, psychology, and urban planning had no difficulty in sounding like a first-class university orchestra. Under the expert conducting of David Epstein, the players from M.I.T. and Wellesley offered their Kennedy Center audience a program that would greatly honor the lists of any of our major orchestras. It was of a kind that the majors all too rarely put together... The might of M.I.T. is clearly well divided between the sciences and the fine arts."

The Council administered a two-day seminar entitled "Town Square Revisited" for developers, retailers, cultural leaders, planners, and government officials in January. Sponsored by the M.I.T. School of Architecture and Planning, with the assistance of grants from the National Endowment for the Arts, the Ford Foundation, the Rouse Company, and the Council itself, the seminar examined the social benefits of mixing cultural and commercial ventures, giving particular attention to the comparatively recent development of shopping malls now proliferating across the country.

The Council sponsored the American Dance Guild's Annual National Conference, entitled "American Dance Into the Future--Trends, Resources, Environments," which was hosted in June by M.I.T. Marking its twentieth anniversary, the Guild presented a three-day program examining recent developments in technology and other art forms as they relate to dance, as well as the latest directions of aesthetics. The highlight of the conference, which included workshops, panel discussions, and demonstrations, was a concert of four new works. Participants were Gus Solomons, Jr., Class of 1961, Toby Armour, Anna Nassif, and Rudy Perez.

The Council also provided administrative support for the first New England College Dance Festival, which was held at M.I.T. in April. The Festival was presented under the auspices of the Department of Women's Athletics, the New England Dinosaur dance company, and the American College Dance Festival Association, and was partially funded by the M.I.T. Council for the Arts.

A particular highlight of the Council's year was the fourth annual meeting, which began on Thursday evening, October 23, with an informal buffet supper followed by an open dress rehearsal of the M.I.T. Symphony Orchestra. The annual business meeting on October 24 opened with the announcement of the appointment of Luis A. Ferré, M.I.T. Class of 1924, as the new Chairman of the Council for the Arts.

Following the announcement of Governor Ferré's appointment, Professor Lamson announced the designation of the new category "Fellow of the Council for the Arts," with Professor Minor White named as the first Fellow. The designation carries with it an honorarium and a public lecture and is designed to further education in the arts at M.I.T. Each year a new Fellow will be recommended by the Council's Executive Committee for designation by the President of M.I.T.

During the business meeting, the Council group of 55 heard about arts programs at the Institute from two groups of faculty members led by Professors N. John Habraken, Head of the Department of Architecture, and Bruce Mazlish, Head of the Department of Humanities. Discussion topics included: a preliminary report on Artrransition; undergraduate teaching in the visual arts; the new doctoral program in architecture, art, and environmental studies; opportunities for the future in film, television, drama, and video at M.I.T.; laboratory studies in ancient art; the idea of progress in art and science; and the Institute's music programs.

The Council met with faculty and students in the arts at M.I.T., and heard a talk by Howard W. Johnson, Chairman of the M.I.T. Corporation. Mr. Johnson, who is also cochairman of the M.I.T. Leadership Campaign, described the scope of M.I.T.'s new fund-raising effort, and the place of the arts within the overall Campaign goals. After visiting the Center for Advanced Visual Studies, the Visible Language Workshop, and the Studio for Experimental Music, Council members gathered in Hayden Courtyard for a small ceremony of appreciation for Mrs. Jacques Lipchitz and Mr. and Mrs. Ralph Pomerance.

The Council's annual dinner at the President's House was the occasion for presentation of the second Eugene McDermott Award, which carried with it a cash award of \$1,000 and is presented by the Council annually "for major contributions to the arts as a means of human fulfillment." Council member Ida Rubin, chairman of the McDermott Award Committee, reported that the Committee had recommended unanimously and the Executive Committee had approved Professor Emeritus Klaus Liepmann as the 1975 award recipient.

The meeting concluded with a discussion of the arts and education led by President Wiesner, preceded by a showing of the final few minutes of the thirteenth and last episode of Jacob Bronowski's television series "The Ascent of Man." His concluding sentences sum up the Council's own general viewpoint: "We are all afraid--for our confidence, for the future, for the world. That is the nature of the human imagination. Yet every man, every civilization, has gone forward because of its engagement with what it has set itself to do. The personal commitment of a man to his skill, the intellectual commitment and the emotional commitment working together as one, has made the Ascent of Man."

PETER SPACKMAN

Information Processing Services (I.P.S.)

The planning and management operation for the Institute's centralized data processing activities, I.P.S. has three operating departments: the Information Processing Center (I.P.C.), the Office of Administrative Information Systems (O.A.I.S.), and the Programming Development Office (P.D.O.) The P.D.O. performs the systems planning function for the other two offices while they serve the administrative, academic, and research computing needs of the campus. The I.P.C. provides support for the faculty, students, and research staff community, and the O.A.I.S. handles the systems design and production needs of the Institute's administrative offices.

OPERATIONS

Information Processing Center

The I.P.C. continued to provide computing service on an IBM System/370/168 and a Honeywell 6180 to the instructional and research components of the Institute. Usage growth on the System/370 leveled off as expected. Because the S370/168 is of sufficient capacity to satisfy the computing needs of the user community for several years, a third party lease of the main frame was signed in December. This arrangement will protect I.P.C.'s costs during the next five years and, if the S370/168 remains a viable product, will provide substantial savings thereafter.

Online charges to Multics users were reduced by 50 percent on July 1, 1975, prompting a 50 percent usage increase from the academic community at M.I.T. However, this increase was offset by the demise of several Multics projects which failed to obtain funding, and the total increase of Multics usage was only 4 percent over fiscal 1975. As in the case of the System/370, the I.P.C. sought to establish a firm commitment to its Multics users at reduced cost to M.I.T. Consequently, a three-year contract with Honeywell was negotiated covering the period through fiscal 1979.

The I.P.C. maintained its extensive library of applications software for the M.I.T. user community. In addition, the staff was available as usual for user consultation and advice, and taught several non-credit computer courses.

Outside M.I.T., the I.P.C. participated in a three-year Network Simulation and Gaming Project conducted by EDUCOM. Project members modeled a university computer network to study the effects of such a network on usage, cash flow, equipment requirements, job migration, and other factors relevant to university computer centers' planning and budgeting activities. I.P.C.'s part to date has been in supplying usage statistics and other pertinent data to EDUCOM. Future involvement will include model verification and use.

Office of Administrative Information Systems

The O. A. I. S. continued to provide data processing support for the administrative offices at M. I. T. Maintenance requests on existing systems continued at last year's level. While the number of completed requests increased slightly, the outstanding requests remained at a very high level. Improvement in this area is slow because the systems are old, poorly documented, and written in obsolete computer languages. Consequently, there was considerable effort during the year to upgrade these systems via a translation process. This effort will continue as a supplement to the new development activity.

The new development section redesigned and implemented a basic personnel system, with modules to process benefits and deductions to be included in the near future. This section also completed an application flow system which records and tracks all applicants' resume referral and transfer data, a new inventory system for the Office of Lab Supplies, and design requirements for the new Payroll and Accounts Receivable systems. As an aid in avoiding major scheduling conflicts, a Calendar-of-Events system was installed at the Information Center to record and access data on events and lectures at M. I. T. These systems provide vast improvements over the old systems by allowing greater processing capabilities and modification flexibility.

The newly introduced structured design and programming proved an effective solution to several major design problems. The concept of structured thinking and the application of the functional approach is now applied to the system development methodology from analysis through installation and maintenance. With experience, these techniques should reduce test time; enhance communications between user, designer, and programmer; and reduce system documentation redundancy.

Improvement goals set for production work during the past year were met, greatly raising the level of confidence of the administrative offices. A full 94.5 percent of all scheduled production was run accurately and on time. The fact that there were minimal machine malfunctions and no major system changes contributed to the meeting of the goal, but implementation of and adherence to standard procedures were primarily responsible for the stable, reliable operation.

As a further benefit of the stabilization, day-to-day production support resources were allocated to longer-range efforts in the area of systems development and documentation. An improved special forms inventory/purchase system, an effort to reduce or eliminate excess output, a reduction in overtime, and the purchase of peripheral equipment resulted in significant savings which will continue into the future.

Programming Development Office

The P. D. O. again maintained the operating systems and language processors utilized by the I. P. C. and the O. A. I. S.

P. D. O. activity on the development of the newest IBM operating system, OS/VS II (MVS), for the I. P. C. System/370 continued. Reductions in the P. D. O. staff and constant additions of enhancements to MVS by IBM combined to slow the MVS installation effort. The initial design phase is complete, and work on modifications to the new system will now begin.

P. D. O. activity on the Multics system included installation of Honeywell's New Storage System. A major reorganization of the Multics file storage system, the new system improves reliability and reduces recovery time when problems occur.

The P.D.O. also maintained operating systems on minicomputers owned by the Sloan School of Management and the Laboratory for Nuclear Science, and helped establish an accounting system for the minicomputer run by the Department of Chemical Engineering. The P.D.O. is heavily involved in the PDP-11 users group, established to promote sharing of software, problem solutions, and innovations among M.I.T. PDP-11 users.

In addition, responsibility was assumed for two M.I.T. software systems during the past year: the Physical Plant scheduling, billing, and inventory system, and INSITE, the Institute's room scheduling and assignment system. Both are run on the IBM System/370.

REORGANIZATION

The functions of the Information Processing Center, the Office of Administrative and Information Services, and the Programming Development Office were reorganized into seven groups under the Office of Information Processing Services in order to improve overall service to the Institute by eliminating artificial barriers and functional overlaps. I.P.S. management will be assisted in policy and planning by two committees. A group of administrative vice presidents will consider new systems design in the administrative systems area. A second group chosen from the faculty and research staff will work to assure that data processing at M.I.T. keeps pace with the state of the art.

Effective May 14, 1976, Robert H. Scott resigned his position as Director of Information Processing Services. Weston J. Burner, Director of the I.P.C. and the O.A.I.S. and Assistant Director of I.P.S., replaced him. Joseph R. Steinberg, former Assistant Director of I.P.C. and Manager of Technical Services, assumed the Associate Directorship. Mr. Burner will focus his attention on administrative data processing needs of the Institute, while Mr. Steinberg will concentrate on academic and research needs.

NEW AREAS OF ACTIVITY

Networking

Sharing of M.I.T.'s computer resources, primarily in the academic/research area, through networks provided by NERComP and TELENET is being tested, under a grant from EDUCOM. Promotional literature on M.I.T. computers is being prepared, and I.P.S. expects to become more actively involved with NERComP and TELENET in encouraging the use of M.I.T. data processing resources by colleges and universities over these networks.

Distributed Computing

The existence of minicomputers throughout the campus has led to the possibility of implementing a distributed computing system. Under such a system, communication is established between computers -- usually a large machine like the S370/168 and one or more minicomputers. Routine processing is handled by the minicomputers, leaving the larger, more powerful machine available for functions beyond the capability of the smaller system.

The feasibility of establishing such a communications link between the minicomputer at the Sloan School of Management and the IBM System/370 is now under investigation. The minicomputer would continue to service its current user base but would also act as a remote job entry station to the S/370. If successful, such a system would reduce the equipment at the remote site, resulting in a savings for M.I.T., and would serve as an appropriate model for future minicomputer installations on campus.

Consolidation of I. P. S. Computer Activities

The reorganization of the I. P. S. Office into functional areas eliminates duplication of effort. Over the next several years, administrative systems software currently running on an IBM System/370/145 will be upgraded to become compatible with the System/370/168. At that time, the S370/145 will be phased out, with systems running on the S370/145 being transferred to the larger S370/168. Although the two IBM systems will merge, the support staff will still be divided along the functional lines of administrative systems, academic and research systems, and operating systems.

WESTON J. BURNER
BRENDA L. FERRIERO

Institute Information Services (I.I.S.)

During the past five 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 three 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

News emanating from or involving M.I.T. took no holiday in 1975-76. The News Office problem was to deal with, maintain, and encourage this news flow at levels realized in previous years despite reduced budget. This objective of business as usual with diminished resources was something the News Office shared with all administrative offices at M.I.T. during a year of austerity.

In general, we succeeded. We issued fewer press releases, particularly in the areas of research results and art/music. We did this through greater selectivity based on ultimate news value. The result was that the ratio of what we issued compared to what was used in newspapers improved markedly. Thus, ultimate effectiveness remained about the same as previous years. Also, we published fewer total pages of Tech Talk. In this case, by reducing type and headline size slightly and by shortening individual items where reasonable, we were able to publish just about the same amount of news as in previous years. In these ways and others, we have coped.

But our record is not spotless. During the second half of the year, the operation known as hometowning -- the sending out of individual news stories about M.I.T. students (their admission to M.I.T., their achievements here, their graduation) -- was an activity that tended to suffer because of work force reduction. Prospects are that this will suffer even more in the coming year. Hometowning was, and continues to be, one area of activity over which the News Office itself has absolute control as to volume and attention. We can choose to do it or we can choose not to do it, as dictated by the ebb and flow of other news demands.

This is not the case in the area of research news, for example. In 1975-76, faculty and others happily continued their relentless production of research results and papers deserving -- and, in some cases, demanding -- popular news attention independent of News Office capacities to deal with them. During the year, more than 60 news stories about the substance of specific research at M.I.T. were moved nationally and internationally by the wire services. Moreover, local, regional, national, and even international events involving M.I.T. programs and people continued to emerge requiring News Office services irrespective of News Office resources. And there were other areas of operations that were immune to being selectively ignored, not the least among them internally generated events for which faculty, staff, and administration sponsors required attention.

Our best efforts to the contrary, hometowning tends to be the activity that suffers in response to other pressures. This is sad. Parents and relatives, many of whom pledge family treasure to see their offspring supported at M.I.T., can reasonably be expected to be proud if the admissions, the achievements, and the graduations receive at least minimal reporting in local news columns.

In 1975-76, hometowning was by no means a catastrophe. For the first half of the year, Ellen Hoffman, editorial assistant, was on our staff and admirably discharged those duties. Midway through the year, she transferred to Resource Planning and Development, with promotion to administrative staff. Hometowning became collateral duty for Katharine Childs Jones, editorial assistant, in addition to her regular assignment of Tech Talk reporting and writing. Through Ms. Jones's heroic efforts and those of other members of the biweekly work force, we did achieve the same volume of hometowning as in previous years. We were sometimes delayed. Some of our formats were not those best suited to command attention from local editors. But we got through, albeit with uncommon strain. It is a problem area that deserves examination during the coming year.

Statistics for the year were down from 1974-75. We published 45 issues of Tech Talk instead of 50, with a total of 356 pages instead of 516. The reduction in pages was 31 percent. We published four issues of M.I.T. Observer with 60 total pages instead of five issues with 92 pages, a 35 percent reduction in pages. The nine issues of Reports on Research, each with four pages, were, of course, unchanged from previous years. Press release production dropped only 5 percent from 483 to 458, but among these there was a 47 percent reduction in the number dealing with research results and a 47 percent reduction in those dealing with art and music subjects. It was an especially busy year with respect to other kinds of news -- administrative, organizational, personnel, student affairs, etc.

Major stories that commanded forceful national attention included the failure to achieve a water resources research contract with the government of Saudi Arabia, announcement of a five-fold increase in the ability of ALCATOR to contain heated plasmas, the ARTTRANSITION program given by the Center for Advanced Visual Studies, the telephone anniversary symposium, the Washington alumni conference where the M.I.T. Symphony Orchestra drew rave newspaper notices for its appearance at the Kennedy Center and where Deputy Defense Secretary William Clements warned of new Soviet weapons programs, public discussions of recombinant DNA research, and M.I.T.'s Taiwan Training Program, and preparations by four groups at M.I.T. for the conduct of experiments from aboard the Viking 1 and 2 Mars landers.

Other stories that kept M.I.T. in the news ranged from two different approaches to the development of artificial skin materials to new discoveries about celestial X-ray sources... from new methods of solar energy conversion to new techniques for underwater welding... from iron deficiency studies among children to development of a vacuum-insulated underground electrical transmission cable... from a new antibiotic, Streptomycin A, to a computer based system of music composition... from Professor Harold Edgerton's search for the Loch Ness monster to a student systems design for a space colony. Worthy of special mention was the considerable attention given to M.I.T.'s Undergraduate Research Opportunities Program by the New York Times.

Calvin Campbell, Assistant Director (Photojournalist), continued during the year to have his photographs reproduced widely in major news media, and the wire service photo networks continued to use his photographs almost at the rate of one a week.

Barbara A. Burke, Assistant Director (Science Writer), left the staff at year's end to relocate in Paris. Her loss will be severely felt. With her departure, other members of the professional staff assumed responsibility for specific segments of the university. William T. Struble, Assistant Director, became responsible for the School of Science and its associated centers; Robert C. Di Iorio, Assistant Director, for the School of Engineering and its associated centers; and Charles H. Ball, Assistant Director, for the School of Architecture and Planning, the School of Humanities and Social Science, the Sloan School of Management, and their associated centers. Special attention should be given to the achievement of Joanne Miller, Assistant Director in charge of production, for reducing Tech Talk space but not informative effectiveness. Susan E. Walker, editorial secretary, continued her management of Tech Talk classified ads and Calendar of Events sections with admirable accuracy while, at the same time, assuming added responsibilities for preparation of faculty biographical sketches. New to the staff last year was Cathryn M. Chadwick, editorial secretary, who had charge of production, tracking, and distribution of press releases. Also new was Katherine Zwerin as News Office secretary. There were other staff and biweekly departures last year. Patricia M. Maroni, Assistant Director, transferred to the staff of the Resource Development office, as did Ms. Hoffman. Sally M. Hamilton, editorial assistant with Tech Talk, resigned to relocate, as did Eileen R. Schuyler, secretary.

ROBERT M. BYERS

CAMPUS INFORMATION SERVICES

The past year in Campus Information Services was marked by intensified efforts to provide more efficient and economical services to the Institute while maintaining the quality and high spirit of service which have come to be associated with these offices.

The close of the year was also marked, sadly, by the death of Carolyn B. Cox, Director of the Registry of Guests. A thirty-year member of the M.I.T. family, Carolyn was "M.I.T." to many of the international visitors and members of the Institute community. She made service to others a matter of professional excellence and personal satisfaction, and the Institute is a better place for her presence. Her spirit and gifts may best be summed up in the words of Virginia Lyons, her close associate and friend in the Registry:

Many times, during a long and difficult illness she pushed herself beyond all possible endurance in order to be here, working at the Institute -- whether to see to Commencement details or to a complicated visa problem. She never ceased to amaze those around her with her warmth, courage, graciousness, and willingness to serve. She had much she could have complained about -- and yet didn't. Instead she stayed optimistic throughout and buoyed up our spirits. A very lovely lady and good friend, she will be long remembered by many at M.I.T. and especially by those who worked most closely with her.

Design Services

In 1975-76, the Office of Design Services undertook 239 graphic design and publishing projects consisting of 373 separate parts.

Notable during the past year were the development of a design system for all publications of the M.I.T. Leadership Campaign, the publishing of several major documents in support of the Campaign, and the appointment of a designer to work full time with the Alumni Association on that organization's communications program. In his year working with the Association, David Colley created new designs for many of the Association's publications and introduced a heightened sense of concern for publications design. At the close of the year, Mr. Colley left the Institute to resume his academic career in the field of graphic design, and Nancy Pokross assumed added responsibilities for developing design systems for the Association. Janet Brown will spend part of her time working with Ms. Pokross as a production assistant on Alumni Association publications. A new designer, Elizabeth Hacker, will be joining the staff in August to assist with Campaign publications as well as other projects undertaken by the office. Elizabeth Ferry and Joan Gale continue to provide production assistance for the office, including primary coordination of those publication projects which do not require new design.

Professional recognition once again highlighted the design efforts of several members of the staff during the past year. The work of Jacqueline Casey and Ralph Coburn appeared in a major Bicentennial exhibition entitled "Images of an Era: Thirty Years of American Poster Design," sponsored by the Smithsonian Institution and Mobil Oil Company. This exhibition opened at the Corcoran Gallery of Art in Washington, D.C., in November 1975. The show traveled to Houston, Chicago, and New York City, and will be touring major European cities and galleries for the next two years. Accompanying this exhibition is a catalogue of the 250 selected posters which will be marketed by the M.I.T. Press.

During the past year, the work of Design Services and the M. I. T. Press was on exhibit at Kent State University. Jacqueline Casey was a judge for the American Institute of Graphic Arts Communications Graphics 1975-76; the work of Ms. Casey, Mr. Coburn, and Ms. Pokross was represented in the annual AIGA exhibition; and Mr. Coburn was invited to serve as a judge for the AIGA Fifty Books of the Year. The work of the designers also appeared in a number of publications: Mr. Coburn and Ms. Pokross were represented in the Graphis Annual 75/76; Ms. Casey and Mr. Coburn were published in the Graphis Poster Annual; two of Mr. Coburn's logos were reproduced in a two-volume set, Trade-marks and Symbols; and a poster of Ms. Casey's will appear in the forthcoming book, Print Casebooks 1976.

Ms. Casey continues reviewing government graphics for the National Endowment for the Arts in Washington, D. C. Also during the year, Ms. Pokross taught a senior independent study program at Simmons College, and Mr. Colley was a guest lecturer at Ohio State University, the University of Illinois, and the New England Society of Industrial Editors.

Information Center

During the past year, the Information Center continued to answer requests from individuals and groups regarding M. I. T. programs and activities, assisted in the distribution of catalogues, registration materials and other publications, supervised the student-guided tours for visitors, maintained a central calendar of events, assisted in the planning and coordination of special events, and provided some additional services in support of Bicentennial activities.

Although we anticipated a large increase in visitors because of the Bicentennial celebrations in the Boston area, the number of visitors (5,000) taking tours from the Center in the 1975-76 year was approximately the same as in the previous year. Nevertheless, summers continue to be very busy in terms of demand for campus tours and other visitor services, and the establishment of a Bicentennial Visitors Committee proved useful as a sounding board and advisory body, and led to the improvement of some of the visitor services. Innovations resulting from the Committee's deliberations included an information booth in the Rogers Lobby, increased student staffing for campus tours during the summer, and the publication of a self-guided tour for those visitors not able to take one of the student-conducted tours. (This guide, "A Walk Around M. I. T.," provides visitors with information on some of the history and programs of M. I. T. as well as the architectural highlights.)

The information booth proved popular with many members of the M. I. T. community as well as with visitors -- with the two student guides fielding some 8,000 inquiries during summer, 1975. The increased summer staffing allowed the Institute to more adequately meet the normal summer demand for campus tours -- although there are still times when the groups become too large for all the visitors to hear the guide. In such cases, the tour is often split into two smaller groups, but we feel that some type of voice amplification system may be needed in order for all the visitors to hear the guide's commentary.

Throughout the year, the Center continued to answer requests from individuals and groups that use the Center as a source for reference, directions, information on meetings and seminars, and various other activities. Listed below are some general figures of distribution on reports, publications, and notices from the Information Center.

Bulletin issues	19,697
Reports	13,812
Maps and Guides	36,283
Other Publications	36,321

In past years, one of the services of the Center was to provide callers with student telephone numbers and addresses. After completing a study on telephone inquiries to the Center, it was decided that it was more appropriate for the telephone operators to supply student telephone numbers as part of their directory assistance. This shift in responsibilities (effective January 1976) enabled the office to broaden and become more effective as an information operation. For example, Mary Morrissey, the Director of the Center, has assumed additional responsibilities in the coordination of special events on campus, and the Center is now maintaining a centralized calendar of events for the Institute. This computerized calendar enables the Center to answer inquiries about current campus activities as well as to assist the sponsors of events in scheduling and planning their activities.

The Director once again noted the high level of enthusiasm and assistance provided by the support staff in the Center.

M. I. T. Bulletin

Having joined the Institute staff in March 1975, the Bulletin editor, Janet Snover, has now assumed full responsibility for coordinating the production and editing, and for negotiating for the materials and services necessary to publish the various issues of the Bulletin: the General Catalogue, Courses and Degree Programs, the Summer Session Catalogue, the Report of the President and the Chancellor, and the Report of the Treasurer. In addition, she has begun to advise other Institute offices on various aspects of publications, and has impressed all who work with her with the efficiency and quality of her work.

During this past year, major efforts were made to produce the various issues of the Bulletin on a more economic basis without sacrificing the quality and serviceability of these publications. Production costs for fiscal year 1976 were \$48,000 (or 25 percent) lower than the previous year, and, while some grumbles were heard about printing Courses and Degree Programs on newsprint, for example, the savings seemed to justify the various changes in production procedures and materials.

An issue of special concern to the Bulletin Office during this past year has been the status of second-class mailing permits for college catalogues. Educational institutions traditionally have been granted the privilege of lower postal rates for some publications so that information on educational opportunities may be made available to people throughout the country. The United States Postal Service recently has revised its interpretation of the kinds of publications which qualify for second-class postal permits, and has notified numerous colleges and universities that their catalogues no longer qualify for mailing at the preferential rate. A number of bills have been introduced in Congress which would assure educational institutions of the right to continue to mail catalogues and bulletins at the reduced rate, but none of these bills has received final action to date. At M. I. T., denial of this privilege would not only complicate our efforts to communicate effectively with prospective students but would turn the cost of such efforts into a major financial burden. We have been able to keep our permit to date largely because of the Bulletin editor's vigilance in keeping informed of postal regulations and her efficiency in seeing that our publications appear on schedule.

Registry of Guests

There were 565 non-US citizens working as staff and faculty members at M. I. T. as of December 1, 1975. Included in that number were 70 from England and 50 from Japan. A total of 668 short-term visitors came to the Institute for 462 appointments arranged by this office with members of the faculty and administration.

During the year, many departments and foreign visitors sought advice regarding appropriate types of visa, the possibility of immigrating to the US, regulations concerning travel outside the US, applications for permission to work, and so forth. It has become increasingly important each year to keep abreast of changes in immigration regulations and enforcement in order to best advise both our visitors and the sponsoring department headquarters. Current information on regulations is gained through publications, conferring with colleagues at other institutions and at the Boston Immigration and Naturalization Service, and through occasional consultation with an immigration lawyer retained by M.I.T.'s law firm.

During the course of the year, the Registry petitioned the Immigration & Naturalization Service on behalf of the Institute for 16 foreign nationals who would like to become permanent residents of the US, and helped many others to apply for non-immigrant visas.

The Registry regularly receives applications for nominees for research grants from the Council for International Exchange of Scholars, the International Atomic Energy Agency, and the International Research and Exchanges Board (IREX) among others. IREX, which handles the exchanges of many Soviets and East Europeans, sent a total of 29 Soviet nominations, and has informed us that M.I.T. is the most requested university by the Soviets. Of these nominees, four Soviets have been accepted for long-term visits during 1976-77, and at least five more are expected to arrive at M.I.T. for short-term visits during the 1976-77 year.

Though many were involved for the first time with the preparations for Commencement this year, the event went smoothly, a tribute both to the efficient methods set up by those who have been working on Commencement for many years, as well as to the superior teamwork involved. This year's Commencement was highlighted by a showing of "The Proposition" -- an improvisational theatre production sponsored by the Senior Class the night before the ceremony, to the delight of an overflow crowd of graduates, parents, friends, faculty, and staff.

The office continued to secure delegates to represent the Institute at various academic celebrations.

Special appreciation and recognition should be given to Virginia Lyons, Administrative Assistant in the Registry, who carried on the day-to-day operations of this office during the past difficult year with an unswerving sense of service and dedication to the Institute and its international community.

KATHRYN W. LOMBARDI

M.I.T. Press

While last year marked the completion of 13 years of publication for the M.I.T. Press, it was in fact the 50th anniversary of publications carrying the Massachusetts Institute of Technology imprint. Our first book, published early in 1926, was Max Born's Problems of Atomic Dynamics.

Arthur C. Hardy's Handbook of Colorimetry, published 10 years later, is still in print. The last book released in the year just ended was Volume I of the Collected Works of Norbert Wiener, our publication number 1,570. These two active titles, both the work of M.I.T. professors, bracket a history of publishing achievement which suggests the magnitude of the contribution the Press has made to the advancement of learning in a wide variety of fields, as both an agent of M.I.T.'s own educational aims and policies and as a resource for hundreds of M.I.T. professors to publish important scholarly works. Since its establishment 50 years ago, the Press has distributed millions of books and journals carrying the Massachusetts Institute of Technology imprint to a global audience. Indeed the Press continues, as it did during 1975-76, to distribute more than 400,000 books and journals each year. In addition, M.I.T. Press books continue to be reviewed each year in journals, newspapers, and periodicals around the world.

The Press's financial problems during the past few years have detracted somewhat from these achievements. In April 1975, when a three-year recovery plan was outlined for the Press (fiscal years 1975 through 1977), the difference between the total debt to the Institute and the cash value of the liquid assets of the Press was estimated at \$2,000,000. This amount was estimated to be the net loss to the Institute if the Press ceased operations at that time. The objective of this recovery plan was to reduce the difference between the debt and liquid assets, and to determine the means by which it would be capitalized at the end of the three-year period. The financial condition of the Press improved somewhat beyond initial expectations during the first two years of this plan. The debt was reduced below expected levels because of a cash surplus of \$450,000 at the end of fiscal 1975, and will stand at approximately \$2,100,000 as of July 1, 1976. Also as of July 1, the Press will have a cash reserve of approximately \$500,000 resulting partly from the success of reduced accounts receivable, and partly because of a curtailed publishing program. The reduction of the publishing program as noted more extensively later in this report, is the result of seriously curtailed acquisitions in these years of crisis and transition.

Last year brought a continuation of previous years' efforts to consolidate the Press's financial condition and to improve management controls. Measureable strides in all areas of the Press's business, management, and publishing operations were made. Our audited financial statements for fiscal 1976 consisted of the most realistic balance sheet in a decade, the largest positive cash flow in the Press's history, and a profit and loss statement which produced a targeted deficit. A larger inventory writedown and an interest payment of \$130,000 accounted for the most significant part of this deficit.

In fiscal year 1976, the Press published 47 new hardcover titles and 28 new paperbacks, as compared to 90 hardcover titles and 45 paperbacks released the previous year. Other comparable statistics of note appear below:

	<u>FY 1975</u>	<u>FY 1976</u>
Net Sales, Domestic	\$2,256,000	\$1,946,000
Net Sales, Foreign	657,000	649,000
Total Sales	2,913,000	2,595,000
Manufacturing Cost	674,000	559,000
Royalty	265,000	240,000
Inventory Writedown	600,000	469,000
Operating Expense	1,569,000	1,502,000
Interest on Debt	284,000	130,000

Sales for fiscal year 1975 included approximately \$300,000 from our inventory clearance sales not repeated in fiscal year 1976. Inventory writedowns for the past two years have been substantial but unavoidable. Of the \$1,069,000 taken in the past two years, about \$600,000 or 11 percent of sales would be normal for an operation of the Press's size. The additional amount is largely accounted for by unrealistic writedowns in the past and large inventory buildups in fiscal years 1974 and 1975.

Last year also witnessed the development of many planning protocols and the launching of a variety of publishing activities, which will have a positive long-term effect for the M. I. T. Press as both the publishing branch of the Institute and as an efficient business enterprise.

During the last meeting of the Management Board in June, the plan for a five-year building phase for the Press was reviewed and endorsed. Fiscal 1977 is to be considered the first year of that plan. In adopting a three- to five-year plan, we make a commitment to a concept of the Press which places equal emphasis on fiscal responsibility, attentive management, and aggressive program development. Such a concept requires that a given level of operating momentum be maintained which may produce interim losses over the next three to five years, but which will allow the Press to fully develop its potential to subsist as a self-supporting operation.

The Acquisition department proceeded to build our program along the lines of the carefully drawn plans. The Editorial department continued to strive to balance the use of internal staff and freelance services in order to address the seasonal needs of business, and to work closely with the Media department in exploring the potential of in-house computer composition systems. The Financial department installed new systems across the board in financial and management planning, inventory control, credit monitoring, and fulfillment. The new warehouse facility, UNISERV, provides an opportunity to explore further efficiencies in customer services and cost savings. The growing Journals department is now beginning to provide a net income to the Press. The Marketing department developed a new definition of responsibilities and strategies which give attention to each new title published, in order to continue to sell more copies of each book both in the domestic and in the international marketplace.

The foregoing is an extract of our expectations as they are embodied in our plans. There are uncertainties of course. In order to meet financial and publishing objectives and to enjoy the full benefit of improved operations, a product line which will generate from \$800,000 to \$1,000,000 in sales from its new publications each fiscal year must be produced, and this pace must be maintained for the foreseeable future. While the forecast for fiscal year 1977 is \$800,000 from the sale of new titles, the projected inventory of future publications

is low as a result of several years of diminished acquisitions activity. What follows is a discussion of how we expect to deal with this uncertainty as well as a description of activities during the last year.

ACQUISITIONS

The progress made in terms of hardening the Press's assets, improving business and financial management, and designing a capital structure for the Press were the most visible products of our efforts. These steps had been long overdue and are vital to the development of the Press as a sound business. At the same time, it must be remembered that the Press is a particular kind of business: a publishing business. Acquisition, in tandem with marketing, is the leading edge of this business, and there can be no substitute for the publication of a list of books which grows both in terms of quality and the potential for producing income. Good books are ultimately the solution to the Press's problems, and provide the basis for all opportunities.

During the last year, the department underwent considerable changes which directed us toward improved efficiency and excellence in manuscript procurement and selection. A clear definition of divisional responsibilities was established and staff positions were filled with qualified personnel to spearhead an accelerated acquisition program.

Following the resignation of Senior Acquisitions Editor Yale Altman early in the year, Acquisitions Coordinator Barbara Ankeny and Senior Acquisitions Editor Frank Satlow ably assumed unusually large project loads. In the spring, Arthur Evans joined the staff with responsibility for Science and Mathematics, and Colin Jones for Architecture, Urban/Regional Planning, and Visual Arts. In January, Ms. Ankeny was promoted to Acquisitions Editor in the Social Sciences, Humanities, and Linguistics, and Mr. Satlow resumed his responsibilities as editor in Engineering, Systems, and Technology.

Planning became an integral part of the acquisition process. Each editor began operating within the context of an overall plan which emphasizes narrowing the focus of the list, increasing the advanced text and reference components, maintaining ongoing review of the Press's backlist to explore the possibility of revisable books, and defining the program thrust through a continuing series of development plans. Among the development plans approved last year were those for the following series: Transportation Systems, Computer Science and Artificial Intelligence, Energy Lab, American Politics and Public Policy.

The acquisition editors presented 80 new book proposals to the Editorial Board at 19 meetings throughout the year. Of these, 76 were accepted for publication, three were declined, and one was withdrawn. These figures compare with 58 proposals reviewed during the previous year resulting in 47 accepted for publication, eight declined, and three deferred.

During the past year, approved proposals resulted in 74 contracts signed with authors. Thirty-one percent of these were with M.I.T. professors or associates. Representing the high standards and selectivity of our editors, these projects withstood discrimination of outside readers who advised rejection of about 250 manuscripts. Another 700 unsolicited manuscripts were declined without review.

The 1975-76 Editorial Board was led for the second year by Professor Hartley Rogers, Associate Provost of M.I.T. Professors Robert M. Fano (Electrical Engineering), Maurice S. Fox

(Biology), John G. King (Physics), and Charles Weiner (History of Science and Technology) served the first year of their terms. Completing the second year of their terms were Professors Daniel M. Holland (Management) and Walter S. Owen (Materials Science and Engineering). Professors Stanford O. Anderson (Architecture) and Morris Halle (Linguistics) served the third year of their regular terms. Professor Donald L. M. Blackmer (Political Science) completed a four-year term. The Press staff is grateful to all the Editorial Board members, whose energies have been generous in bringing interesting book projects to our attention, reviewing and recommending qualified readers, offering manuscript improvement suggestions, and guiding our publishing decisions.

The table below shows the percentage breakdown of new titles published each year in certain broad subject categories:

<u>Year</u>	<u>Social Science</u>	<u>Humanities</u>	<u>Engineering</u>	<u>Science and Mathematics</u>	<u>Art, Architecture and Urban Planning</u>
1969-70	28%	15%	24%	16.5%	16.5%
1970-71	26	12	23	26	13
1971-72	22	11	27	27	13
1972-73	28	14	19	27	13
1973-74	35	14	19	14	18
1974-75	32	12	12	25	19
1975-76	21	17	18	34	10

Last year, the Acquisitions department culminated the publication of 75 titles. Forty-five percent of these were original hardcover editions, 40 percent were paperback editions of previous hardcover editions which had sold well for us. Import, distribution, and consignment books accounted for 15 percent of the title output.

EDITORIAL

Despite a 10-year low in our editorial complement, the Editorial department has continued to reap authors' praise for the refinement and editing of manuscripts. Managing Editor Helen Osborne, with editors Edward Agro, Laurence Cohen, and Cynthia Ware, carried on despite the loss of editor Ruth Gillies during the winter. Part-time assistants helped to alleviate the excessive workload, as did the use of freelance editorial services. In all, 19,250 pages were processed in the last year (compared to 15,000 in 1974-75), about one-quarter of these camera-ready, prepared by authors. These figures do not include readying for composition 6,000 edited pages of the Encyclopedic Dictionary of Mathematics, which is to be published in spring, 1977. Of the manuscript pages (14,555), we were able to handle almost half in-house, engaging freelance editors for the rest. In general, well-prepared manuscripts needing straight copyediting with little rewriting were handled by freelance editors. The three in-house editors concentrated on the more demanding manuscripts, those requiring substantive developmental work or special technical and language skills.

The inside staff will continue to deal with the more editorially-demanding projects and to meet the needs of the increasing shift in the Press's publishing program from the Social Sciences toward the Sciences and Engineering. The heavy use of freelance editorial help will continue as the number of pages to be processed grows in response to the accelerated acquisition program.

We were all saddened by the death of Constance C. Boyd, who was Chief Editor at the Press for many years. Requiescat in pace.

MEDIA

The Media department under the direction of Muriel Cooper designed and produced a total of 63 new books, supervising the importation of another 12 titles. Another 80 titles were reprinted and rebound, among these paperback editions of hardcover books, reprints of books from previously printed and stored sheets, and series paperbacks. The Media department also produced 20 issues of our journals. With a complement of only six full-time people, plus one part-time worker and several freelance designers, the Department supervised the design, composition, printing, and binding of a total of almost 400,000 books. One mechanism which helped to control and schedule this large volume of work for last year was a newly developed in-house master publishing schedule, a log which tracks manuscript delivery; editorial, launch, and production dates; print sizes, prices; and working adjustments. With the help of Mary De Sesa, Office Manager, the schedule became an efficient monitor for all books in process and in helping the Editorial and Media departments to plan their tight schedules.

Among the developments in the department was the exploration for the potential of in-house computerized composition systems. Such a system would ease the pressure of authors, suppliers, and buyers' schedules, and provide an opportunity for considerable cost and time efficiencies. We are eager to continue designing and producing books of the complexity and excellence for which we are reknowned, and such a system would preserve these from the ever rising production costs with which we have been contending. Much valuable advice about in-house computer composition systems was given to the Press by both outside consultants and M.I.T. personnel, including Professors Michael Dertouzos (Laboratory of Computer Science) and Nicholas Negroponte (Architecture Machine Group), and the President's Analytical Studies and Planning Group. We also sought to coordinate the purchase, development, and use of such a system with other potential M.I.T. users. During the next year, we plan to undertake a program of computer composition for a selection of forthcoming titles.

In design, M.I.T. Press books have continued to win praise and awards. In particular we would like to note Mario Furtado's design award at the annual American Association of University Professors (AAUP) show for Professor Negroponte's Soft Architectural Machines.

MARKETING

Last year was spent in reorganization after a long period of uncertain direction. Thomas McCorkle became Marketing Manager early in the year. His efforts have resulted in a more thorough and coordinated marketing of all new titles, while still devoting attention to promotion of the backlist titles which provide the core of our steady sales. New hardcover sales in terms of units per title and dollars per title were approximately 20 percent higher than the previous year.

The following chart gives a comparison of net sales and marketing expense for the last three years.

	<u>FY 74</u>	<u>FY 75</u>	<u>FY 76</u>
	(In thousands)		
Net Sales	\$2,314	\$2,913	\$2,595
Marketing Expense	\$ 498	\$ 484	\$ 392
\$ Sales/\$ Marketing	4.64	6.00	6.61

The successes of the Press are due to the hard work and creative energy invested by our small staff. Brooke Stevens, Direct Mail Manager, produced 29 mailing pieces for individual titles which were sent to a total of 290,000 carefully selected customers. This effort, devoted solely to new books published last year, resulted in the sale of 6,000 units. Total direct sales for last year, which included direct selling of the backlist by way of catalogues and sectionals, resulted in the distribution of approximately 31,000 units. In terms of response to our direct mailing campaigns, Gibson and Levin: Psychology of Reading, and Bishop, Fienberg and Holland: Multivariable Analysis generated the best response.

During the year, Advertising Manager Randall Goff created 80 advertisements for newspapers, magazines, and professional journals; assembled two seasonal catalogues in editions of 30,000 each; and developed sectional catalogues in the Life Sciences books on Art, Music, and Literature titles. Ads appeared in all major media which are addressed to our audiences including The New York Times, The New York Review of Books, The New Republic, Commentary, Scientific American, and a wide book variety of the scholarly journals such as Urban Affairs Quarterly, American Scientist, and Journal of Linguistics.

Publicity Manager Anne Sayre directed review copies of books to a large number and range of periodicals. Eleven hundred and twenty reviews appeared last year as a result of this effort, in periodicals ranging from the Sunday New York Times Book Review (SNYTBR) to the Industrial Bookshelf Newsletter. The SNYTBR reviewed the following books: Rushmer: Humanizing Health Care; Frieden/Kaplan: Politics of Neglect; Martinelli: Gaudi; and Diamond: The Tin Kazoo. Edwin Diamond was featured in 10 television and radio shows during the year. Among the most extensively reviewed books published last year were Diamond: The Tin Kazoo; Rushmer: Humanizing Health Care; Frieden/Kaplan: Politics of Neglect; Brody: Abortion and Human Life; Merrigan: Sunlight from Electricity; Flink: The Car Culture; Whitt/Wilson: Bicycling Science; Luria: 36 Lectures in Biology. Noteworthy was the devotion of the entire issue of the Proceedings of the National Academy of Education (Vol. 3, 1976) to a critical analysis of Gibson/Levin: Psychology of Reading. Muschamp: File Under Architecture won the American Institute of Graphic Arts award for last year, and won Annual AAUP Book Show awards along with Negroponte: Soft Architectural Machines.

Assistant Sales Manager Emily Rosenthal managed all exhibit activities last year including 13 individual exhibits attended by Press personnel, and 42 combined exhibits in cooperation with other university presses. Special attention was given to adoption sales this year by Ms. Rosenthal.

Text adoption mailings were sent out for the first time in the Press's history. Those mailings elicited requests for about 1,000 examination copies for possible course adoption. Where texts were already in use, we sent out about 2,500 desk copies. Among those titles enjoying significant adoption sales this past year were Kavanagh/Cutting: Role of Speech and Language; Akmajian/Heny: Principles of Transformational Syntax; Gibson/Levin: The Psychology of Reading; Bishop/Fienberg/Holland: Multivariate Analysis; Luria: 36 Lectures in Biology; Dondis: Visual Literacy; Beck: Hematology; Lynch: Site Planning; Whiffen: American Architecture; Chandler: Strategy and Structure; Chomsky: Aspects of the Theory of Syntax; Rasmussen: Experiencing Architecture.

Kirk Adams, Subsidiary Rights Manager, supervised international sales activities, and negotiated all book club sales, permission requests, and translation rights. During the year we succeeded in negotiating an agreement with a book distributor in Australia and New Zealand which should allow for a significant increase in sales there in the coming year. In addition, arrangements were concluded with Feffer & Simons to market Press books in the Far East, India, and South America. Last year foreign sales accounted for approximately \$640,000 or about 25 percent of the Press's net sales. Our London Office, operating cooperatively with the University of Chicago Press and Harvard University Press, was responsible for approximately \$410,000 of this total. International sales continue to represent the most promising segment for growth for M.I.T. Press books.

During the year, nine titles were sold to book clubs. We also contracted for the translation of 25 titles into nine foreign languages. These efforts are important to the Press in making our books available to as wide an audience as possible.

Peter Talbert-Hall, our Sales Representative in the Eastern United States and in Canada, was assisted by Judy Kucera on the West Coast and David Blick in the Midwest, in expanding our bookstore sales to 53 percent of total sales for last year. The Press shares the services of Ms. Kucera and Mr. Blick with Harvard University Press.

JOURNALS

The publication of four journals continued at the M.I.T. Press: Linguistic Inquiry, The Journal of Interdisciplinary History, Cell, and Oppositions. The publication of Visible Language was discontinued during the year because its subscription level fell far below that which was necessary to support continued publication.

The Journals department is treated internally as a separate division of the Press, and all expenses are expected to be met directly by Journal revenues. Journals provide a vehicle for bringing related M.I.T. Press books to the attention of interested audiences, and can provide opportunities for book projects to emerge from the editorial dynamics of the journals.

Both Linguistic Inquiry and The Journal of Interdisciplinary History are quarterly publications which were established by the Press, and emerged as fully self-supporting last year. Cell, a journal devoted to articles of research in the areas of biology and microbiology of cells and viruses, commenced publication in 1974 at the Press. In a short period of time it attained a prestigious position as a leading journal in the Life Sciences. This fact is illustrated by a study reported in Current Contents, which stated, "the prominence of the new journal Cell is notable."

The number of papers submitted to Cell continued to increase, and the proportion accepted declined sharply. In 1974, Cell closed with 627 subscriptions, in 1975 with 1,023, and it is estimated that in 1976 subscriptions will rise to 1,400. We expect Cell will generate a net income in fiscal year 1977.

Late in the year, the M.I.T. Press commenced publication of Oppositions, a journal of ideas and criticism in architecture, for the Institute of Architecture and Urban Studies (IAUS). IAUS published the first four issues of the Journal for the period 1973-1976.

FINANCIAL DEPARTMENT

The Financial department is responsible for the financial, business, and fulfillment systems at the Press. The latter is concerned with the management of inventory, warehousing, and shipping operations, and the entire order fulfillment cycle. All segments of the operation improved notably under Financial Manager Michael Leonard's able leadership. With the careful attention of Richard Salmon, Credit Manager, accounts receivables were reduced from \$824,000 to \$520,000 during the year. Many large outstanding accounts were settled, comparative aging of accounts improved through close credit monitoring, and foreign accounts receivables were substantially reduced as a result of new arrangements with Feffer & Simons and Book & Film.

Cornelius Kiely, Accounting Manager, continued to provide firm control over a myriad of financial transactions at the Press. During the year, the adoption of an operating budget and monthly interim reporting of operating performance in comparison to budgets proved invaluable for an effective review of financial activities. This control device will take on increased importance as the Press monitors performance against a three-year operating plan beginning fiscal year 1977.

Barbara Saulenas, Order Fulfillment Manager, continued to keep this cumbersome and sometimes complex process working efficiently despite the hazards imposed by the initiation of new systems and the establishment of a new warehouse facility.

Noteworthy was the move to the new warehouse, a mammoth effort which was completed with less than anticipated problems. This move was supervised by Mr. Leonard's staff, with the participation of the entire Press. The new warehouse facility, UNISERV, situated in Littleton, Massachusetts, is a joint effort of Harvard University Press and the M.I.T. Press.

In general, the assets of the Press continued to harden in line with policies for control over inventory and accounts receivable levels. For the second consecutive year, the cash flow was positive, thereby enabling the reduction of the debt and providing a cash reserve in anticipation of an increase in publishing in 1976-77.

The M.I.T. Press Management Board, which serves as a board of directors of the Press within M.I.T.'s structure, met three times last year in full session and established regular biannual meetings for next year. The members who served on the Management Board in fiscal 1976 were: Professor John Deutsch (Chemistry); Richard B. Gladstone (Senior Vice President, Houghton Mifflin Company); Dr. John F. Rockart (Senior Lecturer, Management); Professor Hartley Rogers, Jr.; Jack Schulman (Director of Cambridge University Press); Constantine B. Simonides (Vice President and Chairman of the Management Board); and W. Bradford Wiley (Chairman of the Board of John Wiley & Sons).

Most unsubsidized scholarly publishers have experienced serious financial setbacks during the 1970s. The large university presses, including the M.I.T. Press, have responded to financial constraints through tightening operations and aggressive marketing. These are short-term solutions, however, and are not sufficient support for the future. Last year at the Press was a year during which the next day's problems were brought under control enough to allow us to define the next year's problems, and to create a plan to guide our development during the next five years.

The Press moved toward a policy of more deliberate definition of program development and a thorough integration of operations. We expect to achieve our publishing and financial objectives by improving the quality of our publishing program; developing operational efficiencies such as in-house composition; developing support for program and product development through subsidies, funded programs, and endowment; and marketing imaginatively. Each of these ingredients is a necessary component of our plan to become self-supporting, with no direct funding of operating deficits by M. I. T.

FRANK URBANOWSKI

Vice President, Administration and Personnel

No single theme has dominated the year just past in those areas of Institute administration for which I am accountable. However, one unifying focus has been the M.I.T. budget. Everyone in this area, deeply conscious of the imperative to close the gap between Institute revenues and expenses, sought to respond constructively and creatively in individual budget reviews. As a consequence, we face the new fiscal year with a budget 11 percent smaller than the year just ending (before salary changes). No major functions have had to be abandoned -- lesser ones have, for example, the letter of acknowledgment of unsolicited resumes. The entire organization is stretched tighter with a little less time for individual employee or applicant needs, for policy planning, and for externally imposed demands. This is not a complaint, but a fact, and it imposes a heavier obligation on us during the coming year to be still more creative in our administration, to examine more carefully our tasks as to their necessity and our processes as to their efficiency. This we will do.

There are, however, rising demands on us beyond our control, imposed principally by governments, which increasingly burden our resources. Most of us would subscribe to the causes in whose interest the court cases are decided and the laws and regulations promulgated: privacy of individual records; education and employment opportunities for the handicapped; greater security and better definition and communication of pension and other benefits; expectation of due process in employment decisions; mandated grievance procedures; employment opportunities for Vietnam war veterans; elimination of discrimination on the basis of sex (Title IX), and of race, color, religion, and national and ethnic origin in education and employment; protection of occupational health and safety; evaluation of environmental impact of our actions, including the modes of transportation of those who work and study here; and increasing constraints on our research facilities. This is by no means a complete catalogue, but it is a growing list. Each calls for administrative action -- assessment of proposed legislation, evaluation and comment on proposed regulations, self-evaluation, planning and local implementation of the new regulations, changing policies, altering facilities, adopting new procedures, and communicating the changes. For commercial and industrial firms these become a part of the cost of doing business and are reflected in material and service prices. For universities whose revenues are only partly derived from educational and research services (and then not at their full cost), and are heavily dependent on gifts and endowment income, the costs of government-mandated programs become a tax on institutional quality.

This is not an expression of hope that the past can be reversed. In fact, federal intervention has been critically important in leading the nation's universities to begin to act affirmatively on behalf of women and members of minority groups, both in education and employment. But it has now become too easy, by conditions on federal funding, to require actions of universities on behalf of interests which are peripheral to the university mission; and by diversion of energy and funds, it is easy to detract from this mission.

We propose to be continually watchful of such encroachments and to counsel opposition to those whose purpose does not warrant monitoring by the legislative and executive power of the Federal government.

While the pages which follow report in some detail on the activities in my area of responsibility, some should be singled out for comment here.

In undergraduate admissions, our efforts produced some satisfying results. Entering minority students increased from 50 to 82. There were other less happy outcomes. The percentage of those accepted who decided to come to M.I.T. dropped from 55 percent to 47 percent this year. We know there is no lessening of the quality of an M.I.T. education, and so we are searching for the procedural or informational cause of this decline, determined to remedy it before the next group of accepted students make their decisions. At the same time we are searching for alternative ways of making admissions decisions which are less costly but no less effective in producing a quality class.

An allied issue is our financial aid package. Because our scholarship endowment is too small to meet the total grant requirements of our aid program, we have been filling the gap with unrestricted funds in increasing amounts. We need to have better information on the probable effects of substitution of more loans for grants in the aid package and we will try to gauge that effect in the coming year.

In the personnel area, there was a modest increase in unionization, with decisions of the M.I.T. Campus Patrol and a group of Faculty Club employees to bargain collectively. An effort begun in fall, 1974 on the part of a group of employees, in concert with a labor union, to organize office/clerical and certain other employees continued. At the same time, turnover and new job openings declined, and employment dropped in some job categories. For example, turnover in the office/clerical area is at an annual rate of 25 compared to 32 two years ago. For the twelve months ending March 31, 1976, nonacademic positions listed with the Personnel Office declined by 10 percent over the previous year.

A major task was the revision of our benefits plans to conform to the Employee Retirement Income Security Act of 1974 (ERISA), and the preparation of benefits descriptions for use of all plan participants.

This year also saw a rising interest in supervisory training and development. Planning is under way for a large scale program at Lincoln Laboratory. Intended to cover 1,000 persons over three years, and with a strong equal opportunity/affirmative action emphasis, this program was initiated by the Laboratory Director and will be conducted by the Office of Personnel Development. The demand is strong for a comparable program being planned for campus supervisors.

Substantial efforts went into affirmative action planning with a comprehensive report to the Federal Government on our progress and a revision of our affirmative action plan in February. An extensive self-evaluation was conducted of the extent of our compliance with regulations implementing Title IX of the Education Amendments of 1972, banning discrimination on the basis of sex in education and employment. Planning is also in progress to respond to the new regulations calling for nondiscrimination on the basis of handicap.

The Working Group on Office/Clerical Issues, formed in winter, 1975, continued to be active. The Group initiated a semi-annual performance evaluation for biweekly employees, recommended a policy statement that supervisors may not require employees to do personal work, and urged a review with new faculty members of their responsibilities as supervisors. Also at the recommendation of the Working Group, a brief course on administrative procedure at M.I.T. began at year's end. Other tasks included revising the Institute grievance procedure, reviewing the biweekly classification structure, developing a proposal on a personal leave allowance, and a careful study of the work environment as it affects office/clerical employees.

During the year a major study of the organization of the M. I. T. Planning Office was undertaken, leading to a recommended realignment effective July 1, 1976. The specific outcome of the study is reported elsewhere, but its purpose was to effect consolidation of the building programming and design review functions of the Planning Office with the design and construction supervision functions of the Physical Plant Department. The Planning Office is thus enabled to concentrate on longer range planning and studies under the supervision of the Vice President, Operations. The Office of Facilities Management Systems, responsible for facilities systems development and operation of the facilities inventory service that M. I. T. offers to other institutions, will continue to report to this office.

In concluding this report, I wish to acknowledge M. I. T.'s debt to all those employed in my area of responsibility for the skill and enthusiasm with which they carried out the Institute's work this past year. We depend so heavily on them; we assume their dedication, their reliability, their commitment, their competence, their pride in their work. We owe them, along with the many others in support and service roles, our thanks and appreciation.

Finally, I wish to note two important staff changes during the year. James J. Culliton, who served doubly as Assistant to the Vice President for Administration and Personnel and Director of Personnel Services, returned full time to the first of those positions. Claudia B. Liebesny was appointed Director of Personnel Services. These moves are intended to add strength to our organization, to enable us to carry out the day-to-day operations more effectively, and to afford a greater concentration on longer term planning and policy issues.

JOHN M. WYNNE

Office of Admissions

The past year saw increasing competition from all sides for top students at a time when intellectual achievement was not always high on the list of priorities of the secondary schools. The next five years will see the need for intellectual rigor to regain its position as a primary objective for secondary schools, if new students at M. I. T. are to move easily into the programs offered here.

For the Admissions Office, the year had some successes, notably the marked increase in applications from minority students (362 applied, 156 were admitted, 86 registered) over the previous year. This was possible because of minority mailing lists that were acquired early (in the spring of their junior year) from those who took Preliminary Scholastic Aptitude Tests. The Office followed up the initial contact regularly both by mail and phone. While the pool of minority students remains limited, our colleagues at other institutions will not be slow in discovering recruiting techniques that work. As has been noted before, the struggle to increase minority presence is a long-term one in which we must persist and move creatively to seek to expand the pool of qualified applicants.

The Office is pleased that M. I. T. publications continue to receive favorable notice. "Our Perspectives of M. I. T." received an award in a national competition sponsored by the College Entrance Examination Board in cooperation with the Council for Advancement and Support of Education.

Our effort to increase the number of applications from women did not show the results for fall, 1976 we had hoped (786 applied, 401 were admitted, 175 registered). New procedures will be considered which might achieve an increased number of women undergraduates. In spite of our best effort, M.I.T. is still considered a male institution.

A five percent drop in yield (the fraction of those offered admission who register) remains unexplained at this writing. An examination of all currently available data suggests a combination of factors working against us: cost, and a persistent image of M.I.T. as primarily a graduate institution with little emphasis on undergraduate teaching, campus life, or the humanities. Even so, the class entering in fall, 1976 compares favorably with any group of similar size and age in the world.

This year, as in preceding ones, the contribution of individual faculty members to the task of selecting students was most helpful to the staff. Gail Wilson joined the Office as Assistant to the Director in the summer, as Robert Schuiteman left to go to Boston University. When school opened in the fall, Anita Horton '75 and David Martin '75 were appointed as interns. John Mack '74 was appointed Assistant Director in January to replace John Mims who had left for graduate school. In June 1976, Sandra Cohen departed. Her contribution to the work of the Office over the past three years has been significant.

PETER H. RICHARDSON

Office of the Advisor to Foreign Students

More than 151,000 foreign students were enrolled in United States educational institutions in 1975-76, an all-time record. Fifty percent of this enrollment was concentrated in those institutions of higher learning reporting more than 500 foreign students. Typically, the foreign student contingent within these universities was about six to seven percent. A declining rate of growth, however, is a reflection of the changing economic, social, and cultural patterns in international educational exchange which began to appear in census figures in the latter half of the 1960s.

The largest enrollment was at Miami-Dade Community College with 6,400 foreign students (21 percent, third in the nation). Woodbury University ranked first in percentage with 820 foreign students (48 percent). Other institutions reporting more than 19 percent foreign student enrollment included Louisiana State University, Howard University, and Texas Junior College. M.I.T. was sixteenth in numbers (1,410) and ranked sixth as a percentage (17.6 percent) of the total enrollment. These figures are taken from the latest edition of Open Doors, published by the Institute of International Education. It may be noted that a decade ago the Institute stood second (in numbers) in the nation with 12.5 percent and 929 foreign students. Howard University ranked first with 14 percent, or 1,100 foreign students. Columbia was third with 10 percent and 2,500 foreign students.

The 1975-76 roster of institutional names represents a significant shift away from the traditional universities hosting international students. Costs and an active recruitment policy may be major factors in this shift. The need of a number of developing countries to provide English language training and access to higher education, and declining US student enrollments have, in some cases, made places available to foreign students that would not have occurred otherwise.

Professor Allan F. Henry, chairman of a subcommittee made up of members of the Committee on Graduate School Policy, reviewed the policies, practices, and concerns of the Foreign Student Office in assessing English language competence and financial status of foreign students selected for admission to the Institute. This review was done in concert with the Advisor, members of the Student Financial Aid Office, and the instructors of the English language classes. This committee recommended to the Committee on Graduate School Policy the establishment of an experimental ad hoc committee on foreign student/foreign staff to increase communication between the organizational components within the M. I. T. community that interact with this contingent. The ad hoc committee also would monitor statistics, loan programs, and other support services available to them. More importantly, the subcommittee recommended the establishment of an English language program on a permanent basis within the Modern Language section of the Department of Humanities.

A large number of foreign students, particularly graduate students, are accompanied here by their spouses. Currently there are about 400 families in residence either on campus, in Cambridge, or in adjacent communities. Building upon previous experience, a significant effort was made this year by Charlotte Schwartz and Myra Rodrigues of the Medical Department to assist spouses of newcomers in learning more about the M. I. T. community through a weekly discussion group. In addition, this year saw the publication of the Wive's Notebook by Carol Hulsizer.

EUGENE R. CHAMBERLAIN

Career Planning and Placement Office

The past year was a busy one for the Career Planning and Placement Office, which means that it was generally a good year for graduating students. A total of 240 employers came to M. I. T. to recruit -- more than in any year since 1969-70 -- and 854 students had 4,295 interviews with recruiters. As usual, the majority of students who had interviews were graduate students. While in some fields, notably the construction industry, employment activity was low, employer interest in other fields outran student interest. One-third of the firms which canceled visits did so because not enough students had signed up to see them.

Besides our own registered students, the Office scheduled interviews for 19 postdoctorals and 24 students from Harvard and Wellesley. The Office is happy to collaborate with its counterparts at Harvard and Wellesley, sending M. I. T. students there who can benefit from their resources and welcoming their students whose interests are well represented here. The exchange tends to put us all on our mettle.

Two types of student would like to take more advantage of the presence of so many employers on campus: those interested in summer jobs and foreign students interested in working in this country after graduation. The Office gave the visiting recruiters about 900 resumes from students who wished to speak with them, but whose backgrounds did not qualify them for jobs. A large number of these were foreign students and those seeking summer jobs. If returning prosperity lowered the barrier which now prevents most foreign students from working in this country after graduation, and persuaded firms to offer more summer jobs, we undoubtedly would again see the sort of interview activity which was commonplace a decade ago. In 1965-66 some 1,731 students, United States and foreign, had a total of 7,374 interviews for permanent and summer employment.

Looking for a job is by no means the only reason students use the Office. A large number of students come to talk over questions they have regarding their career plans. Usually the question that starts the discussion is quite specific. The answer the student chooses, however, may determine the pattern of his or her life, and the discussion tends to be correspondingly wide ranging. The Office is as informative as possible, drawing on every resource at its command: material on file in the Office, remembered articles, and the example and advice of faculty, alumni, and friends. Visiting recruiters are also a valuable source of information.

The Office's location in Building 10 has greatly increased the flow of students seeking information and guidance. Students made more than 670 appointments last year, a level of activity about 80 percent higher than that experienced in 1973 when the Office was still in Building E19. Appointments in the book tell only part of the story, however, for students are welcome to walk in without an appointment if no one is ahead of them.

Alumni activity in the Office reflected a gradual improvement in the market for experienced individuals over the year before. The number of alumni registering declined from 629 to 522, with a higher percentage reporting themselves as securely employed (up to 71 percent from 65 percent in 1975). There was also an increase in the percentage of younger alumni -- 20 to 30 years old -- requesting assistance (up 10 percent from the previous year). Job openings listed with Alumni Career Services totaled 1,519, practically on a level with the year before. The strongest demand, as usual, was for individuals with less than ten years of experience. The Office continued to work with alumni who came or wrote to discuss their careers without registering themselves as job candidates.

ROBERT K. WEATHERALL

Educational Council

We are entering the twenty-fifth year of Council activity, in 1976-77. Since its inception, the Council has aided M. I. T. in seeking out the highest calibre young men and women as potential undergraduates. Though the Council has grown in size and activity, its basic mission remains unchanged -- that is maintaining the high standards of our entering classes.

In many cases the Educational Council is the only personal contact a student has with M. I. T. Our role in Cambridge is to insure that that contact serves to enlighten, excite, and counsel each applicant about M. I. T. To this end, we publish extensively and communicate often in writing. Personal communication during member visits to campus and travel to the field by staff is still the cornerstone of our efforts.

The competition for first-rate young men and women is accelerating. The Council will remain a cutting edge of our contact with potential students. The challenge ahead is to hone that edge and wield it with effectiveness. To this end, increasingly analytical examinations of what is effective and why are being undertaken.

Those of us over the years who have been privileged to work in the Council owe its members a debt. Personally, as an absent Director for a year, I owe not only a debt to the membership but to the Council staff -- Mary Manning, Susan Singer, and Sylvia Borgman, who were ably

assisted this year by Thad Byrd. Without more than a thousand volunteers, we at M. I. T. could not hope to adequately serve the diverse student marketplace.

WILLIAM J. HECHT

Student Financial Aid Office

The year 1975-76 was an exciting one in the realm of student financial aid. The costs of attending the Institute showed another significant rise, and the cost to the Institute for complementing and sustaining the aid program also increased; but unusual, and to some extent unexpected, increases were also experienced in three important parameters: alumni gifts designated for use as scholarships, federal grants, and endowed scholarship funds materializing in response to the Leadership Campaign.

Continuing concern is expressed by friends of M. I. T. for students whose families' financial circumstances put them beyond the reach of the Institute's traditional aid program. They fear that these students will, to a greater extent, choose less expensive education than M. I. T., either at schools with lower costs or at schools whose aid programs reach selectively for the very best students irrespective of need.

This concern does not go unheeded. While there is still no evidence that the family-income profile of the Institute's undergraduates is changing, the Aid Office is continuing to monitor this question and is considering new means of assuring that needs perceived by parents can be accommodated, in ways perhaps dissimilar to the regular aid program which meets needs perceived by M. I. T.

After departing for one year from the College Scholarship Service need analysis tables (recorded in last year's Report of the President and the Chancellor), M. I. T. was once again able to accept the latest parameter revision in good conscience. The Service completely overhauled its approach to the development of "parental contributions" from family financial data. While the basis for its analysis tables is much more empirical than before, the figures that result generally conform with the perceptions of our own experienced staff. We are hopeful that a new period of stability is ahead.

The Federal government's Basic Grants Program was a welcome windfall of much-needed grant funds. We had projected \$100,000 of these awards in 1975-76. The total in fact exceeded \$250,000, thanks to the decision of Congress to fund the Program fully. We were hesitant to project a further increase for 1976-77, but a 25 percent expansion in the Program is possible. The Aid Office cooperated with the Alumni Fund in a solicitation of alumni, directed specifically to reducing the size of the unrestricted-fund supplement that the aid program will require in 1976-77. The results have been gratifying, with gifts exceeding \$100,000. This was the first such direct appeal in many years. These two phenomena, combined with the establishment of several new endowed funds for grants, enabled us to meet the year's scholarship commitments with a supplement of \$411,000, rather than the budgeted figure of \$800,000.

Another stable year passed with respect to the loan program. National Direct Loans remained the prime source of credit for undergraduates. Designated capital for backing the Technology Loan Fund, however, is still short of the needs, and the Institute continues to increase its short-term commercial borrowing level to sustain that part of the program.

The Student Employment Office maintained an aggressive role in identifying jobs for students. Student employment at the Institute expanded rapidly during the course of the year with major advances in both term-time employment and graduate college work-study employment. Annual student market earnings increased by one-third to \$3.4 million with 3,700 student employees. A minimum wage of \$2.55 per hour was established for the student labor market, effective September 1976.

During summer, 1975, Roberta Kurland resigned her position as Assistant Director. Lois B. Levine, a member of the Office clerical staff, was promoted to her position.

JACK H. FRAILEY

Office of Personnel Development

The Office of Personnel Development (O. P. D.) grew out of a personnel reorganization in 1973. Despite significant budget cutbacks since the reorganization, O. P. D. has continued most of its ongoing program responsibilities. In addition, it has responded to increasing demands for new programs. During the past year, new program demands from the M. I. T. community included needs for improved human relations, cost-effective management and supervisory practices, and improved interaction effectiveness between supervisors and supervisees.

The campus Equal Employment Opportunity Committee recommended broader and more extensive participation of M. I. T. managers and supervisors in O. P. D. programs such as the Human Processes/Communications workshops.

The Lincoln Laboratory Equal Employment Opportunity Committee recommended to the Laboratory Director that a training program emphasizing affirmative action and human relations be established for managers and supervisors. The Director engaged O. P. D. to design and administer the program. M. I. T.'s Assistant Equal Employment Officer worked closely with O. P. D. in the planning and development of this program. Her involvement will continue during the implementation phases, which will begin in August 1976. The 20-hour training program consists of 12 mandatory hours on affirmative action and equal employment opportunity to be followed by eight optional hours on management and supervisory skills required for effective implementation. Approximately 1,000 laboratory managers and supervisors will participate in this program over the next three years. During a Department of Health, Education and Welfare (HEW) review this spring, the Institute was highly commended for its plans to offer training of this kind. According to the HEW representatives, the Lincoln program constitutes a first among institutions of higher education.

The Office also planned for supervisory training programs to be presented on campus during fiscal 1977. Requests from departments and offices as well as the results of organizational surveys conducted by O. P. D. among 250 M. I. T. personnel indicated the need for these programs. Among the many specific needs and concerns identified by a significantly high percentage of survey respondents are the following: most employees, regardless of organizational level, would like to receive more and better quality feedback from their supervisors about their work performance; very few employees are satisfied with the amount of influence they have in matters affecting their work; and most people believe that communication between staff and support personnel could be considerably more effective.

Information from the surveys was helpful, as were meetings with managers and supervisors, in identifying appropriate content for campus supervisory training programs.

In the course of the Office's organizational training and consultation services with intact work groups, several groups identified more cost-effective work practices. In several instances, work groups determined that some existing levels of management were unnecessary or counterproductive in the delivery of cost-effective quality services. Where managers elected to introduce change, based on such determinations, important cost savings were achieved.

As a new activity during the past fiscal year, O. P. D. assumed staff responsibility for coordination and support of the Working Group on Office/Clerical Issues. The Office also assisted the Working Group in the design, implementation, and evaluation of a pilot mini-course training program for biweekly and exempt employees, called "Introduction to M. I. T. Administrative Procedures."

Ongoing activities entailed some changes in several areas. Significant cost savings were achieved in the Administrative Development Program (A. D. P.) through changes in instructional costs now borne largely by O. P. D. 's permanent staff. Major substantive revisions were made in the "Guide to M. I. T. 's Administrative Offices" through a community-wide process coordinated by the Office. A new policy and procedures booklet was produced for the Tuition Assistance Program, announcing improvements in the plan effective July 1, 1976. Several variations of the orientation program for new employees at M. I. T. were tried and tested, and the costs of this program also were reduced. An updated version of the booklet "You and M. I. T. " was developed through the collaborative efforts of this Office and the Offices of Personnel Services and Personnel Relations.

O. P. D. utilized a continuous system for obtaining feedback from the users of its services, with overwhelmingly positive responses. Budget factors required the Office to phase out or trim down those programs that did not seem essential to support the Institute's commitment to affirmative action and to develop M. I. T. as a more supportive environment in which to work.

MAUREEN M. YAGODKA
F. ADAM YAGODKA

Office of Personnel Relations

Union Relations

Two new bargaining units were certified by the National Labor Relations Board during the year, bringing the number of units at the Institute to eight. Unions involved were the Hotel, Restaurant & Institutional Employees, Local 26, AFL-CIO representing a unit of dining room and bar employees at the Faculty Club, and the M. I. T. Campus Police Association, representing a unit of Campus Patrolmen. Also on the representation front, a campaign to organize some 1,800 office-clerical employees and several hundred exempt employees was in progress, conducted by District 65 of the Distributive Workers of America, in cooperation with an employee group called AWARE.

Agreements with four unions representing 1,600 employees in six collective bargaining units expired June 30, 1976, and negotiations on the terms of new agreements with these unions commenced in May and were still in progress at year's end. Foremost among the issues were wages and job security, the latter a matter of special concern to members of the Research, Development and Technical Employees' Union because of cutbacks in research activities during the past several years.

The case load of union grievances was especially heavy and time-consuming, many of the cases arising from reductions in the work force and involving complex issues of seniority rights and skill requirements. A total of 85 grievances was heard in the third step of the grievance procedure by the Manager of Labor Relations, and 17 of these proceeded to arbitration.

Wage and Salary Administration

Reflecting the continuing concern over financial stringencies, 1976 merit reviews for all salaried personnel (more than 5,000) were conducted. A single schedule was utilized under which average increases for the various categories were uniformly allocated on the basis of average salary levels. Developed prior to the January 1 to July 1 period in which the salary reviews take place, this schedule enabled the administration to anticipate salary increase costs accurately while making budget decisions, and to hold them to a predetermined level. It represented a departure from the traditional approach of relating average salary increases to outside market trends on a category-by-category basis. However, examination after the fact confirmed that market changes anticipated in the construction of the schedule were accurate within permissible limits, and the competitive positions of the individual categories were not significantly affected.

ROBERT J. DAVIS

Office of Personnel Services

The Office of Personnel Services continued to provide timely information and counsel to members of the Institute community through the identification of personnel officers to serve specific areas of responsibility. Several changes in personnel officer assignments occurred this year as a result of new opportunities and in one case, a tragic death. Richard Cerrato joined our staff from the Information Processing Center to assist the School of Engineering when John E. Newcomb transferred to the Center for Advanced Engineering Study. Claudia Liebesny's appointment as Assistant Director led to the assignment of Carolyn Scheer to advise the Provost's area of responsibility. Lewis Redding joined the staff to serve the departments reporting to Vice Presidents Wadleigh, Wynne, Lampert, and Dean Porter, enabling Evelyn Perez to assume a part-time schedule while attending school. After the death of Philip Knight in August, Kenneth Hewitt assumed responsibility for assisting the organizational units reporting to the Vice President for Research.

Employment Analysis

Total Institute nonacademic employment as of March 31, 1976, was 5,961 persons: 4,053 on campus and 1,098 at Lincoln Laboratory. These data indicate a reduction in the work

force of 340 persons during the year. In spite of the decline in total employment, the representation of minorities and women remained stable. Minority individuals represent 9.8 percent of all non-academic employees. Thirty-one percent of the Institute's administrative staff and 13 percent of the Sponsored Research Staff are women.

Total employment activity slowed substantially last year. The number of available positions during the period of April 1, 1975, to March 31, 1976 dropped to 1,217, a 10.4 percent decline from the comparable period in the previous year. There was a corresponding decrease in the total number of applicants from 3,608 to 3,352 (7.1 percent). Of the number of persons who applied for M. I. T. positions, 2,628 (78 percent) were interviewed in the Office of Personnel Services, and 2,191 were subsequently referred to supervisors having available positions.

The posting of all available positions continued to be a major factor in providing information to employees regarding transfer opportunities, and activity has consequently increased more than 40 percent. The major increase in the number of transfer applicants, the higher proportion of individuals seeking professional administrative and research positions, together with a substantial decrease in the number of positions available contributed to a sharp drop in the transfer placement rate (49 to 24 percent).

Committee Work and Other Activities

While applicant and transfer interviewing and referral required the largest portion of staff effort again this year, personnel officers continued to devote a significant amount of time to other functions, including career counselling, labor relations, grievance mediation, and salary reviews. In addition, members of the staff were involved in special program assignments, Institute committee participation, and internal personnel policy development. Kenneth Hewitt took charge of the 1975 Summer Program, Carolyn Scheer gave particular attention to the ex-offender program, and Susan Lester served on the President's Task Force on the Employment of the Handicapped and on the Institute's Title IX Task Force. Policy clarification was achieved in a number of areas, including parental leave and holiday pay, with review of other policies and procedures still in progress.

New Programs

The computerized applicant flow system was enormously successful in its first year. Further development and refinement of the system in the spring provided important information on referral and hiring patterns, as well as trends in employment as a result of specific recruiting programs, including advertising, job marts, and school visits.

A formalized Semi-Annual Performance Evaluation process for biweekly employees was implemented in October upon development and recommendation by the Working Group on Office-Clerical Issues. This program was established to encourage an open and frank discussion of performance questions and career goals between biweekly employees and their supervisors. Two alternative forms were provided to facilitate the discussions.

Most significantly, Robert Nelson and others in the Records and Data Processing Section with members of the Office of Administrative Information Services completed the initial development of a new Personnel Information System. This new system provides more complete and accurate data and a greater analytical capability.

CLAUDIA B. LIEBESNY

Planning Office

This was a year of great activity for every section of the Planning Office.

Long-Range Planning

The long-range planning section under Reynolds Thompson focused its effort on the Leadership Campaign, translating the campaign's principal objectives into physical, financial, and policy requirements. New academic programs in health sciences, energy, management, and the arts were evaluated and their site needs tested against the development capability of the east campus, the principal area earmarked for academic expansion. Planning assistance also was provided to the Schools of Architecture and Planning, and Humanities as they seek to organize their requirements for the future.

Transportation issues continued to be a major part of our long-range planning concerns. National environmental policy continued to require changes in the way the Institute community moves from home to work each day. Parking space reductions, carpooling, improved traffic control, better graphics, safer pedestrian movement, new cycle ways, and more equitable ways to support the cost of administering these transportation services were part of the long-range planning agenda this past year.

Community Planning

The identification and analysis of changing community policies that affect the Institute's development were the responsibility of the community planning section under Donna Berman. Major areas of activity this year included the Kendall Square Urban Renewal Project, where marketing and environmental impact studies are under way. The planning staff worked closely with the Kendall Square Neighborhood Advisory Group as it monitored the progress of the project. The community planning staff participated in the Cambridge Comprehensive Planning project and the city's Growth Policy Committee. It reviewed proposed ordinances affecting land development, including land owned by the Institute. The staff helped to organize the Charles River Basin Advisory Committee that now assists the Metropolitan District Commission in developing policies for the use of the Charles River Basin and its banks. It assisted the Corporation Investment Committee and its subcommittee on real estate investment as it reviews the Institute's properties in the northwest area as well as those assigned to future academic expansion. The Community Planner assisted the Economic Development Advisor to the Presidents of M.I.T. and Harvard University, and maintained communication with 14 public and private agencies and organizations that have potential impact on M.I.T.

Unfortunately, due to economic considerations, the level of community planning support which was available in the past year will be sharply reduced. Principal responsibility for monitoring community relations will rest with the Office of the Special Assistant to the President for Urban Relations.

Facilities Planning

With the completion and dedication of the Ralph Landau Chemical Engineering Building this year, planning for major new additions to the campus slowed appreciably. The facilities planning section under Harry P. Portnoy turned its attention to the modernization of existing campus facilities and smaller projects. The only facilities currently in the design stage are the proposed athletic center and an animal care facility. Smaller projects such as the renovation and expansion of the sailing pavilion, new quarters for the Center for Policy Alternatives, expansion of the Medical Department, and improvements in Bexley Hall, were all under construction this year.

Also in the planning stages were the proposed rehabilitation of space for women's athletic facilities, the renovation of Building 2 for the Mathematics Department, and the further expansion of the Center for Cancer Research.

The campus landscape and sculpture program moved forward with the installation of a sculpture by Louise Nevelson. Other sculpture additions to the campus in the planning stages included works by Henry Moore and Tony Smith.

Space Administration

The administration and management of the Institute's space continues to reflect the dynamic character of the Institute's academic and research activities. Under Robert Cavanaugh, who provides staff resources for the Committee on Research and Space Planning, the Committee authorized 75 space changes in existing space and 600 new space assignments. In addition, a number of special studies were prepared for the Committee by Planning Office staff.

Office of Facilities Management Systems

Under the leadership of Kreon Cyros, the Office of Facilities Management Systems continued to grow, and achieved its objective of expanding the membership of the "Insite" Users Consortium. That membership now stands at 17. It has now reached the point where its purposes are best served by establishing it as a separate department, which was achieved on May 1. In its new organizational setting, it continues to support M.I.T.'s physical inventory information requirements, and will be able to expand its services to meet the needs of other institutions and industries.

In response to a request by the Chancellor to explore new ways of consolidating the Institute's administrative operations, the Planning Office underwent a number of organizational changes. The Office now reports to the Vice President for Operations and returns to its principal function of serving the senior officers of the Institute for long-range planning and development purposes. The building, programming, and design review functions have been consolidated with the construction and design group in the Physical Plant Department under the leadership of Harry P. Portnoy. Space administration returns to the Physical Plant Department, reporting to the Director.

O. ROBERT SIMHA

Affirmative Action Program

During the past year, M.I.T.'s progress in meeting affirmative action goals and objectives was greatly affected by the intense pressures brought on by an inflating economy. These pressures to a large extent inhibited our overall efforts in recruiting and hiring, and to some extent the development of new programs aimed at enhancing affirmative action and equal opportunity activities. In spite of the effects declining budgets had on all Institute programs, there continued to be a demonstration of commitment at all levels to remain true to our objective to make affirmative action and equality of opportunity in education and employment a reality at M.I.T.

At the national level, hardly a week went by that affirmative action was not the topic of discussion in educational magazines and newspapers. Changes in the administration in the Department of Health, Education and Welfare (HEW) and the Department of Labor (DOL) brought about changes and additions to the Affirmative Action Program format and data reporting requirements for institutions of higher education. With the assistance of the Offices of Personnel Services and Academic Staff Records, we were able to meet data requirements under the new EEO-6 reporting format. Submitted biennially to HEW in Washington, this report provides a statistical update on the Institute's progress in meeting minority and female employment goals. In regard to new program requirements, guidelines for implementing the provisions of Title IX of the Federal Education Amendments of 1972, the Vietnam Era Veterans Readjustment Act, and Section 503 of the Rehabilitation Act of 1973 became effective. Each of the above regulations requires that we develop and maintain a written affirmative action program or self-evaluation.

Recognition must be given to the contributions made by all committees established to ensure equity, and in particular to those made by the Equal Opportunity Committees on campus and at Lincoln Laboratory. Their efforts have been significantly important while striving to meet our overall affirmative action objectives.

On campus, the Committee identified various areas of concern which affect students and/or employees. Those which they considered to be of critical importance were addressed by three subcommittees developed to follow through on all concerns mentioned. Some of the recommendations offered by the committees included proposed changes to the Institute's grievance procedure and a proposal to develop printed materials specifically aimed at increasing the representation of minority and women students pursuing careers in the sciences and engineering.

At Lincoln, the Committee recommended to the Laboratory Director that a supervisory development program with particular emphasis on affirmative action be developed. Through the Office of Personnel Development, plans are currently under way for implementing this recommendation.

We appreciate the support provided by the members of these committees. Their involvement in the development of special projects and activities and the feedback they provided in helping us measure the effectiveness of policies and procedures relating to affirmative action have greatly enhanced our total efforts.

While our efforts this past year spanned the entire range of affirmative action and equal opportunity activities, for purposes of this report we place special emphasis on two of these activities: 1) the Institute's Title IX self-evaluation, and 2) the Department of Health, Education and Welfare on-site review.

We would like to recognize the events which led to the completion of the Title IX self-evaluation. As reported last year, a task force was appointed to assist the EEO Officer in formulating comments on proposed regulations for implementing Title IX of the Federal Education Amendments of 1972. The final regulations which became effective July 1975 called for an extensive evaluation of all Institute policies and procedures in Admissions, Athletics, Student Financial Aid, the Graduate School, Housing, Medical, and Personnel. Members of the task force represented the above departments and offices. Through the efforts of the task force and individuals in their respective areas, the evaluation was completed by May 1976.

As a result of this evaluation, three areas were found to be out of compliance with the regulation: 1) the Athletic Department found that sufficient locker room facilities were not available to women based on their representation in the population. Plans were made to eliminate this problem on an interim basis until more permanent changes can be made. 2) Inquiry concerning an individual's marital status on the admissions application was in violation of the law. Plans were made to delete this question from the application. 3) The regulation called for the adoption of a policy statement on non-discrimination, which was written and approved. This statement will be included in all Institute catalogues and brochures.

Beyond the above considerations, the task force invited individuals and groups having particular interest in these matters to review the report and provide feedback on any areas which were of concern.

In September 1976, a summary of the evaluation will be reported to the Institute community through Tech Talk.

An on-site review was conducted in June by HEW. A team of individuals from the Office for Civil Rights evaluated the Institute's progress in implementing affirmative action goals and objectives. The review schedule included meetings with the Chancellor, the Institute's EEO Officer, the Special Assistants to the President and Chancellor for Minority Affairs and Women and Work, and individuals in the Offices of Personnel Development, Relations, and Services. Topics of discussion included general employment activity, i. e., recruiting, hiring, and promotion of minorities and women; salary equity analysis; and special programs and activities developed to enhance affirmative action objectives.

After the review, President Wiesner received a letter from Robert R. Randolph, Acting Director of the Office for Civil Rights, Region I, stating that the Institute's Affirmative Action Program meets the standards of Executive Order 11246, qualifying M. I. T. for the award of additional government contracts.

Our total efforts cannot be measured without recognizing the employment changes in minority and female representation compared to goals set for July 1976. The following information provides a summary of the most recent data analysis on campus employment.

As of March 1976, women comprised 56 (6 percent) of the faculty, with a goal of 72 (7 percent) established for July 1976. Of the 56 women on the faculty, 4 are minority, 1 black, and 3 Oriental. Total minority representation on the faculty was 77 (8 percent), and the goal was 68 (7 percent). Black representation was 17 (2 percent), compared to a goal of 24 (2 percent).

The number of minorities on the administrative staff was 29 (6 percent), and the goal was 38 (8 percent). Women comprise 138 (31 percent), with a goal of 158 (32 percent) and blacks, 21 (5 percent), with a goal of 25 (5 percent).

As of March 1976, there were 131 (22 percent) women on the sponsored research staff, with a goal of 134 (24 percent). Black representation was 12 (2 percent), compared to a goal of 15 (3 percent), and the total number of minorities was 50 (8 percent), with a goal of 40 (7 percent).

Representation of blacks in the office/clerical category as of March 1976 was 120 (8 percent), compared to a goal of 162 (11 percent); total minority representation was 174 (12 percent), with a goal of 225 (15 percent). In the hourly category, female representation was 193 (17 percent), with a goal of 143 (13 percent); blacks, 158 (14 percent), with a goal of 151 (14 percent). The total number of minorities in this category was 188 (16 percent), with a goal of 193 (18 percent).

The above analysis does not indicate substantial change in relation to our achievements last year. However, it should be noted that these data are consistent with overall employment activity for the total Institute for 1976.

PATRICIA A. GARRISON

Office of Child Care

The Office of Child Care serves as the focus for child care issues at M.I.T., and is responsible for assisting members of the M.I.T. community in finding suitable care for their pre-school children, for developing and operating the Family Day Care Program (F.D.C., home based care for children of any age), and for providing administrative assistance and support to Technology Children's Center, Inc. (T.C.C.), a private, nonprofit corporation which operates full- and part-day pre-school programs.

Approximately 600 inquiries concerning child care were received this year. A total of 198 children used the three on-campus programs: 60 children used F.D.C., 106 used the T.C.C. nursery school, and 32 used the T.C.C. full-day care program.

Family Day Care

In addition to the 60 children enrolled in Family Day Care, 22 children of the F.D.C. providers also benefited from the program. There was a total of 24 providers, 13 of whom were recruited this year. As in the past, most of the F.D.C. providers were foreign student wives.

The function of recruiting, evaluating, and regularly visiting each of the F.D.C. homes was carried out by Helenmarie Zachritz, Program Developer. Each home was screened to assure that the licensing regulations of the state of Massachusetts have been met and each provider was evaluated in light of the Office's expectations for caregivers. This evaluation is an on-going process. Ms. Zachritz has been able to perform this rather sensitive task and yet maintain close relationships with most of the providers.

The Program Developer also was responsible for arranging a series of workshops which give the F.D.C. providers an opportunity to meet together to discuss various issues related to child care. Some of the topics covered were nutrition, health and safety, the development of feelings in children, children's literature, and age-appropriate activities. These workshops are an integral part of the program in communicating information essential to anyone caring for children, and in bridging the gap between the care provided by a babysitter and by professional teachers for families using the program.

The essence of Family Day Care is the relationship between the provider family and the user family. Therefore, careful attention must be paid to the process of referral. Trial and error has proven that the most successful referrals have followed an in-person discussion with the family seeking care. These discussions cover subjects such as schedules, location, and information about the child to be placed. They also, most importantly, deal with attitudes and feelings about parenting and child rearing, and the expectations one has for the provider and the program. Referrals are then made on the basis of compatibility between families. This important task has been performed with great skill and sensitivity by Nancy Russell, Administrative Assistant.

The majority of children (79 percent) using F.D.C. were less than three years old, with the number of infants needing child care increasing. Eighteen (30 percent) of the children in F.D.C. this year were 12 months old or less. There are presently 17 children of the same age currently on the waiting list for next year. The Office's sense of what makes good child care, as well as Massachusetts law, prohibits placement of more than two infants in one home, making it difficult to accommodate a large number of babies. In order to meet this demand, a substantial number of new providers must be recruited.

For the second year, the Child Care Office sponsored an Infant/Toddler Swim Program for F.D.C. members. Fourteen parents learned how to teach their children to swim. The course was taught by Mary Brau, a former F.D.C. provider and a Water Safety Instructor. We are grateful to her for her generous contribution of time and for sharing her understanding of how young children learn.

Technology Children's Center

T.C.C. had a good year both in terms of finances and programs. Although both the nursery school and day care center experienced some underenrollment, all financial obligations were met. A more efficient operation was achieved this year through improved fiscal and administrative organization. One major change has been the Office's assumption of responsibility for accounting and payroll services for the nursery school. As a result of this consolidation, clear and accurate information about T.C.C.'s financial position can be generated at any time during the year.

The nursery school always has been operated as a parent cooperative. Parents are required to spend one to two mornings per month assisting in the classroom and to be actively involved in the maintenance of the school. Although women have traditionally filled the role of parent helper in the classroom, this year there was a greater number of men acting in this capacity. In some cases, it was a question of sharing the responsibility; in others, it was the father (usually an M.I.T. student) who had a more flexible schedule than the working mother. Student families accounted for 66 percent of the enrollment, and faculty families were the next largest group using the program.

Nonacademic employees continued to account for most of the day care center enrollments, with students being the next largest user group (54 percent and 27 percent respectively). Families with academic appointments comprised the balance.

Of the 32 children using the day care center this year, eight (25 percent) received financial aid made available by the Institute. One child's fee was reimbursed by the Federal government. Of the children who received financial aid through M.I.T., five were from single-parent families. All of the families receiving aid were from the biweekly payroll. The weekly subsidy averaged \$25 per child.

This year saw the resignation of Frances Olson, Director of the nursery school and day care center. Ms. Olson made a major contribution to T.C.C. when she assumed the directorship as the day care center was launched in April 1973. Luise Flavin was appointed by the Board of Trustees of T.C.C. as the new director of T.C.C. programs. Ms. Flavin has recently been associated with Head Start as an Educational Director.

In addition to operating Family Day Care, providing administrative and planning assistance to Technology Children's Center, and serving as an information and referral service to the M.I.T. community, the Office of Child Care also provided assistance to several departments which were planning large conferences and meetings and wanted to provide child care services for participants.

The Office of Child Care offered one I.A.P. activity, a successful series of discussions focusing on "The Family in Today's Society." The discussions were led by Dr. Mary Howell, a pediatrician who has studied and worked extensively with families and women.

MARGARET SAND

Office of Facilities Management Systems

Fiscal year 1976 saw seven new users of INSITE, M.I.T.'s computer system for inventorying and accounting for space in buildings. The new users include: Bristol Community College; Wentworth Institute and College of Technology; Affiliated Hospitals Center (Boston Hospital for Women, Peter Bent Brigham Hospital, Robert Breck Brigham Hospital); Yeshiva University (Albert Einstein College of Medicine); Harvard Real Estate Department; Massachusetts General Hospital; University of Rhode Island. This brings to 17 the number of institutions which employ INSITE and its associated methodology to manage their inventories of building space.

To train these new users, the Office of Facilities Management Systems (O.F.M.S.) taught three one-week courses in the INSITE computer language and in the associated methodology for maintaining a space inventory. In addition, O.F.M.S. sponsored two one-day conferences and two one-day workshops to continue the training of those already using the system. Approximately 40 people attended each event. Under the editorship of Martha M. Pennell, O.F.M.S. also published two issues of INSIDE INSITE, a newsletter on facilities management with a circulation of approximately 350.

The Space Cost Analysis System (SCAN), an outgrowth of a Planning Office study done for a School of Engineering task force report, was introduced to the INSITE users at the spring conference. The system was developed and programmed by Ross Schacter, an M.I.T. senior. Facilities Data Manager Judith Lugas gave a two-day training course on SCAN in May for INSITE users. Currently, SCAN is being field-tested by Harvard Medical School, Tektronix, Inc., and Brown University, all INSITE users.

Under the auspices of the Summer Session, O. F. M. S. Director Kreon L. Cyros organized a one-week course on facilities management. There were 30 attendees. Ms. Pennell, John B. Bidwell, J. Terence Meehan, Kreon L. Cyros, Harry P. Portnoy, and O. Robert Simha were among the speakers from the Planning Office.

Under the directorship of Ms. Lugas, there were two major updates for the M. I. T. space inventory data base, one in September and one in January. Each update was followed by the distribution of reports to the various administrative offices. A special study of research space was performed at the request of the M. I. T. Comptroller, to be used to study overhead recovery. Other special reports from both the INSITE and SCAN systems were produced throughout the year for the Planning Office, Physical Plant Department, Director of Finance, and the Dean of the School of Engineering.

Applications of the INSITE file structure and algorithms for other than facilities inventory problems were developed by Mr. Bidwell, and demonstrated at the 1975 Fall INSITE Conference, as well as to potential users within the Institute. These applications included inventories of parking space, of assignments of automobile decals and their associated parking locations, and of assignments of beds in dormitories.

Mr. Cyros participated in a two-day workshop on Facilities Management on the West Coast, and spoke on space management at a New York meeting of the American Institute of Architects.

Ms. Pennell participated in the M. I. T. Administrative Development Program. Mr. Meehan attended a Certificate of Need hearing conducted by the Massachusetts Public Health Council. Ms. Pennell and Mr. Bidwell assisted the M. I. T. Parking Committee in its development of a car pool matching program.

On May 1, 1976, the Office of Facilities Management Systems was reorganized as a department reporting directly to the Vice President for Administration and Personnel.

KREON L. CYROS

Vice President, Financial Operations

In addition to its normal activities, the financial operations group in the past year directed special effort toward providing meaningful data and analyses to assist major segments of the Institute community in coping with continuing financial pressures, including those generated by dynamic activities which grow faster than their funding.

The most extensive support was provided to the senior officers as they attempted to understand the financial base in a rapidly changing environment -- all with the goal of overcoming the presently unfavorable structural imbalance between recurring revenues and expenses and at the same time preserving the basic strengths of M.I.T.

A significant amount of effort also went into simplifying and clarifying the financial reports of the Institute, particularly the summary reports to the Corporation on operations, the balance sheet, and the funds of M.I.T. Financial reporting is always complicated by the concept of accounting by funds. By this procedure, resources for various purposes are classified for accounting and reporting purposes in accordance with: activities or objectives as specified by donors; regulations, restrictions, or limitations imposed by sources outside the institution; or by directions issued by the government board. This is a required and long used practice in college and university finances but unnecessary in commerce and industry and thus not commonly understood. Nonetheless, progress has been made in arriving at a format and structure which make the new reports easier to read and understand. The new approach will appear for the first time in the Report of the Treasurer for fiscal 1976. In addition to the internal group which did most of the groundwork in conjunction with Coopers & Lybrand, the Institute's independent public accountants, the participation of George P. Gardner, Jr., Chairman of the Audit Committee of the Corporation, in reviewing the proposals for change, was invaluable in arriving at practical and sensible solutions.

Sponsored research support increased significantly beyond the rate of inflation for the first time in recent years and the financing of facilities and facilities improvements for research programs required the development of special plans for reimbursement through research indirect costs. The upgrading of Federal standards for the care of laboratory animals also resulted in a major increase in costs which also must be reimbursed through research support.

The new West Campus Residence for undergraduates was financed in June 1976 by a bond issue of \$6,300,000 through the Massachusetts Health and Educational Facilities Authority at an interest rate of 5.989 percent. This was a major activity in the Office of the Director of Finance in the last two months of the fiscal year.

In the Office of the Comptroller, careful scrutiny was given to Federal agency proposals for revising the principles and procedures for reimbursing the research costs at colleges and universities. These proposals could have serious consequences for the financial stability and viability of educational institutions. The situation is developing with little prospect of immediate resolution in a mutually acceptable way.

The Federal Cost Accounting Standards Board continues to issue regulations which require careful assessment by colleges and universities to insure that in trying to achieve an acceptable level of standardization the Board does not destroy the delicate and complex financial fabric of colleges and universities.

The United States Internal Revenue Service has established districts and special offices for each district with the intention of establishing a continuing audit program of every major tax exempt institution in the country. The Institute was audited for the year ending June 30, 1974 and no exceptions were taken.

An organizational change during the year brought the Internal Audit Division into the area of responsibility of this office.

The financial summary reports which are normally a part of the annual Institute Report of the Treasurer are contained in this report in the section entitled Treasurer of the Corporation.

STUART H. COWEN

Audit Division

The Internal Audit Division is responsible for reviewing the soundness, adequacy, and application of accounting, financial and other operating controls, and for promoting effective control. The Audit Division also has the responsibility of assuring that the assets of the Institute are properly safeguarded and used effectively.

Electronic Data Processing Auditing (E.D.P.)

Developing a data processing system measured in six digit dollar figures produces a significant Institute asset. The E.D.P. Audit Section appraises the systems of the data processing group and participates in the system development of the group and the users by maintaining membership and liaison with feasibility, systems design, and quality assurance committees. These committees are sections of the total E.D.P. systems development effort. The E.D.P. Audit Section also has conducted reviews of the current operating systems to assure that appropriate controls are present and operative.

General Auditing

The General Audit Division conducts financial audits, departmental reviews, and business procedure reviews. Financial reviews verify the activities of revenue producing units (such as the M.I.T. Press or the Faculty Club) as compared to departmental reviews of organizations which are funded from research grants or contracts or from the general funds of the Institute. The purpose of these reviews is to determine the state of efficiency of the operations and to assure that the Institute's assets are used properly.

1976 Operations

During 1975-76, the emphasis was on internal control features to improve the flow of source data information and to place charges as currently as possible against accounts.

Along with efforts to bring the Institute's budget in line with its available resources, there was much interest in current reporting and effective procedures. The Audit Division participated in the continuing budget effort by review and appraisal of the financial procedures, and also by evaluation and consultation with departments for the improvements of departmental internal procedures.

The Audit Division maintained liaison with the government and independent auditors who review the Institute's books for certification purposes. Another Audit Division service is to review the estates and trusts accounting reports received by the Institute where M. I. T. is required to sign a consent and waiver agreement for presentation to the courts.

The Audit Division, composed of seven auditors and three support personnel, found that requests for their services outweighed their available time in 1975-76. Emphasis was placed on effective internal controls, and the auditors turned most strongly toward departmental reviews and the evaluation of departmental performance in the processing of source data.

Personnel Changes

During 1975-76, Elizabeth J. Childers resigned her position as Assistant Auditor to move to Pennsylvania. Mary Jane Burke was welcomed to the staff in her place.

EDWARD L. MC CORMACK

Comptroller's Office

During 1975-76, a new system for producing student bills was implemented. This system was designed to maximize accuracy and to provide each student with a readable, timely statement of his or her account and its current status. The new system greatly assists the clerical effort required in maintaining it, provides a detailed analysis of each account, and outputs various reports required in the operation of the Student Accounts Office.

Efforts continued during the year between the Student Accounts Office and the Office of Administrative Information Systems (O.A.I.S.) toward the eventual implementation of an integrated payroll system to replace the five separate systems currently in operation. As of year end, the O.A.I.S. was in the process of reviewing the Department's requirements with prospective software vendors. The design and implementation phases will begin during 1976-77.

Student loan notes receivable reached \$22,000,000 as of the end of 1975-76. These notes were funded by approximately \$8,300,000 of M.I.T. loan funds established by friends and Alumni of the Institute, \$10,000,000 of Federal funds in support of the National Direct Student Loan (N.D.S.L.) Program, \$500,000 in funds borrowed from the Federal government

to support the Institute's contribution to the N. D. S. L. Program, \$1,000,000 in funds borrowed from the Student Loan Marketing Association, and \$2,200,000 borrowed from a local bank.

During 1975-76 a major change in the manner in which indirect costs are recovered under sponsored research agreements was proposed and accepted by the Federal government. This change significantly reduces the cost of Research Assistants charged to sponsored research programs yet has a minimal effect on the overall cost burden of the Institute. This change will be effective for fiscal year 1977.

On July 1, 1975, M.I.T. entered into a new Advance Payment Pool Agreement with the Department of Defense to provide for the financing of all Defense cost reimbursement contracts. This agreement supersedes the Advance Payment Pool Agreement dated March 1, 1961. The new agreement functions similar to a letter of credit and results in a decrease of advance payments authorized from \$19,200,000 to a new ceiling of \$11,000,000.

Because of pressures from Federal government sponsors during the past year, the Institute had to revise project closeout procedures by increasing the level of documentation in support of retroactive cost transfers. The results should be more timely submission of final fiscal reports and a reduction in the number of cost transfers between sponsored accounts.

Personnel Changes

During the year, James B. Enos, formerly Assistant Accounting Officer for Accounting-Computer Input/Output Control, was promoted to Accounting Officer in November 1975. In addition to his prior responsibilities as Computation Control Supervisor he assumed the overall responsibility of the general Accounts Payable operation. Steven A. Lanney, who joined the Sponsored Accounting Office group in April 1975, was promoted to Staff Accountant in January 1976. Mark S. Santangelo, who joined the Sponsored Accounting Office group in June 1975, also was promoted to Staff Accountant in January 1976. Eleanor Smalley, who has been with the Institute since 1955 in various capacities, was promoted to Senior Staff Accountant in the Student Accounts Office on March 1, 1976. In addition, John P. Tower, who joined the Institute in November 1973, was promoted to Senior Staff Accountant in the Student Accounts Office on March 1, 1976. Effective July 1, 1976, Robert E. Lee, Administrative Investment Officer, and Robert W. McQuillan, Financial Benefits Officer, will transfer to the Office of the Treasurer.

PHILIP J. KEOHAN

Lincoln Laboratory Fiscal Office

Funding

Despite the threat of major cutbacks in government funding midway through 1975-76, the Laboratory ended the year with total new funding of \$91.8 million, an increase of 5.4 percent over the prior fiscal year. The Department of Defense continues to provide the principal support for the Laboratory, furnishing 93.5 percent of the total. The Federal Aviation Administration provided 4.2 percent, and the balance of the support was provided by the National

Science Foundation, Bureau of Mines, Energy Research and Development Administration, National Aeronautics and Space Administration, and the Department of Health, Education and Welfare.

The past year represents the final year in which the Federal government will observe the July 1 to June 30 fiscal period. July through September 1976 will be considered a transitory period and the new government fiscal year will commence on October 1, 1976. This is a significant change since the Laboratory operates with 100 percent Federal government support.

Research Volume

The volume of sponsored research performed at the Laboratory during the year totaled \$92.5 million as compared to a total of \$82.2 million last year. The 1975-76 total includes \$475,000 representing the cost of research performed by on-campus laboratories for Lincoln Laboratory. Twenty-five M.I.T. faculty members and 16 graduate students participated in research programs at the Laboratory during the year.

A preliminary review for 1976-77 indicates that Lincoln Laboratory's volume could exceed \$100 million for the first year since the inception of the Laboratory in 1951.

ROBERT V. DODD

Office of Sponsored Programs

For fiscal 1976, the total volume of sponsored research on campus increased by approximately 11.5 percent over the level of fiscal 1975, with programs relating to energy research and development showing the most substantial growth. A new center for clinical instrumentation was established under the Harvard-M.I.T. Program in Health Sciences and Technology, the new chemical engineering building was dedicated, a grant was awarded to M.I.T. for the physical expansion of the Center for Cancer Research, and the redesign and renovation of the nuclear reactor facility was completed. During fiscal 1976, the number of graduate fellows and trainees receiving Federal support independent of specific research projects increased slightly, after declining each year since 1969. The Committee on M.I.T. Research Structure issued its report, and O.S.P. appointed two new members to its staff while three departed.

Campus Research Volume

The total volume of sponsored research performed on campus in fiscal 1976 by the academic departments and interdepartmental laboratories, centers, and programs is expected to approximate \$95,654,000 once final figures have been compiled. This represents an increase of approximately 11.5 percent over the comparable research volume for fiscal 1975, which in turn represented an increase of more than 10 percent over fiscal 1974.

Within this total, research sponsored by the Federal government is estimated at \$78,523,000, an increase of 9.8 percent over fiscal 1975. This includes funding of \$14,138,000 from the

Energy Research and Development Administration (up 24.5 percent); \$16,392,000 from the National Institutes of Health (up 9.9 percent); \$7,112,000 from the National Aeronautics and Space Administration (up 2.5 percent); \$21,165,000 from the National Science Foundation (up 7.7 percent); and \$13,423,000 from the Department of Defense (up 7.7 percent).

Funding from non-Federal sponsors totaled \$16,207,000, up 19.6 percent, and includes \$8,832,000, up 18.2 percent, from foundations and other non-profit organizations; \$5,589,000, up 5.1 percent, from industry; and \$1,781,000, up 135.9 percent, from state, local, and foreign governments as a result of a significant increase in the level of funding under agreements with foreign countries.

The preliminary estimate for fiscal 1977 is that total campus research volume will approach 12 percent.

Research Facilities

Establishment of a Biomedical Engineering Center for Clinical Instrumentation under a \$1,016,439 grant from the National Institute of General Medical Sciences was announced by the Harvard-M.I.T. Program in Health Sciences and Technology in October 1975. The new center will involve interdisciplinary collaboration of engineers and physicians in the research and development of a new class of medical instruments designed to include micro-computers capable of making calculations and presenting patient data in a clinically useful form. The research, evaluation, and testing of the clinical instruments will be performed by collaborative groups from M.I.T. and the Beth Israel Hospital and Peter Bent Brigham Hospital, teaching hospitals of Harvard Medical School. A Core Microprocessing Engineering Laboratory is being established at M.I.T. to perform research on the design of the instruments.

The new \$14.6 million chemical engineering building was named at a dedication luncheon on March 5, 1976, for Dr. Ralph Landau, a noted scientist, engineer, and philanthropist. Dr. Landau was a major contributor to the campaign for the building, which was built entirely with funds from private sources. The new five-story building will allow all the Department's teaching and research efforts to be housed under one roof, providing about 130,000 gross square feet for classrooms, laboratories, and offices.

On May 13, 1975, the Institute received an award of \$340,973 from the National Cancer Institute to fund part of a \$500,000 expansion of the Center for Cancer Research at the Seeley G. Mudd Building. The additional space will expand the Program in Cellular and Developmental Biology of Cancer by adding to it a research group on cellular carcinogenesis and a training laboratory in cancer cell biology.

During the past year a major program of redesign and renovation was completed at the M.I.T. Nuclear Reactor Facility, greatly improving its usefulness as a beam source for research in such fields as physics, chemistry, and materials science. The renovated facility has been redesignated as an independent interdepartmental activity and renamed the M.I.T. Nuclear Reactor Laboratory. Dr. Otto K. Harling, a distinguished authority in the general use of nuclear reactors, was appointed director of the laboratory, effective April 1, 1976. The reactor was built in 1958 and was operated as a part of the M.I.T. Department of Nuclear Engineering until the shutdown in June 1974 for the redesign and renovation.

Graduate Student Support Programs

During fiscal 1976, approximately 385 graduate fellows and trainees received \$2.8 million in Federal support independent of specific research projects (but including National Institutes of Health training grants), compared with 356 students who received \$2.5 million in fiscal 1975. Thus, the decline that began from a high point of 800 students in 1969 has halted.

In fiscal 1976, graduate research assistant salaries totaled approximately \$8,786,000 compared with \$7,750,000 in fiscal 1975, and the head count of research assistants in October 1975 was 1,366 compared with 1,140 the previous year. As noted in earlier reports, studies conducted over the last several years on alternatives for reducing the total cost of research assistants to grants and contracts have resulted in a change in the method of charging research assistants. Effective July 1, 1976, it will lower their cost to research programs through a reduction in the indirect costs applied to their salaries and wages, thereby providing greater incentive for their employment.

Committee on M.I.T. Research Structure

At the start of the past academic year, a Committee on M.I.T. Research Structure, chaired by Professor Frank Press, Head of the Department of Earth and Planetary Sciences, was appointed by Dr. Jerome B. Wiesner to assess the impact of the changing research climate and to recommend necessary changes in the Institute's style of conducting research. Consisting primarily of faculty members and department chairmen, the Committee developed various data and held extensive discussions with present and past members of the M.I.T. administration, including presidents, the chancellor, the provost, deans, departmental chairmen, laboratory directors, faculty, and research staff.

The Committee's report, dated June 21, 1976, was forwarded to the president and distributed to the members of the Faculty Council for discussion at a special meeting to be held in mid September.

The report contains comments on the external and internal factors affecting the research climate at M.I.T., the policy choices available, and the Committee's observations and recommendations with respect to the creation of new centers, laboratories, and programs; full-time research careers at M.I.T.; arrangements with industrial sponsors; large-scale expansion of research volume; budget versus program cuts and selective growth for M.I.T. research; the Leadership Campaign; and an advocacy role for M.I.T. on behalf of American universities.

Personnel Changes

Patricia J. Kress, formerly department assistant, research coordination, at Tufts University Schools of Medicine and Dental Medicine, joined the O.S.P. staff as assistant to the director; Thomas B. Duff, formerly administrative officer in the Department of Nutrition and Food Science, transferred to O.S.P. as a full-time assistant director; Lawrence Gilbert, patent administrator, resigned in March. Assistant to the director Jane Kosut terminated; and assistant director W. Bradford Gove II retired after 13 years on the O.S.P. staff.

GEORGE H. DUMMER

Office of the Director of Finance

Fiscal year 1976 can best be summarized as a year of fiscal restraint on the part of the Institute's academic and support departments. This restraint, coupled with moderate inflation and a real growth in research volume, resulted in an easing of the need for additional unrestricted revenues and funds to balance operations. This need dropped from \$9,005,000 in fiscal 1975 to \$6,493,000 in fiscal 1976, a decline of almost 28 percent.

In 1969, M.I.T. embarked on a budget adjustment program aimed at reducing the need for additional unrestricted funds to balance operations. These adjustments took two basic forms. First are expense reductions resulting from reduced services or consolidation of functions. Second is funding the activity through new revenues or the application of income from endowment or similar funds. The program for fiscal 1976 resulted in a gross budget adjustment of \$2,316,000 which netted to \$1,058,000 after adjustment is made for the effect of indirect cost recovery.

Despite budget adjustments, representing about 2 percent of the base where such adjustments can be achieved, the original 1976 budget anticipated an overall increase in expenses of 7 percent. This increase represented continued inflation and additional program expenses. The inflationary pressures were primarily in energy, up 10 percent, salaries and wages, up 8.5 percent, and employee benefits, up 11.5 percent. The latter was due primarily to salary increases, as well as to increases in social security and medical insurance expenses. Additional expenses were incurred as the new Ralph Landau Chemical Engineering Building and a new residence facility were put into operation. Additional program expenses in both the academic and support areas were more than offset by the increasing revenues derived from these additions.

As the year progressed, it became evident that a real growth in research volume would be achieved in fiscal 1976. By year end, departmental and interdepartmental research was up by 11 percent, while that of the Lincoln Laboratory was up by 12 percent, as opposed to the 7 percent originally anticipated for both. This increase resulted in a 5 percent real increase in campus research salaries and wages over instructional salaries and wages.

The instructional expenses of the Institute increased by approximately 7 percent which was the increase predicted at the beginning of the year. The other expenses of the Institute came in essentially on budget, resulting from tight fiscal restraint and the absence of unusual inflationary or regulatory pressures which had been experienced in prior years. Total expense volume was up close to 9 percent, primarily due to the increase in research, whereas at the beginning of the year a more modest 7 percent growth had been projected.

Tuition and related revenues were up approximately 15 percent, reflecting increases in tuition rates and fees, and in the size of the student body. In addition, certain non-recurring fund balances were "availed of" for scholarships that had to be supported by unrestricted funds last year.

All these factors -- budget adjustments, increased research volume, prudent management, and increased revenues -- resulted in a substantial improvement in the 1976 results.

Perhaps the least predictable source of the additional need for unrestricted revenues and funds is current gifts, grants, and bequests, and campaign receipts. At the start of 1976,

these items were budgeted at \$2.9 million. This was in fact achieved but the Institute availed itself of only \$2.2 million from this source. A major bequest in excess of \$650,000 was set aside by the Executive Committee of the Corporation for addition to capital. While \$1.4 million of funds functioning as endowment was used for operations, the Institute was able to set aside \$650,000 for use as capital, and added approximately \$360,000 to reserve balances, primarily the research reserve. The latter move is in line with the goal of increasing these reserves to protect against inflation. The Institute's fiscal plan for the next few years assumes a modest level of inflation and calls for the elimination of the use of other fund balances and funds functioning as endowment to balance operations. In addition, the Institute plans to return to using a substantial portion of the annual unrestricted gifts, grants, and bequests for capital purposes.

In the spring, the Institute completed the permanent financing for New House, the residence facility at 471-476 Memorial Drive. Funding was obtained through a \$6,300,000 issue of Massachusetts Health and Educational Facilities Authority Revenue Bonds, Massachusetts Institute of Technology, Series C. A year earlier the Institute decided to delay the issue on information from the Authority's financial advisors that the rate of interest would be approximately 8 1/2 percent. The sale of the bonds was for a net interest rate of 5.989 percent with an average maturity of 20 years. The Institute collateralized the issue and this resulted in a Moody's rating of AAA and a Standard and Poor's rating of AA+. This fact, plus a favorable bond market, resulted in the lowest net interest cost of any of the Authority's issues during the year, and also reflects the high regard that the bond buying public holds for M. I. T.

JOHN A. CURRIE

Vice President, Operations

The past year has continued in the mode of less emphasis on physical growth and expansion and more emphasis on crisp and effective operation. As seen in the following section dealing with construction activities, the close of this year saw no major building in construction on our campus for the first time in more than 15 years. For the past several years, this report has identified areas of operational change and improvement. This year is no exception.

Particular note should be made of the Facilities Management System under construction under the aegis of the Physical Plant Department. A major undertaking designed to enhance the cost effectiveness and efficiency of our plant operation, it will come on line in 1976-77.

Underlying the report on our Housing and Food Services, which follows later, is the recent progress in upgrading the general condition of our housing facilities. That section also reflects the progress made toward broader and more effective food service at the Institute.

Life at M.I.T. and the complexity of its operational problems, however, do not allow for complacency. For example, the report of the Campus Patrol indicates some encouraging signs as well as dedicated and able staffing, but the incidence of theft in our community and the frustrations of dealing with it are great. Then, too, the new and exciting directions of teaching and research often bring with them important and demanding safety considerations. All in all, we make progress, yet new challenges forever await us.

This brief introduction would not be complete without mention of an important personnel change. Miles P. Cowen, Assistant Director for Special Services in the Physical Plant Department, and Honorary Member of the Alumni Association, retired after 34 years of dedicated service to the Institute.

PHYSICAL PLANT

Utilities

The effectiveness of the energy conservation (ENCON) efforts of the Physical Plant Department and the total Institute community continues high. A report on ENCON savings issued in June disclosed that the total effectiveness of the program, recorded for fiscal year 1975 as a 25 percent avoidance of fuel oil, gas, and electricity costs, improved in fiscal year 1976 to 29 percent and is forecasted to improve again in fiscal year 1977 to a level of roughly \$2.2 million. These figures demonstrate not only that the Institute has sustained the continuing interest in energy conservation which is necessary to retain results obtained in past years, but also that it continues to make innovations and modifications to obtain new savings. Among the activities of the ENCON Committee and the Environmental Engineer's office during the year were the continued installation of time clocks to control the operation of building heating, ventilation, and air conditioning systems (HVAC); and the initiation of a

series of more detailed energy conservation studies on a building-by-building basis. In addition, an infrared aerial survey of the campus was carried out to detect general heat losses.

The Central Plant's significant activities concerned major maintenance and the extension of the steam distribution system on the West and East campuses. A program of connecting several radial steam lines into a loop greatly improved the reliability of steam supply to the entire complex of West Campus buildings.

Other activities include the upgrading of certain sections of the main steam tunnel, and the completion of the installation of Refrigeration Machine No. 4, a 4,000 ton steam-driven chiller unit, which brings the total refrigeration capacity of the Central Plant to 10,500 tons.

Engineering and Construction

The completion and occupancy of the new West Campus undergraduate house in August and the Ralph Landau Building (Chemical Engineering) in January marked the end of the series of more than \$100 million worth of major building projects which started with the Second Century Fund capital construction in the early 1960s. Except for the addition of two building bays and a finger pier to the Sailing Pavilion and a limited rehabilitation of kitchen and bathroom facilities in Bexley Hall, no new construction was started this year.

Design work is in progress on a one-story, 13,000 square foot, interim animal care facility proposed for a site on Vassar Street between the Cyclotron Building and the Parsons Laboratory. An associated project scheduled to go into design later this year is the rehabilitation and modernization of existing animal facilities in the Whitaker and Ford buildings. Phase I of the proposed new athletic facilities adjacent to Rockwell Cage is currently in the design/development stage. It will include an ice skating rink, which also may be used for graduation exercises and other large functions, and a fieldhouse with an indoor running track. In the spring, design was initiated on 4,000 square feet of additional laboratory facilities for the Center of Cancer Research in the Seeley G. Mudd Building.

Larger renovation and renewal projects completed during the year were offices for the Center for Policy Alternatives in the Webster Building on Amherst Street, student space and offices for the School of Architecture and Planning in Buildings 7 and 10, and the partial new tenancy (Medical Department) in Building 12, formerly occupied by the Department of Chemical Engineering.

Telecommunications

The first phase of the new system of processing toll or long distance calls from M.I.T. was initiated in May. Called Flexible Route Selection (FRS), the new system provides optimum routing of toll calls by the use of Wide Area Telephone Service (WATS) lines, a bulk-rate arrangement for directly dialed station-to-station toll call service. This system analyzes the area code dialed and then passes over an available WATS line which is appropriate to the area code dialed. If all WATS lines are busy, the call is passed over standard long distance circuits.

The second phase in this new toll call system will be initiated around November 1, 1976. This phase will allow partially restricted telephone users to utilize the WATS facilities by dialing into the call the specific account to be charged.

New reporting procedures implemented this past year include a report issued every four months to administrative officers. Outlining departmental telecommunications costs for the period reported on, it is aimed at assisting administrators in defining and controlling these costs.

Administrative Services

With the increased activity related to the installation of a campus-wide site monitoring system for the computerized control of building systems, several organizational changes were made within the department. George N. Petievich assumed the new position of Project Director, Facilities Management System, and was succeeded by Kevin McDonagh as Administrative Officer. An associated change was the transfer of responsibility for the departmental purchasing function to Howard F. Miller, Executive Assistant to the Director.

The Facilities Management System is assuming a real physical existence, having made a successful transition from a conceptual state into an impressive array of hardware and materials. Thirteen miles of triaxial trunk cable have been installed along with 26 miles of other wiring into the 34 buildings to be controlled. These buildings represent approximately 4,000,000 square feet of space for research, instructional, and dormitory facilities. The current schedule calls for the first building to be under computer controlled testing by Labor Day and for all 13 buildings in the first phase to be operational by the end of November. The types of equipment that will be monitored and/or controlled include pumps, converters, steam boilers, compressors, chillers, cooling towers, fans, autocal components, and various other motor loads.

HOUSING AND FOOD SERVICES

The 1976-77 academic year marked an expansion of our housing resources with the opening of a new undergraduate dormitory on the West Campus next to MacGregor House. Temporarily named the New West Campus Houses, and generally referred to as New House, this building provides accommodations for 297 students in six separate living groups. Residents of French House, German House, and Russian House were among its first occupants. The first M. I. T. dormitory to be air conditioned, it was designed to serve as the primary housing resource for Summer Sessions and conference guests. We expect this new service to increase the number of summer guests and to add to the comfort of those who stay.

Personnel changes include the retirement of Cecil Saunders, Manager of MacGregor House, the appointment of August Perry as his replacement, and the promotions of Norman Magnuson to Manager of East Campus and Esther Foster to Manager of Senior House.

Because of the growing size and complexity of the operation and the need to respond quickly to problems of housing almost 4,000 residents on campus, we have implemented a new supervisory schedule providing more on-campus coverage on weekends and stated on-call coverage on holidays.

Maintenance projects completed this year or now under way throughout the system include the installation of new roofs on Baker House and the west parallel of East Campus, and the renovation and overhaul of the heating systems for Eastgate and Westgate. We continued to add to our sprinkler systems in the corridors of all high-rise buildings, completing Eastgate, Tang Residence Hall, and the towers of Westgate and MacGregor House this year.

This program, run in conjunction with the Safety Office, will continue next year. This summer Bexley Hall will be undergoing such major rehabilitation work as renovating all bathrooms and kitchens, replacing the electrical, plumbing and gas systems, upgrading the heating system, installing a new roof, and adding storm windows. This work will be completed in time for occupancy for the fall term. Lounge spaces in several of the dormitories were upgraded. Planned with the residents of each house, these projects range from minimal repair and replacement to total redecorating and refurnishing.

Due to the limited availability of married student apartments and the current level of demand, the Faculty Residence Program at Eastgate will be terminated effective August 31, 1976.

Food Services underwent small but desirable and well-received changes in the service provided. This year's board plan offered three options: 19 meal, 15 meal, and a revised point plan, allowing the consumer a greater flexibility in the selection of meals. Ground work was laid for the start of several major projects in the areas of food costs, recipe and price structure, and the purchasing of supplies and services. We are also in the initial stages of developing a master program which defines both long- and short-term goals and commitments.

CAMPUS PATROL

This year the Campus Patrol began a movement toward civilian personnel to control parking in order to better utilize our highly trained personnel. This change should be completed in the near future. The regular Patrol force was reduced this year because of budget reductions.

This annual report reflects a continuing rise in the number of incoming complaints recorded: 2,158 for this year added to a service call total of 6,638. The most important area, crimes against persons, showed no increase, in keeping with substantial reductions in most of our major reporting categories. Personal property loss dropped from \$32,000 to \$18,000, though theft of Institute property rose alarmingly from \$40,226 to \$55,899. We continue to combat this rise through the use of crime prevention programs and community-wide distribution of information seeking everyone's cooperation. Inasmuch as our records and observations indicate, much property is stolen from open, unattended areas.

Our Emergency Ambulance Service continues to supply excellent service to the community. It handled a total of 1,316 ambulance calls during the past year. We are currently engaged in fulfilling Emergency Medical Technician training for our personnel in compliance with Massachusetts Department of Public Health requirements.

Our overall training programs, under the direction of our Supervisor of Training, provide the Department with the level of professionalism required to fulfill our mission.

The Patrol continues to reinforce its day-to-day contact with other Institute departments such as the Office of the Dean for Student Affairs, the Medical Department, the Safety Office, the Housing Office, and the Physical Plant Department, as well as the necessary liaison with outside agencies.

SAFETY OFFICE

Safety Education

Three more sections of the M. I. T. Accident Prevention Guide were published this year. This has been a major effort of all persons in the Safety Office. The final two sections will be published this coming year. We will promote the use of these guides during the current year so that they provide an extension of Safety Office education into every laboratory and office, and thereby upgrade safety awareness at M. I. T.

Fire Safety

On July 22, 1975, a late morning fire on the nineteenth floor of Tang Residence Hall took the life of 24-year-old Renato C. Ribeiro, a Physics graduate student. The Safety Office, in conjunction with Campus Patrol, Housing, Physical Plant, and insurance carriers, conducted a thorough investigation of the incident, but obtained no conclusive evidence as to the cause of the fire. Review of the event led to formal development of the Physical Plant Emergency Team, which responds to all fires and is able to efficiently coordinate interaction of M. I. T. and Cambridge officials at the scene of a fire.

In addition, significant progress was made in fire protection of high-rise dormitory buildings. All high-rise dormitory buildings have upgraded automatic sprinkler protection systems, particularly in spaces such as corridors, lounges, storage spaces, basements, and closets. Additional sprinklers were installed in Senior House, East Campus, and Bexley Hall. New House is completely sprinklered, except for individual bedrooms.

Four fires resulted in sprinkler actuation. Only one fire was large enough to justify an insurance claim. The following is a brief tabulation of recent fire data:

	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>
No. of fires	40	45	29	17	19
Sprinkler Actuations	7	13	2	2	4

Laboratory Safety

In accordance with new state safety regulations for student laboratories, some 60 fire blankets and 45 emergency deluge showers were installed.

Corridors were becoming overcrowded to the extent that exiting during a fire could be hampered, so a spring clean-up campaign for laboratories was conducted free of charge for items too large for custodians to remove.

The waste chemical disposal situation was stable over the past year in terms of volume, but costs on a comparative basis were three times that of previous years. Research in Health Sciences will significantly increase the volume of hazardous waste, so new methods of disposal must be studied.

Experiments involving energy related research, along with increased activity at off-campus sites such as the LINAC facility in Middleton; Haystack, Millstone, and Firepond facilities in Westford; the Wallace Astrophysical Observatory and the Wallace Geophysical Observatory; and the Lincoln Laboratory; have created new and increased demands for safety services.

In accordance with Federal law, the Safety Office continues to provide first aid training at work locations where immediate medical assistance is not available. Approximately 205 hours were spent training 377 persons in basic first aid and cardiac pulmonary resuscitation.

Industrial and Public Safety Activities

Building facilities surveys for safety are continuing, with emphasis given to on-campus housing. A document which covers safety regulations for fraternities was compiled by fraternity residents during I. A. P. under the supervision of the Safety Office.

The City of Cambridge passed a regulation banning smoking in public places which affects schools and colleges. Posting of signs in designated areas is now in progress at M. I. T.

GRAPHIC ARTS

The Institute-wide budgetary restrictions of the past few years have been reflected in the Graphic Arts operations for fiscal year 1975-76. The dollar volume was down about five percent from the previous year. This sharply contrasts the experience of the previous two years, when dollar volume increased 15 percent and 20 percent respectively.

An increase in the use of the four Copy Centers and a decrease in the use of the Offset Printing section resulted from the trend to more simplified forms of presentation materials in an effort to keep departmental costs down. The glossy brochure and expensively bound report are no longer the mode. This economizing is expected to continue or at least to stabilize at the present level.

The Mailing Service had a 12 percent increase, although much of that represented postage changes. Revenues in the Photographic and Illustration sections remained at the previous year's level. The Audio-Visual and Student Pictures sections also remained at the same levels, with the help of some cost-cutting.

ENDICOTT HOUSE

The Bicentennial year was a busy one for Endicott House, which was open 12 months of the year and continued its pattern of increased usage.

Residence groups used it on a total of 288 days including 223 nights. There were 22 resident conferences, with overnights totaling 5,947 for an average of more than 26 guests per night.

Non-resident groups totaling 89 brought 6,259 guests to the house. Of these, 70 were M. I. T. groups, an increase over last year.

Vice President, Operations

An abbreviated three-year comparison of occupancy figures demonstrates the satisfying use of this beautiful facility and the good work of Mimi Pierson and her staff.

	<u>1973-74</u>	<u>1974-75</u>	<u>1975-76</u>
Days Used	248	275	288
Nights Used	188	205	223
Meals Served	19,271	21,203	23,576

The furnishings program continued with various rug, drapery, and furniture restorations or replacements. Major maintenance and improvement items included installation of automatic sprinklers in the attic and basement, replacement of the main entrance doors, repairs to the exterior limestone joints and roof, and replacement of a refrigerator and freezer for the kitchen.

PHILIP A. STODDARD

Vice President, Research

This has been a year of strong contrasts.

The Laboratory for Nuclear Science has suffered lack of support in some areas because of shrinking national support for basic research in particle physics. In contrast, the Bates Linear Accelerator rose in recognition as a national research resource and has in prospect a significant addition to the facility -- \$5 million is in the fiscal year 1977 Federal appropriation bill for a second underground experimental area.

Professor Henry Zimmermann resigned as Director of the Research Laboratory of Electronics after 15 productive years. M.I.T. was fortunate to have on its physics staff Professor Peter Wolff, who is well known for his work in communications optics and solid state materials, to succeed Professor Zimmermann. Professor Wolff has served as Associate Director of the Center for Materials Science and Engineering since 1974.

Funds for implementing pay loads for space research are in sharp decline. At the same time, funds for research in nuclear fusion, and energy research generally, are growing rapidly.

Taken as a whole, the year has been a good one and the general prognosis for next year is clearly positive.

The reports that follow outline accomplishments and new directions.

THOMAS F. JONES

Francis Bitter National Magnet Laboratory

This year was marked by notable success in the Alcator thermonuclear experiment, continued strong performance in other research efforts, and a sizable increase in funding for a number of programs.

The Alcator thermonuclear experiment, a high magnetic field tokamak, was operated at toroidal confinement fields up to 8 teslas. Plasmas with density-confinement time products of about 10^{13} sec/cm³ were achieved. This is a factor of 5 to 10 higher than has been reached in tokamaks elsewhere. Furthermore, the Alcator plasma is almost completely free of impurities that adversely affect other tokamaks. The Energy Research and Development Administration (ERDA), which supports this program, has approved our proposal to build a larger machine, called Alcator C. A 200 megawatt pulsed power supply to drive the toroidal windings will be installed adjacent to the present motor-generator building. This major new effort will require extensive rearrangements of several laboratory areas.

Late in the year, the Laboratory's Magnet Research and Development Group began work on the evaluation, design, construction, and testing of large superconducting magnets for magnetohydrodynamic (MHD) generators. This long-range program is funded by the Fossil Fuels/MHD Division of ERDA. The Group also is conducting studies of superconducting magnet systems for a Stanford University magnetohydrodynamic generator and for fusion devices at the Oak Ridge National Laboratory.

Work on the new hybrid magnet having both superconducting and water cooled sections is nearing completion. This magnet is expected to generate steady fields up to 300 kilogauss. Continuing improvements on the Bitter water cooled magnets have increased their reliability and high field performance.

In nonlinear optical experiments with high-power CO₂ lasers, noncollinearly phase-matched 4-photon mixing in germanium has been used successfully for the efficient generation of quasi-tunable high-power infrared radiation in the 8 μ m region. This technique may have the potential for providing an infrared source for uranium isotope separation in UF₆.

Cyclotron resonance breakdown and heating of plasmas with high-power sub-millimeter lasers in high magnetic fields has been demonstrated. The application and extension of this technique should provide an important new diagnostic tool for transport studies in tokamaks.

Studies of the ternary lead molybdenum sulfides, the highest field superconducting materials, have continued. In addition, ternary rare-earth molybdenum selenides with comparable high field properties have been examined in a collaborative effort with members of the staff of the University of California at San Diego.

Magnetic studies at high hydrostatic pressures and high fields have been completed on singlet ground state systems. Comparisons with theory show that point charge models are inadequate. The complex phase boundaries of TmSe, a mixed valence system, have been investigated. These phase boundaries are strongly dependent on pressure and allow clarification of existing models for mixed valence systems.

Tunneling measurements of cryogenically condensed beryllium in a magnetic field of 15 teslas showed Zeeman splitting of the density of states and a zero spin-orbit scattering rate within the experimental accuracy. Critical fields were measured for Pd-H and V superconducting films less than 100 Å thick to determine their spin-orbit scattering rate. Comparison with theory for Al, Ga, V, In, Sn, and Pd-H shows a much slower increase of their spin-orbit scattering rate with atomic number, Z , than the predicted Z^4 relation. The electron spin polarization of alloys of Ni with Fe, Mn, Ti, and Cr was measured by tunneling from superconducting Al in a high magnetic field and was found to be nearly proportional to the saturation magnetic moment for the full compositional range in which these alloys are ferromagnetic.

Magnetization and Mössbauer spectroscopy measurements have been made on synthetic analogs of the active sites of both reduced and oxidized rubredoxin, an iron-sulfur protein with one Fe atom per molecule. The comparison between the unconstrained analogs and the actual protein shows that the entatic state hypothesis is not valid for rubredoxin.

The spin theory for the density of electrons at the surface of a ferromagnetic electron gas has been obtained using a density functional formalism. In addition to the separate Friedel oscillations in the up- and down-spin density, the work function, surface magnetization, and surface energy as a function of the magnetization of the ferromagnetic electron gas have been calculated. In the limit of small magnetization, an accurate result is obtained for the surface susceptibility of the alkali metals. For gadolinium the change in the work

function and surface energy between the paramagnetic state and the ferromagnetic state below the Curie temperature has been calculated and found to be in good agreement with experimental results.

The Laboratory has created a new interface with the scientific community in the area of biochemistry and medicine. The Molecular Biophysics Project was the recipient of an award from the National Institutes of Health to operate a national nuclear magnetic resonance facility for biomolecular research. Two spectrometers, operating at proton frequencies of 270 and 290 MHz, are being used by Laboratory and visiting scientists on a scheduled seven-day, 24-hour-per-day basis to study biomolecules in both the liquid and solid states. In addition, significant progress has been made in the construction of a 120 kG superconducting magnet to serve as the polarizing field in a unique 500 MHz spectrometer.

The Low Field Project has developed a computer based system employing magnetic tracing dust to study lung diseases. They recently put into operation the most sensitive magnetic field detector known, which is sensitive enough to detect all normal electrical events in the human brain. A new method has been found to extract basic information on the heart function from the measured magnetocardiogram.

The use of a solenoid electromagnet in treating certain congenital defects in infants has proved to be quite effective. The magnet is the key element in an automated device which lengthens the esophageal segments in cases of esophageal atresia and lengthens the colonic pouch in cases of supralelevator imperforate anus. In collaboration with Dr. W. Hardy Hendren, Massachusetts General Hospital, a total of eight patients have been treated, all successfully; four of each type of anomaly. Six of these were treated during a span of only 11 months.

The Applied Magnetism Project has been studying the application of magnetic separation techniques to the problem of coal desulfurization. Significant progress has been made in reducing the sulfur content of liquefied coal. In earlier work the direct removal of pyritic sulfur from pulverized coal had been demonstrated.

The basic research program and the operation of the magnet facility as well as some applied programs are supported by the Laboratory's primary sponsor, the National Science Foundation. Other applied programs are supported by a number of Federal agencies. In the latter half of the past academic year, the Laboratory entered a period of growth resulting from a number of new and augmented research contracts. The Laboratory's support from all sponsors is expected to further increase from this year's \$6,400,000 to \$9,650,000 in the next academic year. New personnel are being added to the staff and additional office and laboratory space is being sought. The coming year, then, promises many administrative challenges as well as exciting new research opportunities.

BENJAMIN LAX

Center for Materials Science and Engineering (C.M.S.E.)

The aims of C. M. S. E. are to initiate, encourage, fund, and coordinate interdisciplinary research in materials, based largely on core funding by the National Science Foundation (NSF) and further supported by smaller block funding and individual grants to faculty members.

Such additional support may be through other government agencies, industry, fellowships, and M.I.T.

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 C.M.S.E. programs.

The NSF core-funded program supports research in five major areas, each staffed by faculty from several departments with common interests. These areas are Deformation and Fracture, with emphasis on Temperature and Strain Rate Effects; Materials Processing, with emphasis on Structure and Property Studies of Rapidly Quenched Materials; Surfaces, with emphasis on Catalytic Materials and Catalysis; Electron Optics; and Phase Transitions.

About 35 faculty are supported under the NSF-MRL program with about 100 graduate students, visiting professors, scientists, and other staff. In total, more than 45 faculty participate in C.M.S.E. programs. C.M.S.E. provides research funding of the high risk seed type, and for new faculty who need funding on first arriving at M.I.T.

In addition to support of research, C.M.S.E. initiates and maintains a group of Central (Service) Facilities in support of materials research throughout the Institute. Supervised by faculty members, the facilities provide special materials in special forms, characterization and analytical services, testing laboratories, and a machine shop. C.M.S.E. is equipped with the latest and best equipment and instrumentation in most instances and tries to maintain a leading position in such services in all instances.

Some highlights of research are given below as examples of the types of studies which are supported. 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 internationally by C.M.S.E.

Strain Rate Effects in High Temperature Fatigue

Professor Regis M.N. Pelloux

Fatigue crack growth rates were measured in three solid solution superalloys (two nickel base, one cobalt base) at 1000, 1200, 1400° F over a range of frequencies from .001 to 10 cps. Three different crack growth regimes were clearly identified. The low Δk and high Δk regimes are frequency independent. The intermediate Δk regime shows a strong frequency dependence over the test temperatures investigated. The test data show that creep-fatigue interaction problems can be treated from only a fatigue crack growth viewpoint because of the simplicity of the dependence of the crack growth rates upon loads, geometry, temperature, and test frequencies.

Constitutive and Process Equations for Arbitrary Strain Histories

Professor Frank A. McClintock

A solution technique has been formulated to allow relatively realistic constitutive and process equations to be applied to low cycle fatigue of commercial alloys. From the literature on dislocation and particle microstructure, especially the work by Stoltz and Pelloux, and from continuum mechanics work on distortions of the yield locus, it appears necessary for low cycle fatigue under varying stress history to model simultaneous slip on perhaps 24 different slip systems in a polycrystal. The resulting increase in equations to be solved makes

finite element methods quite impractical. By keeping track of only two internal parameters per slip system, and giving the strain rate on each system as a function of its stress, the plastic strain can be regarded as known at any given time. Boundary integral techniques then may be used. These techniques are of special value in studying stresses around cracks and at grain boundaries. We have established that the allowable plastic strain increment is limited to the order of the elastic strain divided by the strain rate exponent, but have found some ways of greatly increasing the steps. Finally, in order to test these or other stress-strain formulations in practical applications, we have developed computer programs for pipes with histories of homogeneous stress, bending, or torsion.

Crazing and Fracture in Forming High Temperature Glassy Polymers

Professor Ali S. Argon

A theory for craze growth in glassy polymers was developed which recognizes that a craze resembles a traction transmitting crack that pushes in front of it a small plastic zone where the solid polymer is at a state of yield. As in the case of blunted cracks, the negative pressure at the tip of the craze has a positive gradient away from the tip. In this respect the craze tip resembles a fluid meniscus advancing under a positive suction gradient, and as in the case of the meniscus can break up into a series of fingers that shoot ahead into the region of high negative pressure. In simple fluids and metallic glasses this leads to rupture of the fluid along a series of furrows and ridges, also called veining. In chain polymers that can undergo orientation hardening the convoluted front can repeatedly close on itself and generate the characteristic oriented tufts of craze matter that bridge the craze faces -- all without requiring independent cavitation ahead of the craze. The theory has not only led to a successful model for craze extension in carbon-chain polymers, but also has been remarkably successful in thus far explaining all aspects of the fracture of ductile glassy metals.

High-Vacuum Modification of Alloy Surfaces

Professor Roy Kaplow

In research concerned with the controlled processing of atomically clean surfaces, under conditions in which the various treatment parameters of atmosphere constitution, time, pressure, temperature, etc., are functionally definable, we have been successful in showing that "abnormal" reactions can be made to occur, yielding surfaces otherwise not readily obtainable. For example, we have demonstrated a simple procedure which seems to supply a usefully passivated surface on pure iron. Patent applications are being drawn up by the M.I.T. Patent Office on the relevant approach. Patent applications also are being considered on two devices developed in the course of this work, which may have broader application: a high-intensity, high-energy, windowed U.V. lamp; and a versatile sample manipulator for multiexperiment operation in ultra-high vacuum.

Characterization of Small Particle Size Distributions by Quasielastic Light Scattering

Professors George B. Benedek and David J. Litster

An apparatus to undertake the measurement of ultra-fine particles by light scattering methods has been constructed and tested on polystyrene latex spheres (PLS), precipitated silver iodide from a chemical reaction, and Ludox (a commercial suspension of colloidal silica used as an intensity light scattering standard). Measurements on the PLS gave a diameter of 897 with a variance of 10-15 percent compared with electron microscope measurements yielding 910 Å

with a variance of 6 percent. For Ludox we obtained a diameter within 5 percent of the manufactures value of 154 Å (determined by the intensity of light scattering), and we found a variance in particle size of 50 percent (no data given by manufacturer). The dependence of the size upon scattering angle was less than 3 percent, indicating essentially spherical particles. Confident that the apparatus was performing reliably, we began to work with Professor John Vander Sande to study the size distribution of carbide precipitates in an alloy (Vitallium) of CoCrMoC. The procedure requires solution of the matrix in order to recover the precipitates in solution and study them by light scattering. After several unsuccessful trials we have had some success with a mixture of HCl and H₂O₂ to dissolve the matrix. Results will be compared with those obtained by electron microscopy. A subject of considerable interest is the catalytic activity of submonolayer vacuum deposits of metals such as silver, palladium, nickel, etc. We propose to prepare such deposits on soluble substrates (such as gelatins or alkali halides) and to characterize the particles produced with our method and compare the results with other techniques.

Theoretical Investigation of Catalytic Materials

Professor Keith H. Johnson

Spin-polarized SCF-X α -SW electronic-structure studies have been carried out for small iron clusters representing the active centers of supported iron catalysts. Results indicate significant paramagnetic spin polarization and ligand-field splittings of the cluster d-orbitals, which may be compared to spin-polarized band-structure descriptions of ferromagnetic crystalline iron. The molecular dissociative chemisorption of dinitrogen on these clusters is currently under study in an attempt to elucidate precursors in the reduction of dinitrogen to ammonia by iron catalysts. Effects of the supporting environment are also under investigation. This work is being closely coordinated with concurrent SCF-X α -SW studies of the active centers, Fe₄S₄(S-Cys)₄, of ferredoxin, an iron-sulfur protein of the type which is believed to be important in the process of nitrogen fixation by soil bacteria. In both studies, physical properties including electric field gradients, quadrupole coupling constants, magnetic hyperfine parameters, and Mössbauer isomer shifts are being calculated for comparison with available experimental data, using recently developed computer programs which permit the calculation of such properties directly from SCR-X α -SW orbital wavefunctions. The above theoretical studies suggest that there are interesting analogies to be made between the active centers of supported metal catalysts and the active centers of certain metallo-proteins or enzymes. These analogies may ultimately be useful in the molecular design of new catalysts.

Heterogeneous and "Heterogenized" Catalysts

Professor George M. Whitesides

A central problem in large-scale catalysis is the development of practical methods for manipulating and recovering catalysts. We have addressed two problems in this area: the recovery of very small (<10 μ) heterogeneous catalyst particles from liquid product mixtures, and the immobilization of enzymic catalysts required to operate at liquid-solid interfaces. For the first, diamagnetic catalyst supports -- alumina, silica, carbon, phoephine-functionalized polystyrene -- have been rendered ferrimagnetic by deposition of collidal magnetite particles. Small particles of these materials, and of ferromagnetic (Raney nickel, Co/WC) and paramagnetic (MnO₂, CoMoO₃, NiO) catalysts have been separated from suspensions in diamagnetic liquids by high-gradient magnetic filtration. This technique appears to have potential for use in a range of catalyst recovery problems to which other separation techniques are not readily applicable. In the second, a representative enzymatic catalyst (glucose-6-phosphate dehydrogenase) has been "immobilized" by partitioning into the hydrophilic (Ficoll) phase of a Ficoll-UCON two phase aqueous ternary polymer system. This type of immobilization is

particularly mild and convenient, and holds real promise for a range of problems requiring enzyme immobilization.

Surface Spectroscopy Using Tunable Lasers

Professors Chenming Hu, David J. Epstein, and Clifton G. Fonstad

In the first year of this project, we have developed a sensitive and novel optical waveguide technique for measuring the absorption spectrum of adsorbed surface species. This technique shows promise of being several orders of magnitude more sensitive than conventional transmission spectroscopy. Progress also has been made in the development of tunable diode laser sources for surface spectroscopy in the mid - IR. In the new spectroscopic technique, a tunable laser beam is coupled into a micron-thin dielectric film, thus creating optical fields highly concentrated at the film surface. By measuring the attenuation of the light in the film caused by the molecules adsorbed on the film surface, the adsorption spectrum of the adsorbed molecules is obtained. At present, the technique is being evaluated at visible wavelengths using a tunable CW dye laser. We plan to apply the new technique to wavelength regions beyond that of the CW dye laser, and to extend the technique to fluorescence spectroscopy and to systems involving metallic islands on dielectric supports. In the IR laser program we have analyzed the theoretical performance of the distributed feedback lead-tin-telluride laser, and in the first phase of the fabrication of these lasers we have successfully constructed distributed feedback structures (gratings) in lead-tin-telluride crystals by a holographic photo-exposure technique followed by ion-milling. Frequency tuning using external gratings will also be considered.

Elementary Steps in Catalysis by Temperature-Programmed Desorption

Professor Richard G. Donnelly

High-resolution temperature-programmed desorption (TPD) studies with single crystals present very formidable experimental problems which have kept other researchers from fully developing what could be an extremely useful surface study technique. During TPD from a single crystal, interferences may arise as a result of electron-induced desorption, desorption from mis-oriented regions (i. e., the crystal edges), and desorption from the crystal holder. Perhaps more importantly, it previously has been virtually impossible to maintain the very flat temperature profile which is required in order to obtain high-resolution data. An extensive design and fabrication effort during the past year has resulted in a unique experimental TPD cell/catalytic reactor which eliminates each of these problems. Furthermore, the pressure and temperature ranges over which experiments may be accomplished have been extended considerably. Finally, the catalysts holder design allows rapid interchange with any disk-shaped sample. Assembly of this equipment has been nearly completed during the past year. When complete, an extremely versatile system for the study of a wide variety of substrate-reaction systems will have been created.

Cathodoptic Materials and Devices

Professors Cardinal Warde, David J. Epstein

Research was centered around techniques for measuring spatial resolution in electrooptic materials. Electric fields were applied with hard-wired, transparent electrodes of Indium-tin-oxide, and the longitudinal electrooptic effect was utilized. We now are able consistently to get 25-50 Ω/\square resistivity with 85 percent transmission in the visible. We have demonstrated that the fringing of the field in the material can be observed by recording the phase change it produces via the electrooptic effect. We have investigated this with three different techniques: 1) Double exposure holography, 2) The Mach-Zehnder interferometer, and

3) the Michelson interferometer. The materials used for these demonstrations were LiNbO_3 and $\text{NH}_4\text{H}_2\text{PO}_4$. The holographic technique offers the advantage of biasing out the flaws in the crystal, thereby recording only the path differences due to the applied field. It also offers the advantage of magnification during playback. The Mach-Zehnder interferometer is a single pass, transmission system and offers the advantage over holography that real-time viewing of the phase changes are possible. The Michelson interferometer is a double pass system, and offers the advantage of a reduction of the half-wave voltage as well as real-time viewing of the phase changes.

Optical Device Physics: An Optical Transistor

Professor George W. Pratt, Jr.

An optical transistor has been proposed based on the great sensitivity of second harmonic generation, and optical mixing in general, to conditions of phase matching. The coherence length in an optical medium can be affected significantly in certain situations by a weak signal beam so that the output signal derived from a pump beam is controlled by the signal beam and power gain realized. This can be done in Te where the signal beam generates free carriers, changing the plasma frequency, and consequently the phase matching condition. It also can be realized by using the signal beam to produce variations in the electric field at a junction and through the electrooptic effect to change the phase matching condition. A variety of logic elements is possible wherein one optical signal directly controls another optical signal. The power levels encountered in optical communications situations appear to be compatible with the operation of these devices.

Optical and Magnetic Studies of Chemical Bonding in Solids

Professor Marc A. Kastner

Early measurements of reflectivity as a function of hydrostatic pressure were limited to observing energy shifts of the reflectivity peaks. Measuring the variation of the magnitude of the reflectivity is difficult because the refractive indices of the pressure fluid and the window depend on pressure. We developed a new experimental method with which we can measure fractional changes in reflectivity as small as a few parts in 10^4 . Pressure induced changes in the window transmission are canceled by measuring the ratio of the reflectance of the sample to that of an aluminum mirror placed next to it in the pressure cell. The reflectance change resulting from the density change of the pressure fluid (helium) is known and can be subtracted. Our initial experiments on trigonal and amorphous Se produced surprising results. In addition to derivative structure corresponding to shifts of reflectivity peaks, we observed that the average change in reflectivity $\Delta R/R\Delta P$ is large and positive over the entire photon energy range studied (0.5 - 4.5 eV). This average $\Delta R/R\Delta P$ arises from local field and excitation effects; that is, the charge density in Se is sufficiently localized that photon-induced excitations are local. In such a case, increasing the density increases the matrix elements for the excitations. This is just the case of the Lorentz solid composed of localized polarizable centers. Thus our new technique has provided stronger evidence for the localization of the valence charge density in selenium; we expect that it will be a powerful tool in probing chemical bonding in a wider class of materials. Furthermore, this is the first measurement of the hydrostatic pressure dependence of interband matrix elements.

Phase Transitions in Multi-Component Systems

Professor Robert J. Birgeneau

Percolation is a problem of general interest which is relevant in a remarkable variety of

disciplines, including geology, agriculture, engineering, communications, and basic statistical physics. As discussed by a number of workers, perhaps the simplest percolative system is a dilute magnet with only nearest neighbor bonds. In this case, as a function of dilute concentration, the phase transition temperature T_c drops continuously until at the percolation concentration p_c one has $T_c = 0$. For $p < p_c$ the system breaks up into finite clusters, and there can be no long-range order. The special point $p = p_c$, $T = 0$ is a new type of multicritical point exhibiting "geometrical" critical behavior as a function of $p - p_c$ at $T = 0$ and thermally driven critical behavior as a function of T at $p = p_c$. We have carried out neutron scattering experiments on the dilute [2d] antiferromagnet $Rb_2Mn_5Mg_5F_4$. For this system $p_c = 0.59$ so that we are below the percolation limit. The experiments yield remarkably simple, but quite novel and informative, results. The critical scattering at general T is found to be Lorentzian indicating that there is only one fundamental length. This "correlation" length grows as T decreases until it reaches the size of the larger clusters and then it saturates. We then approximate these percolative clusters as self-avoiding random walks on a two-dimensional lattice. This model is exactly soluble for classical spins; we find that it reproduces quantitatively the detailed behavior of the correlations in $Rb_2Mn_5Mg_5F_4$ over the complete range of temperatures. If this result stands up to further experimental tests, then we believe that it represents an important step forward in the percolation problem. At the minimum we have shown that neutron scattering experiments can yield detailed and interpretable microscopic information in a complicated problem.

Elimination of Random Compositional Inhomogeneities in Czochralski-Grown Silicon

Professor Harry C. Gatos

Random compositional inhomogeneities invariably present in silicon crystals pulled from the melt were eliminated for the first time by introducing pronounced thermal asymmetry in a Czochralski-type apparatus. The elimination of convective interference made possible the quantitative microsegregation analysis of silicon. Employing the Burton, Prim, and Slichter theoretical model, it was shown that near steady-state microsegregation takes place under these conditions. The observed small deviation between the experimental results and the theoretical model was manifested as a solute redistribution transient associated with the variation in the microscopic growth rate (phase shift between dopant concentration and microscopic growth rate). The present results now make possible a detailed study of solute redistribution at the growth interface as well as the study and origin of segregation phenomena in silicon crystals, for example, random inhomogeneities and radial concentration gradients. In addition, we believe that the present results have far reaching implications for the silicon industry.

NICHOLAS J. GRANT

Center for Space Research

The 1975-76 academic year marked the 13th year of research activity by the Center for Space Research. The initial tasks of the new Space Center evolved through the administration of a large sustaining University Grant from NASA for basic research in a multiplicity of science and technology fields that found outlets in some 14 departments of the Institute. Out of this initial support of space related research grew many projects and laboratories that eventually became separate, self-sustaining research enterprises at M.I.T. In the

formative years of the new Center, an engineering laboratory for the design and fabrication of space experiment payloads was formed, and became known as the Laboratory for Space Experiments. Its activities grew to a peak level in 1972, with 75 staff and support personnel and five to six scientific payloads under parallel development. Its peak annual operating budget was more than \$3,000,000. In 1967-68, the science oriented Cosmic Ray Group led by Professor Bruno Rossi, of the Department of Physics, transferred from the Laboratory for Nuclear Science to the Space Center bringing with it 30 faculty, postdoctoral staff, and support personnel engaged in X-ray astronomy and interplanetary plasma research.

Three other groups have had long associations with the Center. These are the Man-Vehicle Laboratory, engaged in research on the role of the vestibular system in the aerospace environment and led by Professor Laurence R. Young, of the Department of Aeronautics and Astronautics; the theoretical astrophysics research group led by Institute Professor Philip Morrison, of the Department of Physics; and the neuroendocrine research group led by Professor Richard Wurtman, of the Department of Nutrition and Food Science.

Other disciplines of research added more recently to the program of the Center include studies of the applications of composite materials to space structures under the supervision of Professor John F. McCarthy, Director of the Center, and Dr. Oscar Orringer, Associate Director, Aeroelastic and Structures Research Laboratory in the Department of Aeronautics and Astronautics.

Total research operation in the Center for Space Research for 1975-76 was about \$4,500,000 and engaged 20 faculty, 75 research staff and support personnel, and approximately 70 students. Primary support for the Center's program came from NASA. Additional support was supplied by NSF, the Air Force, and the Navy.

Some highpoints of research follow below in condensed form. More technical detail for certain of the research efforts may be found in appropriate departmental sections of the annual report, and Center research project reports and publications.

The design and development of a plasma experiment for the Mariner Mission to the Outer planets is nearing completion, and two flight units and a spare will be delivered to the Jet Propulsion Laboratory, NASA Program Manager, by fall, 1976. Professor Herbert S. Bridge, Department of Physics and Associate Director of the Center, is the Principal Investigator.

The Mission is planned to carry a wide complement of visual, IR, UV, and particle and fields experiments past Jupiter, its Galilean satellites, then on to Saturn, its rings and Titan, and a possible future encounter with Uranus. The Plasma experiment is designed to investigate the flux of ionized particles emanating from the sun while in the interplanetary region, to study the morphology and composition of the Jovian and Saturnian magnetospheres, and to measure the plasma interactions with the inner satellites, their possible atmospheres, and the rings of Saturn.

In spring, 1976, a Center for Space Research solar wind experiment was carried into orbit on each of two Naval Research Laboratory Earth satellites, Solrad 11 A and B. The experiments were under the supervision of Dr. Alan Lazarus, Senior Research Scientist, Department of Physics, and are unusual in that they were designed and developed by undergraduates working under the supervision of staff members. The participation of undergraduates was an outgrowth of an Undergraduate Research Opportunities Program. The experiments are working well and provide rapid measurements of solar wind properties. The solar wind parameters are being made available in real time in support of an ongoing international study of the earth's magnetosphere.

The Third Small Astronomy Satellite, SAS-3, carrying the X-ray observatory developed at the Center, has been operating successfully for over a year under the direction of Professor George W. Clark, Department of Physics. Professor Clark and other members of the M.I.T. X-ray Astronomy Group have monitored SAS-3 from the data reception area in the Center. Among the most significant results have been the discovery of several X-ray bursters -- sources of intense X rays, one of which was discovered by Professor Walter Lewin, Department of Physics, and his colleagues, to repeat as often as once every ten seconds.

In another area of investigation with SAS-3, observations of several binary X-ray stars have yielded information from which Professors Saul Rappaport and Paul Joss, both of the Department of Physics, have obtained precise results on the properties of the binary systems, including information on the masses of the neutron stars that these systems contain.

Final tests are being made on the focal-plane Bragg crystal spectrometer that will be one of four instruments used with the X-ray telescope to be flown in 1978 on the High Energy Astronomy Observatory satellite, HEAO-B. This project is supervised by Professors Clark and Claude Canizares.

Balloon-borne experiments under the direction of Professor Lewin are in progress with the aim of investigating high energy X-ray sources in the Southern sky. Also under Professor Lewin's direction is the development of techniques for high energy X-ray observations to be employed in the joint University of California at San Diego-M.I.T. collaborative experiment on the HEAO-A satellite, scheduled for launch in 1977.

Optical observations of X-ray source counterparts, coordinated with SAS-3 data, have been performed by Professor Canizares, Dr. Jeffrey McClintock, and several graduate students at the new McGraw Hill Observatory on Kitt Peak, Arizona.

Search for new sources radiating at infrared wavelengths has been the primary goal of Professor Susan G. Kleinmann, Department of Physics, and collaborating graduate students. Their observations using the 28-inch telescope at Mt. Lennon, Arizona, led to revisions in the Air Force Cambridge Research Laboratory catalogue, and had impact on the program for the proposed NASA Infrared Astronomical Survey. A long list of new sources were located that should provide new information on the nature and distribution of cosmic dust. Observations of these objects using radio telescopes at Haystack and National Radio Astronomy Observatory already have led to the discovery of 15 new OH and H₂O masers. Further observation of these sources may lead to the identification of new astrophysical objects, classes of stars most likely to be seen in the NASA IRAS Survey, and a new capability to distinguish various classes of infrared stars. A program has been initiated during the past year using the 1.3 meter telescope at Kitt Peak National Observatory. These observations have provided the first infrared observation of a nova at maximum light, thereby placing constraints on the temporal evolution of the ejected shell of matter. The results imply that the X-ray emitting region of the bright X-ray nova AO620-00 is small, and provide strong evidence that the cluster found near the rapid-burst X-ray source MXB1730-335 is a compact globular cluster with an extinction equal to or greater than eleventh magnitude at visual wavelengths. Professor Kleinmann's research has been supported by NASA grants and M.I.T. basic research funds.

The research of Professors Young, Renwick E. Curry, and Charles M. Oman of the Department of Aeronautics and Astronautics, assisted by Senior Research Associate Howard T. Hermann and Research Associates Alan Natapoff and Alfred D. Weiss, principally involves applications of technology to problems of human equilibrium. This research has two major thrusts: one is the use of instrumentation and research methodology, developed in conjunction with the space program, to the diagnosis and treatment of patients complaining of

disorientation and dizziness; the second is the application of research on the underlying physiological mechanisms of spatial orientation to problems of particular interest in the aerospace field. These programs include display and ride qualities in aircraft, development of adequate flight simulators for pilot training, and the understanding and countering of space motion sickness experienced by US and Soviet astronauts in the manned space program. It is in this last area that the Man-Vehicle Laboratory has worked most closely with the Laboratory for Space Experiments within C.S.R. They jointly developed a major proposal in conjunction with the Defense and Civil Institute of Environmental Medicine of Canada for a series of tests of vestibular functions to be carried out aboard an early Spacelab mission.

During the past year, the Laboratory of Neuroendocrine Regulation, under the direction of Professor Wurtman in cooperation with the Center for Space Research, continued its examination of the effects of several environmental inputs -- particularly light and food -- on the physiology of humans and experimental animals. The inputs of light and food tend not to be freely available in space flight since the lighting conditions and the food available to space passengers can only be those provided, prior to flight, on earth. Further, the passenger cannot step outside to obtain exposure to natural sunlight or to alternative foods. Experiments have specifically dealt with 1) the control of human pineal gland function (estimated by measuring levels of the pineal hormone melatonin in blood and urine) by various lighting spectra and intensities; 2) factors other than light (e.g., sleep, age, sex) that normally contribute to the tendency of the human pineal to secrete its hormone in a pattern displaying daily rhythmicity; 3) the relations between dietary protein content and the times of meals and the daily rhythms in plasma amino acid levels; and 4) plasma levels of such hormones as insulin and growth hormone. Professor Wurtman has shared the responsibility for this research with Professors John D. Fernstrom and Loy D. Lytle. Key participants were Lecturer Harry Lynch and Research Associate Michael A. Moskowitz, all of Nutrition and Food Science. The research also has involved five graduate students and two postdoctoral fellows. Sponsorship has been principally provided by NASA and NIH.

Professors Philip Morrison and Kenneth Brecher, of the Department of Physics, have pursued a range of topics in theoretical astrophysics and cosmology. Among these have been: implications of observations of neutron stars and white dwarfs for the physics of dense matter; nature of the transient X-ray sources and cosmic X-ray bursters; proposal of a new ("bloated dwarf") model of novae; problems of active galaxies from the rather passive M82 to the violently eruptive Cygnus A; tests and consequences of the existence of intergalactic matter ranging from the X-ray emission from clusters of galaxies, to the cosmological evolution of double radio sources, and to the formation of bound gravitational systems. NSF has been the chief sponsor of this research.

The application of composite materials to space structures has been the subject of a continuing study supervised by Professor McCarthy and assisted by Dr. Orringer and other research staff of the Center's Laboratory for Space Experiments. The research is being sponsored by the US Air Force Flight Dynamics Laboratory. Under this program, a preliminary design was carried out for a large communications satellite signal-feed truss. The truss structure was required to be extremely stable in its dimensions over a wide range of operating temperatures in order to minimize defocusing of the broadcast antenna. Several conceptual configurations were considered employing high strength, low expansion fiber composite materials. A similar truss structure which had flown on NASA's ATS-6 satellite was employed as a baseline for the study.

New proposals for research have been submitted during the past year to broaden the base of disciplines represented in the Center's current program of space research. This approach is vital in establishing continuity of effort and efficient use of engineering capability and physical resources at the Center. These proposals include, with Professor Thomas McCord, Department of Earth and Planetary Sciences as Principal Investigator, a lunar surface

mineralogy experiment using reflectance spectrographic techniques from a lunar polar orbiting satellite, and a separate experiment for earth applications using a reflectance spectrometer to measure the fraction of solar radiation reflected from the earth's surface as a function of wavelength; with Professor Young as Principal Investigator, a group of closely related Shuttle-Spacelab experiments designed to investigate the changes in sensitivity of otolith functions during weightlessness and the carryover of any such changes to post-flight conditions; with Professor Wurtman as Principal Investigator, a program to design and develop specific instrumentation for monitoring the intensities of visible and ultraviolet light in a spacecraft thereby providing in situ measurements of the light experienced by future astronauts; with Professor Bernard Burke, Department of Physics, a study of a Shuttle based very long baseline interferometer for precise observations of quasars and interstellar maser sources; and with Professor Lewin, an expanded program of X-ray astronomy from high altitude balloons to be carried out jointly by M.I.T. and Leiden University, the Netherlands.

For the last two years, the Center has been going through a transition stage marked by a serious diminution of unmanned planetary and earth orbiting space science experiment opportunities. This has resulted in extremely active competition for available programs among the agency, industrial, and university groups which have established capabilities in the space research field. The basic contributing factors have been threefold: a fairly level national space budget in the face of serious inflationary pressures, a large investment by NASA of its available funds in the engineering and construction of the space shuttle system, and an ever increasing percentage of in-house expenditures by NASA. There are serious questions raised by some as to whether selected contributors to past science successes will survive in this new era. For the Center for Space Research, an infusion of innovative concepts representing a multidisciplinary approach to these new challenges is needed. M.I.T. has the resources to originate new ideas. They need to be sought out, synthesized, and organized into timely and viable proposal formats tuned to the new NASA space launch capabilities in the era of the space shuttle transportation system.

JOHN F. MCCARTHY, JR.

Detroit Institute of Technology-M.I.T. Association

The Detroit Institute of Technology (D.I.T.), is a small, private, four-year college located in the inner city of Detroit, which offers Associate and Bachelor degrees in the College of Arts and Sciences, Business Administration and Engineering. The cooperative effort between M.I.T. and D.I.T. grew out of meetings in 1970, and led to the establishment in 1971 of the D.I.T.-M.I.T. Association. The purpose of the Association is "to improve and strengthen the academic program of D.I.T." Activities of the D.I.T.-M.I.T. Association are funded by the Detroit Institute of Technology, which receives partial support for M.I.T.'s participation under a US Department of Health, Education and Welfare Title III grant for strengthening developing institutions.

During the past year, nine M.I.T. faculty, staff, and outside consultants have assisted D.I.T. faculty and administrators in improving D.I.T.'s academic program. In addition to those involved with the Association on a continuing basis, a number of other M.I.T. deans, administrators, faculty, and students have contributed to M.I.T.'s effort on a more limited basis. M.I.T. personnel have spent an average of 12 days per month working with their counterparts in Detroit. D.I.T. administrators and faculty have visited the Boston area and also have met

with deans and faculty at Franklin Institute, Wentworth Institute, the University of Lowell, and Bunker Hill Community College to investigate programs in engineering technology, architectural engineering, and remedial programs to improve student skills.

Institute personnel and consultants continue to work in the areas of biology, chemistry, physics, mathematics, engineering (electrical and manufacturing), and to a lesser extent the social sciences and business. Some highlights of the past year were: a two-week Minicomputer Workshop run by Paul J. Murphy (University of Lowell) to introduce D.I.T.'s newly-acquired Hewlett Packard computer to faculty and staff; the development of an Urban Food Science course by Ernst R. Pariser (M.I.T., Sea Grant Program, and the Department of Nutrition and Food Science) and Dr. John N. Vournakis (Syracuse University); a talk by Professor Kenneth R. Manning (M.I.T., Technology Studies Program, Department of Humanities) entitled "The Role of Blacks in Science and Technology;" and the contribution of library equipment to D.I.T.'s library by Mr. and Mrs. Henry C. Johnson. Mr. Johnson is a member of M.I.T.'s Class of 1936 and a member of D.I.T.'s Board of Trustees.

Notwithstanding the catalytic role M.I.T. personnel and consultants have played in D.I.T.'s development during the past five years, both institutions recognize the need for D.I.T. to move toward greater self-sufficiency.

MARTHA S. DRAPER

Energy Laboratory

In November 1972, M.I.T. established the Energy Laboratory to focus and stimulate interdisciplinary and mission oriented energy research at M.I.T. Since that time, the Energy Laboratory has grown in both funding and personnel. Current research programs involve 35 technical staff members supplemented by some 80 faculty and research associates from 10 departments and all five M.I.T. Schools. Over 80 students, including graduate research assistants, fellowship students, and undergraduates, also are participating. The Laboratory's recent growth has necessitated further expansion of its administrative support staff and has fostered greater diversity and depth in the coming year's programs.

During the past year, a cooperative effort at M.I.T. resulted in an institutional agreement between the Energy Research and Development Administration (ERDA) and M.I.T., coordinated here by the Energy Laboratory. This institutional award, the first of its type to be made by ERDA, provides a funding mechanism for ERDA support of an interdisciplinary energy research program at M.I.T. To date the agreement covers more than a dozen task orders at M.I.T., and new tasks are being added as they receive Energy Laboratory approval and ERDA consent and funding.

In response to the original guidelines, ERDA allotted \$300,000 to the Energy Laboratory to be used for exploratory research, educational activities, and program coordination. Currently being developed are two new courses for the upcoming academic year concerning fossil and non-fossil energy resources, and materials for advanced energy systems and conservation. The exploratory research program provides for preliminary work to determine the scientific basis and merit of generating more specific, mission oriented projects such as energy estimation and macroeconomic modeling; electric vehicle demand; coal and nuclear fuel design, management and markets; marine impact determination; and behavioral issues in energy consumption.

The traditional four administrative units, each with a full-time program director, selected faculty coordinators, and associated faculty and research staffs, are: Fossil Fuel Technology; Energy Economics, Management, and Policy; Nuclear, Environmental, and Electric Power; and Special Programs.

FOSSIL FUEL TECHNOLOGY

Under a second long-term contract, the magnetohydrodynamics (MHD) power generation project continued into its fifth year. Professor Jean Louis is directing this interdepartmental effort toward developing open-cycle, coal-fired MHD as a promising source of electrical power. This contract is part of a national MHD program coordinated by ERDA; cooperation with other contractors such as AVCO Everett is proving productive.

Eight engineering and computational tasks included: 1) development and characterization of materials for electrodes and insulators, 2) superconducting magnet fabrication development with emphasis on the saddle configuration, 3) construction of and materials testing in a combustion facility under conditions simulating the extreme temperatures and other stresses of an MHD environment, 4) coal combustion studies emphasizing devolatilization of several different types of coal, including ash behavior and slag layer characterization, 5) mathematical and computational studies of key phenomena affecting MHD generators such as plasma non-uniformities, presence of a slag layer, time-dependent behavior, and inter-electrode breakdown, 6) construction of and studies in an MHD disk generator powered by a six-inch shock tube, 7) computer analyses, based on M.I.T. developed models and programs of MHD components, and 8) integrated computer modeling of an MHD generator.

Members of the M.I.T. MHD group faculty and staff also assisted ERDA in its national schedule of design reviews, working groups, and evaluation of proposals. In addition, M.I.T. continued its close theoretical and practical involvement in the ERDA coordinated US/USSR Cooperative Program in MHD Power Generation, including visits and exchanges of information with our Soviet counterparts as well as actual testing of some US theories and materials in the Soviet U-235 and U-02 installations.

Professor Kent Bowen tested new MHD electrode materials under simulated conditions at M.I.T.'s small scale facility and in the larger generator at AVCO. Special modules were developed for the US-USSR cooperative program. Several new systems were designed and new materials developed. The use of flame spraying to create thin film ceramic electrodes for the high test fluxes of large generators was demonstrated. Spinel electrode work led to the first system compatible with coal slag.

Professor John Heywood and Dr. Rodney Tabaczynski developed a spark-ignition combustion model incorporating the effects of turbulence and fuel composition for assessing lean burning engine concepts and components.

Professor Jack Howard's research on coal pyrolysis and hydrogasification focused on variables pertinent to practical scale operation and their effects on rates and extents of conversion of the coal to specific products. Non-catalytic methane yield, char yield values, and product distribution control were central issues.

Professor John Longwell suggested a method of producing from coal clean, economically storable fuels for peak load electric power generation. Professor Longwell, Professor Howard, and Dr. William Peters studied its technical and economic feasibility. The approach

was based on pyrolysis of coal in the presence of hot, sulfur-accepting stones derived from a fluidized bed combustor.

Professor Jean Louis and Dr. Shao Tung developed a system model for a fluidized bed combustor for coal. The system model is being structured through five component models, namely: a fluid dynamics submodel, a combustion submodel, a heat transfer submodel, a desulfurization submodel, and a materials submodel.

ENERGY ECONOMICS, MANAGEMENT, AND POLICY

An era of limited resources and increasing societal complexity has motivated the use of effective decision support systems. Professor John Donovan's basic research developed an experimental software for data manipulation and analysis -- Generalized Management Information System (G.M.I.S.) Applied research has integrated G.M.I.S. into the complex of local, regional, and state energy related decisions and actions being monitored and evaluated by the New England Energy Management Information System (NEEMIS). The NEEMIS effort provides a computer facility with: advanced flexible tools for data management and analysis; a body of energy related data for the New England region; a number of application programs and models for analysis and policy studies of the region's energy problems; and this year, with the support of the New England Regional Commission, a group of energy specialists continually accessible to all of the six state energy policy officers.

Professor Donovan also reported that the Time Series Processor system for econometric and statistical analysis was adapted to the Federal Energy Administration's computer system. Enhancements include various simultaneous equation estimation procedures, a model analysis and solution capability, and a data bank subsystem to permit efficient use of tape, disc, and drum storage.

Professors Heywood and Howard Margolis and Dr. Lawrence Linden made detailed examinations of the Stirling and diesel engines and the electric car for their published report on the Federal role in supporting alternative automotive power system development. These studies examined the current state of these alternative technologies, potential gains in vehicle lifetime operating costs relative to internal combustion engines, and the problems associated with introduction into mass production.

Professors Ted Greenwood and Eugene Skolnikoff and Dr. Michael Brenner organized and ran a workshop on June 2-3 entitled "International Diffusion of Energy Technology." Industry, academic, and government participants discussed a variety of issues of government-industry relationships, policy, and organization. A workshop report is being published and follow-up research planned.

Professor Greenwood continued his investigations into Canadian energy policy. Among the subjects under study were: changing Canadian perceptions of its fossil fuel resource base; the effects of world oil market changes; Canada's growth in the nuclear power sector; environmental constraints; the various political dimensions of Canada's energy policy; and the impact of all these on Canadian-American trade in energy resources.

Professor Henry Jacoby's evaluation of the world petroleum market centered on gathering data of consumption patterns in the industrial nations, and estimating the effects of prices and incomes. Present and future reserves and productive capacity, as affected by prices, were estimated, most precisely in the North Sea and more approximately elsewhere. Cartel models were suggested and tested.

The M. I. T. Regional Electricity Model (R. E. M.) is an engineering-econometric-financial model of the electric utility industry in the United States. Professor Paul Joskow completed the simulation model and used it to examine a number of utility public policy questions: the future of nuclear energy as a generating alternative; capital requirements of the industry; regulatory reform effects on prices; demand and industry ability to raise money through conventional channels; and fuel utilization projections for each of nine census regions through 1995.

Professors Gordon Kaufman and Eytan Barouch built a probabilistic model of the oil and gas discovery process. It constituted the physical component of an economic supply function of reserves from new discoveries. Computational methods for estimating parameters of the model and forecasting new field sizes were developed and applied to the North Sea petroleum province.

Professor J. Daniel Nyhart and Drs. Linden and Ogden Hammond began an inquiry on the impact of regulatory policies on the commercialization of energy technologies developed under ERDA auspices. Initially they examined the regulatory regimes relevant to coal gasification and shale oil technologies. Future work will develop more generally applicable methodologies for analyzing similar regimes for new technologies.

Professor Robert Pindyck continued work on the M. I. T. econometric model of the natural gas industry. An improved and more detailed model for the reserve accumulation process has been specified. With the data base updated through 1974, the entire model has been re-estimated. The model is now being used for policy simulation experiments.

Dr. Alan Strout explored energy problems of developing countries. Their resources and consequent possibilities for economic development over the next 75 years were assessed from investigations of the total available raw materials, population conditions and potential, and environmental factors. Major emphasis was on the specific materials for urbanization.

David Wood and Dr. George Argyropoulos's group supported the Office of Technology Assessment in a review of ERDA's initial plan for research, development, and demonstration. Members of the M. I. T. community participated in six review panels which considered major programmatic areas of the plan. In addition, five issue papers dealing with energy policy were commissioned. These papers explored international issues, manpower considerations, net energy analyses, and national energy demand.

The Policy Study Group explored the broad economic and policy issues surrounding government support for the commercialization of new energy technologies. Synthetic fuels are most prominently discussed. The Group's issue paper focused on the nature of ERDA planning procedures and the potential impact of demonstrations of commercial scale facilities.

NUCLEAR, ENVIRONMENTAL, AND ELECTRIC POWER

Professor Michael Driscoll initiated work to improve uranium utilization and fuel cycle economics by improving light water reactor core performance, with major emphasis on thorium utilization.

Professor Donald Harleman and Dr. Gerhard Jirka began evaluating the external circulations generated in the ocean around floating thermal energy conversion power plants. This inquiry

will aid the assessment of the concept's feasibility by identifying the potential for recirculation and its attendant efficiency reduction and by limiting the maximum plant site for natural oceanographic conditions.

Dr. William Hinkle completed a project in which a natural circulation water test loop was used to simulate liquid metal fast breeder reactor geometry and flow conditions predicted to exist at the time boiling is initiated during a Loss of Pipe Integrity (LOPI) accident. Information and data were obtained on post-voiding heat transfer and critical heat flux.

Dr. Leon Glicksman and Professor Warren Rohsenow continued working on the cooling of underground high voltage transmission lines. They have written a design manual for the thermal and hydraulic design of transmission lines based on their work for the last three years. Transient cable performance also was studied.

Dr. Glicksman and Professor Rohsenow began experimental performance measurements of their unique design for a wet/dry cooling tower. The tower, similar in design to a conventional evaporative tower, has an evaporation rate less than one-half that of a conventional wet tower for the same heat rejection rate.

Professor Rohsenow and Drs. Glicksman and Bruce Andeen continued their research on the periodic cooling tower. This innovative design consists of a regenerative heat exchange surface rotating between hot power plant effluent and the atmosphere. The design, when operated as a dry tower, is economically superior to conventional dry towers, and also has the flexibility of operating as a wet tower.

Professor Fred Schweppe worked on the field demonstration of a supplementary control system for sulfur dioxide from coal burning power plants. The system design included realtime monitors, meteorological and air quality forecasting, and a probabilistic multi-plant control strategy utilizing linear programming at the unit commitment time scale.

With utility cooperation, Professor Schweppe developed and tested a model for the planning of electric power plant construction. In addition to traditional planning factors, the generation expansion model (G. E. M.) also considers environmental constraints and standards. It has been modularized to make it readily transferable to other uses.

Dr. Tung led an assessment of the potential environmental impact of advanced energy conversion technologies in order to avoid the need for retrofitting control equipment when these plants are a commercial reality. The advanced cycles considered in this program include open and closed magnetohydrodynamics (MHD), open and closed cycle high temperature gas turbines, combined cycles, liquid metal topping cycles, bottom cycles, supercritical CO₂ cycles (Feher), advanced steam cycles (Field), thermionics, and fuel cells. Analytical models will be developed in order to estimate effluents, pollutants, and waste energy. Preliminary assessments of important parameters and the required analytical models were developed.

Since 1973, the Energy Laboratory Electric Power Program has served the research and development needs of the regional electric utilities through the development of specialized facilities and computer codes, the performance of specific research and development projects, the development of a professional staff familiar with regional problems and capable of responding quickly to utility requests, and through the education of utility staff.

The Electric Power Program concentrated on five aspects important to both immediate and long-term interest for plants which are operational, under construction, or on order in the northeastern United States. Current projects in the Nuclear Power Reactor Safety group are described below.

Professor John E. Meyer's group researched methods to calculate nuclear fuel rod performance during normal operation and transients. Computer codes treating a range of relevant physical situations are now operational. Ongoing efforts include: code evaluation by comparison to experiments, in-depth investigation of physical modeling details, and application of the codes to problems of interest.

Professor Neil Todreas modified and validated a sub-channel computer program of one pass procedure for steady state analysis of a pressurized water reactor core. An outgrowth of this work will be the development of a method for transient analysis.

Impact and damage to nuclear power plant structures caused by tornado generated and other missiles such as pipes, rods, poles, plants, automobiles, and aircraft were assessed to devise more rational transient response prediction methods than now exist. Finite element analysis methods were developed by Professor Emmett Witmer to analyze response of structures subjected to impact. This work was supplemented by experiments involving the impact of steel spheres and aluminum rods against simple structures.

The Waste Heat Management portion of the Electric Power Program evaluated the environmental impact of the heat rejected from the energy conversion processes and their discharge and dispersal systems. The current projects complement the research programs already under way, under other sponsorships, by members of the Waste Heat Management group. Brief descriptions of the projects follow.

Professor Michael W. Golay worked to reduce emissions of drift entrained, salt-laden droplets in the exhaust of evaporative cooling towers. A low speed wind tunnel was constructed for measuring drift eliminator performance, and a numerical simulation program for performance analysis has been applied to a broad range of currently used eliminator designs.

Professor Harleman and Dr. Jirka investigated submerged multiport diffusers in once-through cooling systems for steam-electric power generation. Experimental diffuser designs were tested in a shallow laboratory basin. Complementary theoretical research then led to the development of an initial predictive model for the temperature and velocity field generated by a unidirectional diffuser. This research is leading to improved assessment capabilities for environmental impact and to engineering designs with optimal environmental/cost trade-offs.

Professor Stephen Moore is evaluating field sampling programs to improve the cost effectiveness of monitoring systems at New England coastal power plants. Marine fouling organisms naturally deposited on exposure panels at the Millstone Harbor plant were analyzed with no statistically significant effects detected. Particular recommendations were made for re-designing the experiment and analysis of shore zone fish data collected with seine nets has started.

SPECIAL PROGRAMS

Dr. Glicksman continued his study of heat pumps. Innovations to heat pump designs were identified which will result in a 25 percent increase in heat pump efficiency over the heating system. The new designs are cost effective for northern climates.

Thirty faculty and research staff members met in July 1975, to discuss the potential of satisfying some of the nation's requirements for solar energy. Professors Roy Kaplow and David C. White cochaired the workshop and published a summarized review of research on most solar energy technologies, the workshop's view on near- and long-term prospects, and the discussions of present and future work in the field, especially at M.I.T. The included abstracts are optimistic about the potential of solar energy when integrated with widespread energy conservation and recommend a larger effort devoted to longer-range research.

Dr. James W. Meyer led the conceptual design of a solar collector system to supplement domestic hot water heating at the new Shiraz Technical Institute in Iran, and design of equipment for use by students in a solar component of the Institute curriculum.

Drs. Meyer and Glicksman directed a feasibility study of an experimental 20,000 square foot, south-sloping solar collector proposed to power a sprayed liquid dessicant dehumidifier for the top 25 floors of Citicorp's new bank headquarters in New York City. While technically feasible, the benefit/cost ratio and construction schedule uncertainties combined to discommend it economically. Evaporative cooling offered an important savings of purchased energy and also proved technically feasible. Other site consideration was urged, as was experimental evaluation of the energy use in the completed Citicorp building.

Dr. Meyer and William Jones conducted a survey of the physical facilities of a private school to identify opportunities for the most effective application of solar energy as a supplemental source. The experience gained will aid in developing effective survey procedures for other small institutions, public and private.

Professor Rene Miller's study of wind energy conversion systems emphasized the coupling between the electric power generating system and the rotor aeroelastic characteristics, the fatigue loads acting on the rotor, and the rotor's nonlinear dynamics. Both theoretical and experimental studies were carried out and a model built for test in the wind tunnel under simulated gusts and boundary layer stream flows.

DAVID C. WHITE

Laboratory for Nuclear Science (L.N.S.)

The L.N.S. provides support for research by faculty members and associated research staff in the fields of nuclear and elementary particle physics. It supports the activities of the Center for Theoretical Physics in these fields, and provides a computing facility for the experimental and theoretical programs. Use of this facility is shared by some activities of the Center for Space Research and some other Institute programs. The Laboratory supports experimental programs in three areas: intermediate energy nuclear physics, centered at the Bates Linear Accelerator operated by L.N.S. in Middleton, Massachusetts; elementary particle physics, with current programs at three accelerator facilities in the United States and two in Europe; and heavy ion nuclear physics with major programs at two American accelerator facilities and lesser projects at several others.

Despite the difficult funding situation, the year 1975-76 saw important progress in the experimental programs of L.N.S. Progress of the work of the Center for Theoretical Physics is reported under the Department of Physics.

INTERMEDIATE ENERGY NUCLEAR PHYSICS

The Bates Linear Accelerator completed its first full year of research operations, providing approximately 2,100 hours of high energy electron beam for various experiments out of a total of somewhat more than the projected rate of 3,000 hours. Accelerator reliability and beam quality continue to be improved. The high resolution energy loss spectrometer continues to be used extensively in the electron scattering program. A notable achievement has been the installation of a new detection system in the focal plane of this spectrometer. It is novel in concept and simple in construction. It determines the angle as well as the position of an electron from the spectrometer. This allows corrections for spectrometer aberrations. With this detector, a momentum resolution of 10^{-4} has been achieved for approximately one-third of the acceptance range. Approval has been obtained for the construction of a second experimental area which will greatly extend the capabilities of the installation.

Thirteen experiments utilized the beam during the year. In addition to L. N. S. staff, physicists from 16 other institutions participated in these experiments, including two in Canada, one in Scotland, and one in Brazil.

The most active research program involved elastic and inelastic electron scattering to study the distribution of charge and magnetism in nuclei and the properties of electromagnetic transition moments. Important new results were obtained, particularly for deformed rare earth nuclei. Other interesting results include new excited states in light nuclei. Other research programs study the production of positive and negative pions from light nuclei near threshold and the ejection of protons from oxygen nuclei. These experiments utilize secondary photons produced by the electron beam.

The Bates accelerator is now recognized as one of the pivotal facilities in the national program in nuclear physics. The next year should see an increase in accelerator operation, construction of the new experimental area, and an expansion of office and laboratory space.

EXPERIMENTAL ELEMENTARY PARTICLE PHYSICS

The experimental work in high energy physics of L. N. S. is the largest university based program of its kind in the United States. This and demands of increasingly complex accelerator facilities at the National Laboratories set limits to our possible growth. These considerations promoted the consolidation of our research efforts into three major groups conducting experiments at accelerator laboratories, usually in collaboration with similar groups at other institutions.

During 1975-76, L. N. S. supported efforts at Brookhaven National Laboratory (BNL), Fermi National Accelerator Laboratory (FNAL), Stanford Linear Accelerator Center (SLAC), and the European Center for Nuclear Research (CERN) and a lesser effort at the German Electron Synchrotron Laboratory (DESY).

The Electromagnetic Interaction group continued experiments at BNL with the large dual magnetic spectrometer designed by them. The discovery of the J particle in fall, 1974 was made with this apparatus. Additional detectors have been constructed and installed for the identification of K mesons and mu mesons. The group made a very sensitive search for particular meson pair combinations expected as decay products of "charmed" particles, postulated by current theories. The result of this search was negative, indicating that, if such particles exist, they do not appear under the conditions of this experiment.

The apparatus has been dismantled and the main effort of the group is now concentrated on preparation of an experiment designed to study mu mesons produced at the Intersecting Storage Ring (ISR) at the CERN. This will clarify the dynamics of their production and search for new particles decaying into such pairs. The ISR facility provides the highest energy presently available for these processes, and this is one of the high priority experimental projects currently under way at this facility. The construction of the apparatus is a major undertaking involving substantial support from CERN in addition to the resources provided by L.N.S. It consists of particle detection equipment and a very large magnet partially constructed in the L.N.S. shop from parts of the old cyclotron of Carnegie Mellon University. The innovative drift chamber detectors, among the largest ever built, are constructed entirely by L.N.S. personnel.

The Accelerator Physics Collaboration (A. P. C.) group is primarily engaged in bubble chamber experiments. A large part of its effort is devoted to the measurement of photographs, utilizing the L. N. S. "P. E. P. R." facility (Precision Encoding Pattern Recognition), a device pioneered by this group and now adopted by numerous laboratories throughout the world. This group has developed the concept of a hybrid bubble chamber spectrometer which utilizes a bubble chamber in conjunction with counters and proportional chamber detectors. This device has been implemented by the group in collaboration with other institutions at FNAL, and the CERN laboratory has adopted a similar facility to be installed at their new accelerator.

The main effort of the Counter Spark Chamber group has been concentrated on experiments with the single arm spectrometer facility constructed by this group in collaboration with other institutions at FNAL. The aim of this program is a very careful study of elastic and inelastic scattering processes with a variety of particles similar to the highly successful program involving electron scattering at SLAC. The first completed experiment carried out in collaboration with the other groups has produced the most precise measurements of elastic scattering of various hadrons by protons and neutrons. A second experiment is under way in which the secondary particle detected differs in energy and kind from the incident particle. In another experiment, members of the group have followed up the very interesting result, reported by them in the preceding year, that secondary particles produced by energetic projectiles from heavy nuclei are similar in number to those produced from hydrogen. This was an important and unexpected result.

Within the funding limitations outlined at the beginning of this section, the quality of the work carried out in L. N. S. is being recognized by sufficient funding to maintain substantial progress in all major programs.

HEAVY ION PHYSICS

Although this is the smallest of the three programs in L. N. S., it is the largest effort supported in the United States at an institution without an accelerator in this field. During the past year, the main effort of this group was focused at BNL. Important new results were obtained concerning highly inelastic collisions of heavy nuclei, fusion of intermediate mass nuclei, and an indication of quasi-molecular states of colliding carbon nuclei. A second experimental program was carried out at the Superhilac Laboratory in Berkeley. This program pursues the detection of fission fragments under conditions in which superheavy nuclei might be identified.

Other Projects

The Laboratory has provided support, either administrative, logistic, or through staff participation, to several spin-off projects applying techniques developed in L.N.S., primarily in the biomedical field. We expect that this activity will increase in coming years.

Summary of Support

There were approximately 450 participants in the various research programs during the past year. This includes 57 academic staff, 72 graduate students and at least 97 undergraduates from M.I.T. and other institutions. The latter were involved in senior theses, UROP, work-study and similar programs. There were 57 research staff members with Ph.D.s including visitors and guests and 163 employees in supporting categories such as engineers, technicians, machinists, and computing and administrative personnel. More than 30 active user physicists from other 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.

Support during fiscal year 1976 from the contract with the US Energy Research and Development Administration totaled \$7,756,000. This represents an increase of about 10 percent over the preceding year. This sum breaks down as follows. Operational costs (salaries, wages, materials, services, travel, and overhead) were \$6,744,000. Of this, \$2,824,000 went toward experimental and theoretical high energy physics, \$3,000,000 for intermediate energy nuclear physics, and \$920,000 for nuclear structure theory and heavy ion experiments. Equipment costs totaled \$932,000. Of this, \$278,000 was for high energy physics and \$654,000 for medium energy and heavy ion physics. \$80,000 was expended for general plant projects associated with the Linear Accelerator.

MARTIN DEUTSCH

Law-Related Studies

Much has been done over the last four years to forward the role of law-related studies at M.I.T. The Institute has achieved the teaching capability, reflected in more than 30 law-centered subjects, of educating our students about the impact law has on their professions and their lives. This capability reaches the graduate and the undergraduate, the engineer, architect, planner, manager, economist, and entrants into other professional fields. Enrollment in law-centered subjects has grown from 115 seven years ago to more than 750 during 1975-76.

Participation in off-campus fieldwork and on-campus UROP work has grown, as have the counseling needs of students interested in a law career or just learning more about law. These needs were facilitated by the establishment in 1972 of the Office of Preprofessional Advising and Education and the simultaneous creation of the Prelaw Advisory Council.

Institute researchers have made excellent contributions to the understanding of technology and law in specific areas -- ocean resources policy and management, environmental protection, occupational health and safety, Federal regulation of communications, transportation,

and other applied fields. However, there is not yet a substantial amount of law-related research projects or talent flowing into these areas. Without this, there has been no consolidation of our capability into an identifiable, viable institutional structure. It has been demonstrated that no other university in the country is in a better position to provide the nation with a unique capability to combine legal, engineering, economic, political, and managerial capabilities in a given research project.

M.I.T. has the inherent potential to train engineers and scientists to become lawyers, and therefore to widen the national base for sensible management and regulation of technology. Three and a half years ago, Professor Nyhart outlined several steps for implementing a successful law-related studies program at M.I.T.* Their achievement over the next four to five years would put the Institute in a position to consider a number of options, ranging from continuation of a decentralized program to establishment of a law school. We are behind on that time line, yet we have taken steps toward achieving a solid law-related studies program.

On the teaching side for the fall agenda is the writing and advocacy of a proposal for a humanities concentration in law, an idea which receives increasing inquiries from students. A means by which faculty can share research and fieldwork counseling with UROP must be established. A review of our prelaw advising structure is in order, to assess the impact of the reduced interest in the law school option.

It is necessary to continue developing mechanisms by which those faculty and staff involved in law-related subjects can share in the tasks of supervising and counseling students in a "law and..." field at M.I.T., or who are considering law as their professional field.

RESEARCH

An enduring program in law at M.I.T., whether focused on regulation of technology or on more broadly defined law-related studies, must be firmly grounded in research. During 1975-76, the Coordinator's efforts were concentrated in two areas pertinent to this observation: creation of a law preserve within the Energy Laboratory, and widening the awareness in government agencies of M.I.T.'s capability in research in which law is a component.

Legal Capability in Energy Research

In spring, 1975, the efforts of the Law-Related Studies program were directed toward integrating law studies into the work of the Energy Laboratory. A year later, these efforts were reflected in several ongoing projects. Professor Mason Willrich, of the University of Virginia Law School, was enlisted as a consultant to the Energy Laboratory to help guide this effort. At roughly the same time, the Coordinator established a relationship with the Office of General Counsel of the Energy Research and Development Agency (ERDA). ERDA's general counsel recognized the significance of our effort in technology and law and said that he would like to find ways for ERDA to assist us. One major outcome was a study this summer on radiation waste. Professor Willrich, as a Visiting Professor of Nuclear Engineering, acted as Principal Investigator. Funded by ERDA at \$55,000, Professor Willrich was assisted by an M.I.T. graduate student in Nuclear Engineering, a 1976 M.I.T. graduate

* J.D. Nyhart, "Law-Related Studies at M.I.T.: A Study," January 1974 (mimeo).

with an S. B. in Physics, who will be at the University of Virginia Law School next year, and two University of Virginia law students.

Another result of Professor Willrich's efforts is an Energy Laboratory proposal to ERDA in which Sloan School Professor Thomas J. Allen and Ben Ball would study the institutionalization of relationships between industry and ERDA. In the fall, Professor Willrich will begin a two-year term as Director of the new Division of International Affairs of the Rockefeller Foundation.

The Energy Laboratory's interest in commercialization of energy alternatives has evolved two more law-related projects. Professors Nyhart and Ted Greenwood of the Department of Political Science drafted a section on legal and political implications for an issue paper on commercialization, prepared by Sloan School Professor Henry Jacoby and Dr. Lawrence Linden of the Energy Laboratory.

Dr. Linden and Professor Nyhart are co-Principal Investigators on an Energy Laboratory project to examine regulatory impacts on ERDA's commercialization program. Presently funded for \$75,000 through November 1976, the whole proposal has been accepted in principle by the Office of Commercialization at ERDA. In addition to examining the regulatory frameworks surrounding individual energy alternatives such as oil shale and high BTU coal gasification, the project provides a better understanding of the generic processes of regulating new technologies and resources.

The Office of General Counsel and Professor Nyhart have discussed the possibility of M. I. T. undergraduates serving as interns at ERDA. Plans for one graduating student to work there progressed quite well, then collapsed when his starting time was delayed until mid-summer because of administrative snarls within ERDA. In the meantime he joined Professor Willrich's team.

Outside Contacts

In addition to the ERDA contacts already mentioned, Dr. Thomas Jones and Professor Nyhart called on the Special Consultant to the Administrator and the Assistant Administrator for Conservation at ERDA as well as staff in its Office of University Relations. They also met with the Deputy Under-Secretary for Labor; the Director of the National Science Foundation; Congressman Charles Mosher, Ranking Minority Member of the House Committee on Science and Technology; senior staff in Ocean and Coastal Resources at the Congressional Reference Service, Library of Congress; and staff at the Administrative Conference of the United States.

In addition, the Chairman of the Consumer Products Safety Commission and the Assistant Secretary for International Affairs, Department of Transportation, and lawyers in that Department's Office of General Counsel were contacted. Professor Nyhart met with staff in the Department of Commerce/National Bureau of Standards' Experimental Technology Incentives Program; the Coast Guard; and the Administrator and staff of the National Oceanographic and Atmospheric Administration, as well as personnel in its Office of Sea Grant. Meetings were held with the NSF staff in the Law and Social Sciences, RANN, and Energy programs; and senior personnel of the National Assembly of Engineering Marine Board, National Advisory Committee on Oceans and Atmosphere. On Capitol Hill, those contacted included Congressman Thornton, a member of the Committee on Science and Technology; staff Minority Counsel on that committee; staff of the Office of Technology Assessment; and staff of the National Oceans Policy Study.

Contacts were maintained during the year with the Hazen Foundation in New Haven, the Union Pacific Foundation in New York, and the American Bar Foundation in Chicago.

A somewhat different but complementary activity was involvement with the American Bar Association/American Association for the Advancement of Science conference on Law, Science and Technology. The conference comprises the efforts of these institutions to bridge the two worlds with which M.I.T.'s law-related research is primarily concerned. Professor Nyhart attended a conference on Legal and Scientific Uncertainties of Weather Modification at Duke University in the spring, and participated at the conference's request in its spring planning meeting.

Though their direct returns to our law-related studies effort are spasmodic, these efforts are necessary and useful. There is now a recognition of our interest and capability in a wide range of government agencies.

Nature of Law-Related Research

As a third part of the effort to build research capability last year, a formal examination into the nature of the law-related research at M.I.T. was undertaken. Though the inquiry is not yet completed, some observations seem worth noting here. Most of our work deals with regulation of technology or technology related matters. The regulatory management of existing technologies -- whether of economic, health and safety, environmental, or other regulation -- requires continuing re-evaluation. Dr. Nicholas Ashford's study of decision making in regulation of chemicals, Professor Ithiel deSola Pool's study of communications regulation under the FCC, and Professor Joseph Vittek's and the Center for Transportation Studies' inquiry into railroad line abandonment serve as examples.

There are usually legal reactions to technologically induced changes in our society. Every significant technological innovation inevitably triggers a legal response, as do many small, but cumulative, changes. As society sets goals for managing the problem, law may be both an obstacle and an aid in their achievement. What it should be becomes critical. Thus a newly-established regulatory area may be the focal point, as illustrated by Dr. Ashford's recently published study on occupational safety and health, Crisis in the Workplace: Occupational Disease and Injury, or Professor Nyhart's study of Federal regulation of offshore structures.

Increasingly, legal reactions are being anticipated simultaneously with the development of new technology. As that new technology comes into use, its successful introduction is in part dependent upon an understanding of the existing legal environment which surrounds it. Several M.I.T. studies conducted in the oceans policy and law area provide illustrations. These include Professor Michael Baram's study of artificial islands for energy facilities, part of Professor Judith Kildow's study of an economic evaluation of deep seabed mining, and Professor Nyhart's complementary study of an engineering cost model of deep seabed mining.

Finally, technology and scientific information play a significant but frequently overlooked role in the implementation of regulation. The use of technology in standard setting, monitoring, and enforcement often sets the effective parameters of a regulatory regime. One example was Professor Nyhart's proposed inquiry into the new technologies or applications which might be required for offshore regulation when the US implements extension of its ocean jurisdiction.

A considerable amount of research not primarily related to technology was also conducted. A study focused on regulation was Professor Martha Weinberg's *Managing the State*, and Professor Jeffrey Pressman's study, *Implementation*, concerned a related governmental process. Research also has been done on segments of the legal institutional structure, bringing to bear analytic skills from outside the legal profession. Professors Leonard and

Suzann Buckle's studies, *Bargaining for Justice: Case Disposition and Reform in the Criminal Courts*, and *Standards for Planning for Juvenile Justice*, and Professor Richard Larson's early study on the criminal justice system offer illustration.

In sum, most law-related research last year was oriented toward the law of technology, at different stages of its service to society. The regulatory processes play a focal role because it is primarily in that part of our legal institutional structure that technology is dealt with in sufficient detail to require technically oriented input as part of useful analysis.

TEACHING

Last year, 32 law-centered courses were taught in nine departments. Enrollment in these subjects numbered 795. Comparable figures for two, four, and six years ago are:

	<u>Courses</u>	<u>Departments Involved</u>	<u>Students Enrolled</u>
1975-76	32	9	795
1973-74	22	10	295
1971-72	14	9	213
1969-70	11	7	156

These figures reflect the progress made in recent years toward the goal of providing sound, well-taught subjects for M.I.T. students, both graduate and undergraduate, who wish to gain an understanding of how the law relates to their chosen field. Three introductory law courses were designed to provide an understanding of the nature and functions of law as it relates to the professionals M.I.T. trains. One such course was primarily oriented toward management and social science (15.616), one basically used planning materials (11.251), and a new two-semester sequence was introduced for undergraduate engineers, *Introduction to Technology and Law, I and II*. Taught by Professors Nyhart and Joseph Vittek and Dr. Ashford, this latter effort is one outcome of a study done two years ago on the prospects for a special course in law and technology for undergraduate engineers.

In addition, law subjects in the areas of construction, information, planning, ocean resources, management, environment, international regulation, and criminal justice planning provided for more detailed examination of these fields. Subjects also were given pertaining to the legislative process, the judicial process, and constitutional and labor law.

Fieldwork

Fieldwork was seen four years ago as a valuable part of the law-related studies effort. It provides experiential learning and introduces students to law as practiced, not professed. Last year was the fourth for the Undergraduate Legal Studies Program (U. L. S. P.) During the summer, this program, run by students, placed M.I.T. and Wellesley students in state agencies and research projects connected with the law. In summer, 1975, the Union Pacific Foundation was a generous supporter of this program, along with UROP and the President's Fund.

During term time, an estimated 65 students worked in off-campus agencies. Approximately 35 percent of these were UROP projects. Twenty-five percent evolved through the Seminar/

Internship in State and Local Politics, initiated last year by Professors Weinberg and Alan Altshuler (17.26J, 11.197J).

Advising and Counseling

The final category of the Coordinator's work is providing advice and counseling to students concerned with law or law-related alternatives. Last year, 16 M.I.T. students went on to law school, a markedly lower number than in recent years. Several factors probably are related. The number of students applying to law schools nationally has leveled off, in fact declined for a year or two. There has been widespread publicity about the abundance of young lawyers coming out of school onto the market. More M.I.T. graduates are working for a period after graduation, delaying law school matriculation. Schools of public administration, management, and planning may offer better alternatives to some.

Practically all the undergraduates considering law go through the services of the Office of Preprofessional Advising and Education of the Dean for Student Affairs. Assistant Dean Susan Houpt estimates that she saw 100 this past year. Professor Nyhart, as Chairman of the Prelaw Advisory Council, and the other members of the faculty, staff, and student body who serve on the Council, see a good number of students. This double-barreled system is a good one. Students are encouraged to seek out lawyers, political scientists, and others who represent interests in different areas of the law, and who come from different law schools or other professional backgrounds. Its structure and services must be re-examined in light of the reduced number of applicants.

Organization and Personnel

During 1975-76, steps were taken toward organizing an ad hoc committee of alumni and others from government, the judiciary, the bar, and industry who could provide advice and insight which might help to build M.I.T.'s capability in technology and law. Herbert Hansell, '46, (VI), a senior partner in a Cleveland, Ohio firm, agreed to chair this group. Two internal groups were established to assist the Coordinator: the Law-Related Studies Advisory Group, comprised largely of M.I.T. teachers and researchers in law; and a group of senior faculty, mostly with departmental or laboratory administrative responsibilities, established by Dr. Jones and Professor Nyhart to advise on forwarding research and education in technology and law.

Next year, Professor Judith Kildow, of the Department of Ocean Engineering and a member of the Advisory Group, will be on leave at the University of California at La Jolla. Professor Vittek will be Director of Research at Franklin Pierce Law Center, but he will still be teaching with Dr. Ashford and Professor Nyhart.

At the end of the year, the fieldwork effort suffered a loss when the appointment of Timothy Bird, Assistant for Fieldwork, was not renewed. Mr. Bird divided his energies between Professors Altshuler's and Weinberg's effort, Law-Related Studies, and the Laboratory for Architecture and Planning of the School of Architecture. He had for the last two years been funded from the President's Fund. His loss can be attributed to the period of financial stress through which M.I.T. is passing.

These frustrations and the seemingly slow progress on a good idea are counterbalanced by that idea's enduring value and prospect.

J. D. NYHART

Nuclear Reactor Laboratory (N.R.L.)

The Nuclear Reactor Laboratory was created as an interdepartmental laboratory on July 1, 1976. Facilities of the N. R. L. include the MITR, a five megawatt research reactor, a trained staff of approximately 25 operating and support personnel, and various facilities associated with the reactor. The MITR has operated safely and effectively as a nuclear radiation source since 1958. Prior to shutdown in May 1974, for extensive planned modifications and overhauling, the MITR has been used to produce extensive research results including nearly 1,000 theses, journal articles, and reports.

Direction of the N. R. L. is the responsibility of its first director, Professor Otto K. Harling, who recently has joined the M. I. T. staff. His broad experience in relevant research areas will enable a fuller exploitation of the MITR's research capabilities and a sounder fiscal posture for this important facility.

During 1975-76, the activities at the MITR were concentrated around modification and rebuilding. Substantial power levels and reasonably reliable reactor operation were not achieved until near the end of the academic year. The MITR user groups carried out their research at other facilities and began preparations for use of MITR when it was again available. By the end of fiscal year 1976, substantial neutron fluxes were provided at the beam tubes. This major use of the MITR was reinitiated by Professors Clifford Shull and Sow-Hsin Chen. Professor Shull obtained promising results using a new single crystal neutron interferometer. This interferometer, when completely operational, will have sufficient sensitivity to measure the influence of the earth's gravitational field on the optical paths of slow neutrons. Professors Chen and Sidney Yip's group is constructing a new spectrometer in support of their NSF sponsored program to investigate molecular forces and potentials. The construction of their new instrument is being rapidly expedited by the N. R. L. staff as the demands for their time due to the reactor modification decrease.

Several new projects and research areas are being pursued at N. R. L. These areas include an in-core coolant loop for studies of coolant systems in light water power reactors; radiation damage studies to obtain needed information related to the first wall of future fusion reactors; the sale of reactor core space for service irradiations in support of power reactor pressure vessel steel studies; and large-scale specialized isotope production.

OTTO K. HARLING

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 initially organized to encourage interactions between teaching and research in the Department of Electrical Engineering and Physics. Over the years, the Laboratory has sponsored projects involving participants

from as many as 12 academic departments. The research groups, which currently number about 30, conduct research in three areas: communication sciences, general physics, and plasma dynamics.

Research in R.L.E. is conducted primarily by academic faculty and students. Approximately 90 members of the faculty are affiliated with the Laboratory, working with about 280 graduate students and 150 undergraduates. Research in R.L.E. spans a broad spectrum of topics, thus providing opportunities for a wide variety of student thesis work. During the past year, research in the Laboratory provided the basis for 44 doctoral, 5 engineer's, 28 master's, and 39 bachelor's theses.

Major support for research is provided by the Joint Services Electronics Program of the Army, Navy, and Air Force, as well as other agencies of the Department of Defense, the Energy Research and Development Administration, the National Science Foundation (NSF), the National Institutes of Health, and the National Aeronautics and Space Administration.

GENERAL PHYSICS

The Laboratory's research in general physics is largely based on atomic and molecular phenomena. The experimental techniques required to observe basic properties of matter and to exploit them in engineering applications span most of the electromagnetic spectrum from radio wavelengths to X-rays. Various experiments include the use of extremely high frequency vibrational waves, liquid helium temperatures, and computers. A few of the research topics in this area are as follows.

Professor John G. King and his associates report progress in studying desorption of small molecules from biologically interesting surfaces and will soon use the recently completed scanning desorption molecule microscope to study cells and tissue. In vitro studies of epithelia by molecule microscopy to study cells and tissue continue both at M.I.T. and at the Boston University Medical Center, and will be extended to non-volatiles by the volatile enzyme product technique developed by Dr. James C. Weaver. This group also has completed an apparatus for the production of small clusters of He_3 and He_4 (circa 50 atoms). The clusters have been observed and experimental and theoretical studies of these small quantum fluid systems are under way.

Professor Daniel Kleppner and Drs. Richard R. Freeman and Theodore W. Ducas have carried out studies involving highly excited atoms. The structure in a strong electric field has been experimentally mapped, revealing a rich pattern of levels never previously observed. High resolution infrared spectra have been observed which combine the absolute precision of CO_2 laser frequency reference with the flexibility of Stark tuning methods. Microwave spectra of the Rydberg states have been interpreted to yield a precise value for the ionic polarizability and the first experimental determination of an atomic quadrupole polarizability. Tunneling experiments have pointed to major discrepancies in long accepted tunneling theory. A variety of new techniques using highly excited atoms have been analyzed, including possible applications to plasma diagnostics, radiation detection for communications and astronomy, and to isotope separation by photoionization.

Professor David E. Pritchard and Dr. Jerome Apt have measured the velocity dependence of the collision process in which laser excited sodium atoms are changed from one fine structure level of their first excited level to the other (from $3p_{3/2}$ to $3p_{1/2}$). These measurements were performed using a technique based on the Doppler shift to select the velocity of the sodium atoms which was proposed over a year ago by Dr. William D. Phillips and

Professor Pritchard. Recent measurements of the velocity dependence of this process in Na-Ar collisions, made by Dr. Phillips using a crossed beams machine, have confirmed and extended the results obtained using the Doppler shift technique. These experiments represent a significant advance in the rapidly developing field of interactions among excited atoms.

Professor John D. Joannopoulos is continuing the development of a new theoretical method for the study of infinite non-periodic solids which allows, for the first time, an exact treatment of the lack of periodicity. The method is being used to study the electronic properties of amorphous solids, surfaces, and vacancies.

Professor Jin-Au Kong and his students have pursued a number of projects in electrodynamics, including: 1) geophysical subsurface probing and communication with dipole antennas, 2) microwave remote sensing of the earth, and 3) fiber optics and integrated optics. Seven journal articles, six meeting presentations, and several technical reports have been published in the past year.

Investigations of saturable absorber modelocking of lasers, conducted by Professor Hermann Haus and his students, yielded criteria for the achievement of such modelocking in a given laser configuration. The theoretical question of the stability of modelocked pulses has been resolved satisfactorily. Studies of surface acoustic wave grating resonators, which are being developed for filters at very high frequency, have pinpointed the main source of loss in these resonators. Ways to reduce this loss have been found.

The spectrum of resonance fluorescence induced by a monochromatic field in a two-level atom has been measured by Professor Shaoul Ezekiel and his students. A good agreement with theory was demonstrated. This fundamental measurement contributes greatly to the understanding of the interaction of radiation with matter.

Professor Ezekiel and his group also are developing a new laser inertial rotation sensor using a passive ring. The sensor is free from problems encountered in conventional laser gyroscopes and should find applications in precision navigation, measurement of earth wobble, and fundamental experiments in general relativity and atomic physics.

During the past year, Professor Alan H. Barrett, Dr. Philip C. Myers, and graduate students have continued their studies of microwave spectroscopy of the interstellar medium. Dark interstellar clouds, dark globules, infrared sources, and molecular clouds have been studied in transitions of formaldehyde, carbon monoxide, carbon monosulfide, methanol, ammonia, hydroxyl, hydrogen, and water, using telescopes at Haystack Observatory, the Goddard Institute for Space Studies in New York City, the National Radio Astronomy Observatory, Arecibo Observatory in Puerto Rico, the Max-Planck Institute in Bonn, West Germany, and the Itapetinga Observatory near São Paulo, Brazil. These studies yield information on the chemical, physical, and evolutionary properties of such clouds.

Among the specific projects have been: a comparative study of dust globules in millimeter wave spectral lines; observations at the Orion molecular cloud in six inversion transitions of ammonia; observations of the Rho Ophiuchi dark cloud in seven molecular transitions; and a survey of infrared sources for maser emission.

Professor Barrett, Dr. Myers, and their graduate students have continued their use of microwave radiometers to sense subsurface temperature anomalies in the human body. A pilot program at Faulkner Hospital uses these instruments in the study of the detection of tumors of the breast. Preliminary results indicate cancer detection rates greater than 70 percent, a figure comparable to those for X-ray and infrared methods.

Professor Bernard Burke and his group have continued the study of interstellar masers and quasars. The study of H₂O masers by means of VLBI (Very Long Baseline Interferometry) was marked by several achievements during the past year. By mapping 12 different maser complexes, a definitive picture of H₂O maser source complexes has been derived. Typically, each maser complex is a collection of bright spots, each having an apparent size of the order of an earth's orbit diameter (one astronomical unit), with the entire complex occupying a region of the order of one-tenth of a light year in size. The systems must be unstable, with lifetimes of the order of 300 to 1,000 years, and are probably associated with a very early epoch in the process of star formation. The work was done by a joint M.I.T.-Smithsonian Astrophysical Observatory-Naval Research Laboratory collaboration.

VLBI measurements of the polarization properties of OH maser sources by M.I.T. and the California Institute of Technology yielded the first definitive measurements of magnet fields in such sources. A clear Zeeman pattern established that the fields are a few milligauss, a weak field by terrestrial standards but representing enormous magnetic energies on a cosmic scale.

Measurements with the 300-foot telescope of the National Radio Astronomy Observatory of quasar-galaxy pairs yielded a fine hydrogen absorption line in one case, the galaxy NGC 3067. The absorption line is very narrow, and is seen against the quasar 4C32.33 which must, therefore, lie beyond the galaxy. This establishes with certainty that quasars are not local objects, and adds confidence to the assumption that the very large redshifts of quasars are cosmological.

Many normal galaxies have nuclei that are prominent radio sources, although they are weak compared to the more dramatic quasars and radio galaxies. In the course of study of normal galaxies, the nearby spiral M81 was observed over several years, and it was discovered that its nucleus is a time-varying radio source, sometimes changing its strength in a few days. This implies that the galactic nucleus of M81 is very small, and may be only a few light-days in size.

PLASMA DYNAMICS

A major goal of the plasma dynamics program is extension of the basic understanding of phenomena in ionized gases and in solids in relation to such problems as controlled fusion, space physics, and collective phenomena in solids. The research includes methods of producing highly ionized plasmas by electron beam injection, high-power lasers, microwaves, low-pressure arcs, and so forth. Plasma diagnostic techniques involve measurements in various portions of the electromagnetic spectrum (microwave, millimeter wave, infrared, optical).

Professors Bruno Coppi and Robert Taylor, Dr. Ronald R. Parker, and their associates have achieved record values for the combined particle density and energy confinement time of thermonuclear plasmas produced in the Alcator device.

The Alcator experiment has, in fact, made possible the investigation of new plasma regimes, which are of basic interest for an understanding of the physics of high temperature plasmas and at the same time represent important steps toward the goals of controlled thermonuclear research. The basic philosophy for this experiment is to create plasmas capable of carrying large currents and current densities, in order to produce conditions where plasma heating results either from (discrete) particle-particle collisions, at relatively high plasma densities,

or from collective effects (microinstabilities) at relatively low plasma densities. The Alcator experiments are a joint venture of R. L. E. and the National Magnet Laboratory.

The relevant thermonuclear regimes have been realized thanks to the experimentally attained possibility to vary the plasma density over two orders of magnitude.

At the lowest densities obtained, the plasma behavior is dominated by the effects of microinstabilities. One of these excites a wave (the so-called lower-hybrid) that leads to a sharp enhancement of the proton temperature. The importance of this is related to the fact that the injection of microwave at the same frequency is thought to excite the same type of wave and provide a means to enhance the plasma temperature. The process of ion heating is a wave-particle resonance process (Landau damping) for which Alcator has provided the first experimental evidence in a thermonuclear plasma.

In the opposite regime, characterized by relatively short particle mean free paths, the plasma behaves almost like a fluid. Therefore, it has been possible to achieve for the first time particle density values such that the thermal energy density and confinement time reach the limits predicted by the relatively simple theory of collisional fluid-like plasmas. The maximum peak density obtained is about $7 \times 10^{14} \text{ cm}^{-3}$ with a peak ion and electron temperature of about 1 keV and a confinement time of about 20 msec.

The Rector Confinement Device developed by the collaboration of Professors Coppi and Taylor, Frank Martin, and Dr. G. Bosia, has produced reliably toroidal plasma equilibrium with non-circular cross-section. For the first time, non-circular isobaric plasma surfaces have been measured by Thompson scattering experiments so that a detailed comparison with theoretical predictions has become possible.

During the past year, detailed ultraviolet and soft X-ray spectroscopic measurements were carried out by Professor George Bekefi and his group on the Versator I tokamak, a device which produces magnetically confined plasmas for fusion research. The purpose of these studies was to obtain a clear picture of plasma impurities and the effect of instabilities on the impurity level.

A second major undertaking by Professor Bekefi and his group is the construction of an extremely versatile, superclean machine (Versator II). This device will be in operation by the end of this calendar year, when a series of basic experiments using novel diagnostic techniques will be undertaken.

Professor Bekefi and his group also have achieved a breakthrough in the area of intense relativistic electron beams in which the relativistic electron beam was used in a magnetron configuration. Intense bursts of linearly polarized 10 cm long microwaves were observed at unprecedented power levels. Radiation of 1.7 GW was observed; the efficiency of converting electron beam energy into microwave energy was almost 35 percent.

We have achieved a better understanding of how plasmas may be heated with the use of high power microwave sources. This work is part of a continuing theoretical project of Professor Abraham Bers and his students concerning nonlinear wave interactions in plasmas. These results are of importance to the current quest for achieving controlled thermonuclear fusion as a new means for energy generation.

COMMUNICATION SCIENCES AND ENGINEERING

This research spans a broad range of topics pertinent to communication processes in man-made and living systems as well as interactions between them. Fundamental studies of signals and systems are coupled with various applications such as speech and picture transmission, seismic detection, and optical communication channels. A major portion of the effort is related to the life sciences. A combined program of research and training in communications bioengineering includes areas such as communications biophysics, neurophysiology, cognitive information processing, and speech communication. Much of this work concerns the sensory or perceptual mechanisms, and the related program in linguistics seeks to improve our understanding of languages, which form the basis for communication.

The cognitive information processing group, under the direction of Professor Murray Eden, has continued studying the ways in which humans process visual information and the development of automatic procedures and computational techniques for performing similar tasks.

Visiting Professor Goesta H. Granlund from Sweden has continued to develop a system for automated analysis of human chromosomes. The new approach implies that the system assembles the information about chromosomes from several cells at a time, thereby filtering out noise due to variations in slide preparations and artifacts. The system can thus give a precise description of the chromosome complement in terms of distribution function parameters, with the uncertainty of the parameters specified. The system also is adaptive with respect to the initial reference parameter set so that both recognition of normal chromosomes, in spite of the variation displayed among individuals, and identification of aberrant chromosomes are possible. The precise chromosome descriptors produced by the system can be used in search for chromosomal "fingerprints" of humans.

Professors Eden and Barry Blesser, together with Dr. Robert J. Shillman, have carried out psychophysical experiments in an attempt to discover how humans recognize handprinted letters. One goal of this work is to construct a machine capable of equaling human performance in the task of reading. In addition, a grammar of printed characters has been framed and is being tested with a variety of type fonts. The goal of this work is to construct a font-independent reading algorithm.

The group recently has implemented a number of its findings on a digital computer, and the results were highly satisfactory. On a difficult set of unconstrained handprinted characters, the computer's error rate was substantially lower than the average error rate exhibited by human subjects viewing the same letters.

Professor Jonathan Allen and his co-workers have extended the capability of a system for conversion of unrestricted text to speech. A new modular system framework has been implemented, and a phrase-level parser is now part of the system. Recently completed studies have led to a new pitch algorithm which determines the effects of modality and discourse, and the influence of syntax on word duration has been characterized further. Following revision of the system morph lexicon, improvements were made in the phonemic synthesis algorithm, which also was restructured for ease of modification.

Three special purpose digital processors were built for signal processing research and speech waveform generation.

The "electronic darkroom" project conducted for the Associated Press by Professor Donald E. Troxel and his students has developed into a fully operational system with a wide range of practical image processing capabilities useful in news picture distribution. Pictures are

automatically received into and transmitted from computer storage. At the same time, the editor can electronically enlarge, reduce, crop, combine, and enhance other pictures, as well as add captions.

Professor William F. Schreiber and his group have developed a digital facsimile system for high fidelity transmission of medical X-rays. Full-size films, ready to use, are produced by the receiver after transmission over a communication line or subsequent to computer processing.

Professors Alan V. Oppenheim and James H. McClellan and several graduate students have applied a number of new digital signal processing techniques to speech processing and seismic data processing. The speech processing work is directed specifically toward enhancement of degraded speech as experienced, for example, on a faulty communication channel. The seismic data processing has led to the development of a number of significant new techniques potentially useful for exploration seismology.

The neurophysiology group, under the direction of Professor Jerome Lettvin, has been working on: the mechanism of visual receptors and their interaction with pigment epithelium; threshold processes in peripheral nerve with particular attention to long-term changes following activity; normal and regenerated connections of the optic nerve in amphibia; an artificial larynx, now in use on patients in Buffalo; the substantia gelatinosa of spinal cord, with good records found for the first time in this structure; the mechanism of color vision; transmitters in the visual system; metabolism of retina; nodal mechanism in peripheral nerve; anatomically distinguishing electrogenic from non-electrogenic membrane; measuring the spherical aberrations of the human eye; and the nature of peripheral vision.

Active M.I.T. cooperation with the Massachusetts Eye and Ear Infirmary and Harvard Medical School continued in the research of the Eaton-Peabody Laboratory of Auditory Physiology. A new program with Dr. Nelson Y.S. Kiang as Principal Investigator involves a consortium of four institutions (M.I.T., Harvard Medical School, Massachusetts Eye and Ear Infirmary, and Massachusetts General Hospital) in research aimed at applying the basic physiological knowledge for clinical purposes in neurological and otological patients. Professors William T. Peake and Thomas F. Weiss, Dr. John J. Guinan, and their students are collaborating in both the basic and clinically motivated aspects of the program.

Research on the physiology, perception, and acoustics of speech is continuing under the direction of Professor Kenneth N. Stevens. Studies of the acoustic attributes of sentences have led to the specification of detailed rules for timing and other aspects of sentence production, and this research is leading to improved procedures for the machine generation of speech with good intelligibility and quality. Experiments on speech perception have resulted in new insights into the predisposition of the auditory system for processing the transient or types of sounds that characterize many of the events of speech. The role of sensory feedback in ongoing speech production is being examined through experiments in which interference is improved on feedback during ongoing speech production.

Research in linguistics has continued at the usual pace and as in past years has dealt with all areas of language. In his researches, Professor Noam A. Chomsky has been developing further the so-called "trace theory of movement rules," which stipulates that, when an element (specifically an NP) is moved by a transformation, it leaves behind a phonetically unactualized element (which may, however, have indirect phonetic consequences) that can be interpreted as a bound variable. Professor Chomsky and others have shown that such bound variables are strikingly similar to variables introduced in the interpretation of quantifiers and the analysis of focus. These investigations suggest that the logical form of a sentence can be captured only with the help of a logic -- such as the predicate calculus --

which makes use of variables. This result is of great importance for it opens up the possibility that empirical data can be brought to bear on the question of what is the appropriate logic for representing the information about the scope of logical elements (quantifiers, connectives, modal operators) and properties of anaphora. A further consequence of the trace theory of movement rules is that it appears to permit a unification of the theory of semantic interpretation. Whereas it was previously thought that grammatical relations (subject, object, etc.) would have to be read off the deep structure representation of a sentence, while the rest of the semantic information would have to be read off the surface structure, the trace theory of movement rules suggests that all semantically relevant information can be obtained from the surface structure alone. A third consequence of the trace theory is that it leads to the formulation of a uniform set of conditions on transformations as well as rules of semantic interpretation. For cases such as relativization, which appear to violate the postulated conditions, Professor Chomsky has proposed reformulations that overcome these violations. These theoretical proposals have resulted in a number of empirical investigations by students in the Department as well as by scholars both in the Department and elsewhere.

An important result of Professor Kenneth L. Hale's recent work has been his discovery that number agreement may be quite distinct from person agreement. In languages where number agreement is morphologically distinct from person agreement there is a corresponding syntactic distinction. Typically, number agreement applies early in the derivation of a sentence, while person agreement applies late. In fact, in the languages Professor Hale has been studying, no transformational rule has been shown to precede number agreement, which may, therefore, be a nontransformational process. If this should indeed be the case, then a whole series of syntactic arguments will have been reviewed because they were based on the putative transformational character of number agreement rules.

Professor Hale also has been actively investigating the educational potential of linguistics in communities that are seeking to define the role that their native language should play in elementary and secondary education. In connection with his work with community languages, Professor Hale has remarked that physical, chemical, and biological phenomena do not possess any particularly privileged status as regards the manner in which they illustrate the methods of science, and that much of value about these methods can be derived from investigation of one's language. Children can be taught to frame hypotheses of considerable sophistication about their own language, to test these hypotheses against newly gathered data, and to investigate the relationship between a proposed hypothesis and hypotheses previously emitted to handle other facts. Professor Hale has participated in the development of a number of educational games, puzzles, and other teaching devices that can be used in the classroom to introduce children to the scientific study of language.

Professor R. Paul Kiparsky's work has centered on phonological questions. In spring, 1976 he conducted an extensive phonological study of English versification. Its object was to test different theories of the linguistic nature and representation of stress currently being debated in the field. The work is now complete and will be reported in Linguistic Inquiry.

In collaboration with Professor Wayne O'Neil, Professor Kiparsky undertook an analysis of Old English phonology. This was stimulated by an earlier article by J. Keyser, which reached conclusions in some ways incompatible with the theory earlier proposed by Professor Kiparsky. Professors Kiparsky and O'Neil found a solution in many respects more elegant than Keyser's, which fits into the more restrictive framework indicated by recent research.

Professor David M. Perlmutter's work on the theory of Relational Grammar has been carried out in collaboration with P.M. Postal of IBM. It has now progressed to a point where Professor Perlmutter feels the need for new support. His application for an NSF grant was

accepted, enabling him to devote more of his time to this theory during the current year. An intriguing proposal resulting from this work is the possibility of replacing the well-known tree-like base structures of transformational grammar and the set of transformations which help to generate surface structures in a step-like procedure, by a single object which has the formal properties of a network in graph theory and from which the surface structure can be read off directly with the help of a set of language-specific rules.

Professor John R. Ross has continued to develop his ideas on non-discrete grammars. His major theory is that most, if not all, metalinguistic predicates are quantifiable. Similarly, Professor Ross believes that grammatical processes are differentiated with regard to the degree of their sensitivity to the presence of a given property. These two hierarchies interact to form what Professor Ross has called squishes.

In collaboration with William Cooper, Professor Ross has been exploring applications of notions of non-discrete grammar to the study of such set expressions as "here and there" (but not "there and here"), "bits and pieces" (but not "pieces and bits").

The reconstruction of the Indo-European accentual system has been a classical problem in linguistics for well over a century, but, in spite of efforts on the part of some of the best minds, the problem has resisted solution. Professors Kiparsky and Morris Halle have proposed a new approach to the old problem, and judging from the critical comments of specialists to whom they have presented their proposal it would seem that headway has been made. A preliminary report of the most important results has been submitted for publication.

HENRY J. ZIMMERMANN

Undergraduate Research Opportunities Program (UROP)

The Undergraduate Research Opportunities Program developed out of the tradition of undergraduate (particularly upperclassmen) access to Institute research activities through senior theses, project laboratories, and special problem subject numbers. UROP was created in 1969 to broaden this access to underclassmen, to include activities of all academic departments and many Institute offices, and to catalyze intellectual collaboration between faculty and undergraduates. As a vehicle for creating and promoting research opportunities for undergraduates, UROP strives to keep abreast of the overall research trends of the Institute. The program is designed to provide immediate response to faculty and student requests for change, expansion, or emphasis.

Participation in UROP has grown from the first 125 to the more than 2,000 students involved during 1975-76. During the past year, more than half of the faculty collaborated with undergraduate colleagues on topics ranging from music composition to land use planning, from windmill design to alloy preparation. UROP attracts students from every class, department, and background. The UROP experience includes all phases of research activity: acquiring basic laboratory skills, proposal writing, finance procurement, design of the experiment or research scheme, conduct of the experiment or inquiry, interpretation of its results, presentation, and rewards.

This year, UROP actively pursued collaborations with M.I.T. academic departments and programs to broaden the spectrum of departmental undergraduate opportunities. UROP

symposia were hosted by the Departments of Architecture, Physics, Nutrition and Food Science, and Chemistry. In addition, a capacity audience attended a UROP colloquium in I.A.P., and many people from outside M.I.T. attended a formal UROP-I.L.P.-Sigma Xi symposium on energy sources in March. The symposium was covered by the Christian Science Monitor, which was an unexpected extra after the extensive New York Times article on UROP by Gene Maeroff in January. These symposia, along with presentations at alumni functions and M.I.T. clubs, offer undergraduate researchers the chance to present their work and discuss their findings with faculty, other students, and outside professionals. A recent award to UROP from the Sloan Foundation enables undergraduates to present their work to other students via the fledgling campus cable TV system. Several alumni have volunteered to rehearse and critique the students as another educational facet of their research experience.

Most UROP students receive academic credit for their efforts, though UROP continued to award limited wages and materials and supplies support to a number of students. In 1975-76, there was a substantial increase in faculty willingness to expend contract monies in support of UROP student wages. In addition to general funds, monetary support for undergraduate research was provided by grants to UROP from: the Uniroyal Foundation; COMSAT, MITRE, and Draper Laboratories in memory of James McCormack; the Society of Sigma Xi, M.I.T.'s Class of 1970; the Clapp and Poliak Fund; and the MacGregor Fund. Besides awards to individual student researchers or teams, UROP worked closely with the Departments of Political Science and Urban Studies and Planning in support of student internships in Washington, D.C., and Massachusetts government agencies. UROP contributions also helped finance the Urban Legal Studies Program and the Summer Projects in Community Affairs Program.

Off-campus UROP, initiated in 1972 in response to student requests for opportunities outside the M.I.T. campus, offers research projects with approximately 110 organizations including industry, hospitals, government agencies, and museums. In 1975-76, approximately 350 students participated in the off-campus program, with heaviest concentrations of student interest in the computer technology and medically related areas. A continuing interest in the public policy sector also was apparent. During the past year site visits to students working on off-campus projects continued to afford the UROP office valuable insights into the nature of off-campus organizations as educational settings.

The maturity of the program is vividly demonstrated by the increasing sophistication of students' work and the routine expectation of many faculty for undergraduate research colleagues. The number of inquiries to M.I.T. by high school students desiring a research education has risen sharply. Consequently, the number of students scheduling a UROP project into their four-year plan as a complement to their formal classroom work is also on the rise.

This is an auspicious time for M.I.T. to consider seriously the merits and national purpose of a research based undergraduate science/technological education, and to evaluate M.I.T.'s unique position to undertake such an effort.

MARGARET MACVICAR

Vice President, Resource Development

Throughout 1975-76, the M.I.T. Leadership Campaign was the focus of activity for the Resource Development organization. Announced in April 1975, the Campaign goal is to increase the Institute's endowed and expendable funds by \$225 million over five years. At the end of June 1976, gifts and pledges to the Campaign totaled \$81.1 million, compared to the April 1975 nucleus fund total of \$43 million.

The effort of the past year was marked by: careful, thorough planning; a strong commitment of time and effort by M.I.T.'s senior officers; willing and sustained support by the M.I.T. Corporation, the Corporation Development Committee, and alumni and friends of M.I.T.; continued development effort abroad, especially in Europe and Japan; establishment of a regional organization of alumni to help in planning and solicitation efforts throughout the United States and abroad; further development of a strong research, writing, and monitoring staff at M.I.T.; continued strengthening of the Industrial Liaison Program and the M.I.T. Associates Program; progress in planned giving programs, such as trusts and estate arrangements; continued and increasing cooperation between the Alumni Association and the Resource Development organization; and a high level of devoted effort from every member of Resource Development.

The Council on Resources of the Institute continued as the senior administrative organization overseeing all development effort. Its membership was expanded to include M.I.T. Leadership Campaign Cochairman Paul F. Hellmuth, of the Boston law firm of Hale and Dorr, and Executive Vice President of the M.I.T. Alumni Association James Champy. Glenn P. Strehle replaced Joseph J. Snyder on the Council, when he succeeded Mr. Snyder as M.I.T. Treasurer in July 1975. Professor Irwin W. Sizer, Dean Emeritus of the Graduate School, assumed part-time responsibilities in Resource Development.

Among the senior members of the organization whose efforts deserve special mention are Professor Samuel A. Goldblith, Nelson C. Lees, Kenneth S. Brock, and Donald P. Severance.

Edgar M. Gemmell of Princeton, New Jersey, continued to render advice and assistance as Campaign consultant.

PRIVATE SUPPORT

Total private support of M.I.T. during the past year was \$24.1 million; this consisted of \$22.4 million in gifts, grants, and bequests, and \$1.7 million in other support through membership in corporate liaison programs described in detail below. This total is a five-year high, compared with \$21.7 million received in 1975, \$22.7 million in 1974, \$21.7 million in 1973, and \$22.1 million in 1972. The increased total for 1976 clearly reflects the impact of the M.I.T. Leadership Campaign.

Sources of gifts for the fiscal year 1976 were: alumni, \$5.9 million; non-alumni friends, \$2.9 million; corporations, corporate foundations, and trade associations, \$6.9 million;

foundations and charitable trusts, \$6.7 million; and others, \$49,000. Included in the totals for alumni and friends are gifts of \$310,000 made to the William Barton Rogers Pooled Income Fund which was inaugurated in fall, 1975. Total income for corporate liaison programs was \$1.7 million, an increase of 21 percent over the previous year.

Gifts were designated for the following purposes by donors of both expendable and endowed funds: unrestricted, \$4.1 million; departmental, \$7.3 million; faculty salaries, \$3.2 million; graduate scholarships and fellowships, \$1.0 million; undergraduate grants, awards, and loan funds, \$2.0 million; building construction funds, \$3.2 million; and other funds, \$1.6 million.

M. I. T. LEADERSHIP CAMPAIGN

Campaign Progress

At the end of the year, the M.I.T. Leadership Campaign total stood at \$81.1 million, representing an encouraging advance from the nucleus fund of \$43 million contributed between January 1, 1974, and the Campaign announcement date in April 1975.

Senior officers concentrated their fund-raising efforts on visits with key prospects -- individuals, foundations, and corporations -- and on activities involving the field volunteers. Progress toward the 1976 goal of 150 key visits to prospects is well under way.

Of the Campaign total of \$81.1 million, \$21.1 was raised toward the objective of \$100 million in new endowment; this includes funding for 14 of the 50 new endowed professorships which form half of the endowment goal. The 1974-75 Report covers the goals of the Campaign in detail.

Campaign Organization and Staffing

Chairman of the M.I.T. Corporation Howard W. Johnson and Mr. Hellmuth served as co-chairmen of the Campaign. (The detailed organization was described in the 1974-75 Report.) Oversight of the Campaign was provided by the Council on Resources of the Institute in conjunction with the Campaign Steering Committee (see below). General James B. Lampert '39, Vice President for Resource Development, was Campaign Director. Campaign plans were presented to the Corporation Development Committee at its annual meeting (see below) for review, and then to the Corporation, and were discussed and endorsed by both bodies.

Steering Committee

The Campaign Steering Committee met three times during the year, in conjunction with regular meetings of the Corporation, to review the progress of the Campaign and to discuss objectives and activities relating to it. Members of the Steering Committee, coordinated by Mr. Hellmuth, took responsibility for the solicitation of members of the Corporation. Great progress was achieved in this effort by the end of fiscal year 1976. The members of the Steering Committee are: Mr. Johnson and Mr. Hellmuth, cochairmen; Paul M. Cook, '47; Luis A. Ferre, '24; Cecil H. Green, '23; Robert C. Gunness, '34; Kenneth Jamieson, '31; Breene M. Kerr, '51; Paul V. Keyser, '29; Ralph Landau, '41; Carl M. Mueller, '41;

Clint W. Murchison, Jr., '44; William B. Murphy; D. Reid Weedon, Jr., '41; and John J. Wilson, '29. Staff support for the Committee is provided by Mr. Lees. We note with special regret the death of Marshall B. Dalton, '15, who brought unusual perception and experience to the Committee's efforts.

Special Solicitation Efforts

In conjunction with the overall Campaign, a number of special funding efforts in support of Campaign objectives were pursued through assigned staff support, often with special sponsoring committees and usually with the aid or leadership of one or more faculty members. Some of the projects included: a new athletic and special events center (\$6.8 million), with a sponsoring committee headed by Mr. Murchison; additional funding for the Harvard-M.I.T. Program in Health Sciences and Technology (\$10 million in endowment and \$2 million in operating funds), with a sponsoring committee headed by Charles F. Adams and George W. Thorn; additional funding for the Energy Laboratory (\$7.5 million in operating funds); the Vannevar Bush Professorship (\$1 million); the Charles Stark Draper Professorship of Aeronautics and Astronautics (\$1 million), with a sponsoring committee headed by Vice-Admiral (USN-Ret.) John T. Hayward; the Erwin H. Schell Professorship (\$1 million), with a sponsoring committee led by Professors Herbert F. Goodwin, '37, and Leo B. Moore, '37; and new funding for the M.I.T. Council for the Arts (\$1.2 million in operating funds), whose financial development committee is headed by Max Wasserman, '35.

CORPORATION DEVELOPMENT COMMITTEE

Members of the Corporation, many of whom also serve as the Development Committee, and other Committee members continue to provide leadership in all aspects of securing private support for the Institute. Each member has undertaken an assignment related to the Leadership Campaign, and serves on some other M.I.T. group that enhances his or her knowledge of the Institute. The 155 alumni members are an extraordinary resource with a high level of personal commitment.

The Committee's major formal activity was its annual meeting, held on campus on December 4, with approximately 90 members in attendance. Between meetings, the Committee continued to function informally, with most of its members working on specific assignments. The program at the annual meeting included a report on the financial state of the Institute, a description by each academic dean of the needs of his School, and opportunity for discussion and comment on the conduct and progress of the Campaign. The meeting concluded with a reception, dinner, a special historical slide presentation of M.I.T., and the first committee award for "distinguished service," presented to Mr. Dalton, who was the first Chairman of the Development Committee and was Chairman of the Committee for Financing Development which led the historic capital campaign of 1950. We were greatly saddened by Mr. Dalton's sudden death, only a few months later.

The Committee sincerely regrets the untimely death of another member, Carl W. Blanchard, '18, and of Honorary Members Samuel Berke, '15, and Joseph R. Mares, '24.

RESOURCE OPERATIONS

With the announcement of the Leadership Campaign, all Resource Operations activities were directed towards organizing volunteers, identifying prospective donors, and arranging

for solicitations. The effort was led by Mr. Brock, Director of Resource Operations, with the support of Mr. Severance, Director of the Volunteer Leadership Appeal.

District Officers

To give direct field support to volunteers, four District Officers and one District Director were appointed. Robert H. Bliss joined the staff on July 1, Kevin J. Kinsella on August 1, and Edith E. Nelson on December 15 -- to handle the Midwest, Far West, and New England, respectively. Alice Tripp helped to establish a new District Office on campus and organized an extensive training/indoctrination program for the officers.

James N. Phinney, formerly with the Alumni Association, became District Director for Metropolitan New York, and Institute Secretary Arnold H. Singal became District Officer for the Southeast.

By fall, 1975, these officers had begun to work with volunteers in their districts, and their organizations were in full operation by mid-spring.

Volunteer Organization

The 1974-75 Report listed members of the Leadership Committee, who direct the Campaign activity in their local communities. Six new members were added: Yaichi Ayukawa, '52 (Tokyo, Japan), Franklin M. Jarman, '53 (Nashville, Tennessee), Gilbert Mar, '52 (Taipei, Taiwan), Howard L. Richardson, '31 (New Britain, Connecticut), Harry Tecklenburg, Jr., '50 (Cincinnati, Ohio), and William D. Walther, '50 (Dayton, Ohio). The 32 committee members represent nearly all parts of the country where significant numbers of alumni reside.

As the year progressed, plans were designed to establish more formal volunteer organizations in areas with large alumni concentrations. Area chairmen are assisted by vice chairmen, who take responsibility for solicitor recruitment and follow-up with the aid of District Officers. Boston and New York began to organize in this fashion, and plans were developed for other areas.

Prospective Donors

In these early stages, the Campaign is focusing on larger donors, who are generally defined as those who have the capacity to contribute over \$10,000 during a five-year period. Meetings conducted by Leadership Chairmen and numerous personal reviews with volunteers by District Officers aided the initial research of the Development Office. At year end, the prospect list had reached 2,800. Since a substantially larger number of prospects is required to meet the Campaign goal, screening is a continuous process and responsibility for all volunteers and staff.

Activities

A fundamental tenet of the Campaign has been to match the solicitor and the prospective donor in terms of mutual interest, peer group, and personal acquaintance. Making these match-ups has occupied the greatest amount of the District Officers' time. By year end, about 250 solicitors had been enlisted to accept responsibility for 2,400 prospects, and had begun to make their calls.

In addition to making calls on selected prospects, the Chairman of the Corporation, President, and Chancellor participated in several meetings of business leadership, Campaign volunteers, and alumni in Akron, Boston, Chicago, Cleveland, Houston, Miami, New York City, Palm Beach, Rochester, San Francisco, Seattle, Tampa, and Washington.

In June, the first issue of "tlc" was published. This special bulletin for Campaign volunteers will be issued approximately every two months.

The report of the Department of Chemical Engineering describes the dedication and concurrent convocation to celebrate the opening of the new Ralph Landau Building. This magnificent facility, financed entirely by private funds, was dedicated on March 5, 1976, following the meeting of the M. I. T. Corporation. James T. King and Ms. Tripp assisted Mr. Brock in coordinating the event. Patricia A. Golding of Chemical Engineering and Joseph J. Martori of the Alumni Association were responsible for planning and supervising dedication activities, and many others contributed to the program's success.

RESOURCE PLANNING

Principal responsibility for Campaign planning and support functions was carried out by Mr. Lees who also took on overall administrative responsibility during the year for the Resource Development organization. Activities of several elements of the Resource Planning group are noted below.

Development Office

The Development Office, under the direction of Dr. Michael F. Luck, appointed Director in November 1975, continued its central mission of providing direct support to the senior officers of the Institute, particularly in the evaluation of prospects for the Leadership Campaign. It also provided support to development activities both for the Resource Development organization and for a variety of funding efforts being carried on by other offices at M. I. T. During the year, approximately 2,000 prospects were evaluated, and more than 200 visit profiles were prepared.

Donald B. Johnson was promoted to Associate Director from Assistant Director, with added responsibility for foundation relations, and Richard W. Keefe joined the staff as Assistant Director.

Proposals and Publications

Written materials for the Campaign were prepared during the year by the Proposals and Publications group, headed by Joseph G. Carr. The group has been involved with preparation of proposals for solicitation efforts by senior officers, various publications detailing the goals of the Campaign, and other materials related to the overall resource development objectives of the Institute. A number of basic Campaign statements were completed; others are in preparation. As anticipated, the number of proposals handled by the group increased significantly as the Campaign moved forward with the solicitation of major prospects.

Mr. Carr was promoted to Manager of Proposals and Publications in January, and directed the subsequent reorganization of the group. He was joined by Deborah J. Cohen, who was promoted to Associate Staff Writer in December; Patricia M. Maroni, Associate Staff Writer;

and Ellen N. Hoffman, Assistant Staff Writer. Ms. Maroni and Ms. Hoffman were formerly associated with the M.I.T. News Office. They joined the Proposals and Publications group in 1976 following the resignations of Joyce Bowden, Senior Staff Writer, and Michael K. Hubner, Assistant Staff Writer.

Resource/Alumni Data Systems

Major efforts of the R/ADS group under the direction of Manager Victor M. Maslov, included the development of a monthly Campaign summary report as well as a group of nine other reports showing the status of the Campaign by fund number, geographical area, and goal. A number of Alumni Fund analytical reports were modernized and reprogrammed, and the District Officers were provided with numerous geographical listings designed to serve their needs in the field. These efforts were supported by Robert F. Matson, Systems Analyst, and Merry C. Peterson, Analyst/Programmer.

Donor Relations

Approximately 2,000 acknowledgement and cultivation letters to donors from senior officers and others were drafted by Barbara V. Zeilenga. These emphasized personal responses to donors of \$500 and more, as well as a variety of stewardship letters reporting on the use of previous gifts and funds. Special arrangements continued to support a number of phone calls to donors by the President.

Campaign Room

In conjunction with many members of the Resource Development staff, Jurate J. Barnes continued and expanded the operation of the Central Prospect Control System. The system contained data on approximately 2,800 individuals, foundations, and corporations at the close of the year. Ms. Barnes also produced, in conjunction with R/ADS, a significantly larger number of regular and special reports in support of Campaign solicitation activities. She expanded her interaction with the District Officers, and provided an increasing number of statistical analyses of Campaign data for use by the Institute administration.

INDIVIDUAL GIVING

Individual giving for the year was \$8,720,522 in gifts, grants, and bequests from alumni and friends. Individual giving to M.I.T. is encouraged through the Institute's planned giving program, directed by Institute Estate Secretary D. Hugh Darden. The planned giving program seeks outright current gifts and gifts in trust, and encourages plans for bequests through individual programs of giving. During the year, an intensive promotion of the Institute's new life income plans program was carried forward with highly effective support from the Office of the Treasurer of the Corporation. Results of the planned giving program were as follows:

	<u>Donors</u>	<u>Dollars</u>
Outright gifts generated by program	24	\$194,105
Separately invested unitrust	4	203,297
William Barton Rogers Pooled Income Fund	16	310,204
Receipts from bequests, testamentary and other trust arrangements	<u>61</u>	<u>3,101,350</u>
Total	105	\$3,808,956

In summary, gifts generated by the planned giving program represented 43.7 percent of the total received by M.I.T. from individual donors.

During April, another in the series of mailings on planned giving was sent to more than 22,000 alumni in post-25th reunion classes. Response to this mailing, together with other program activities, brought the total number of known plans for future gifts to 1,022. Of this total, 176 involve trust arrangements in which funds have been irrevocably set aside for M.I.T. The aggregate of such funds held by the Institute, or by trustees for the Institute's ultimate benefit, is in excess of \$30 million at current values.

Excellent results were realized in promoting life income plans, especially in reunion classes. As a result of the new life income plans program many additional opportunities developed for Mr. Darden, assisted by Allan S. Bufferd, to provide support to M.I.T. Leadership Campaign District Officers, Resource Development and Alumni Association staff, and volunteer workers in developing or concluding various gift arrangements.

During the year, continuing attention was given to proposed changes in the Federal tax law which would have adversely affected charitable giving. The year also was marked by much activity in providing counsel on a wide variety of legal matters concerning Resource Development activities.

Mr. Bufferd, who has ably assisted Mr. Darden over the past two years, transferred to the Office of the Treasurer of the Corporation toward the end of the year to assume special responsibilities in the area of Institute pension plans.

FOUNDATION SUPPORT

Gifts and grants from foundations and charitable trusts during fiscal year 1976 amounted to \$6,704,455, a nine percent decrease from the 1975 total of \$7,368,105. In conjunction with the Leadership Campaign, a number of major proposals were submitted to foundations and discussions were continued with several large foundations on key projects.

Paul H. Burr relinquished his duties as Institute Secretary for Foundations at the end of the year. The responsibility for foundation matters was assumed by Mr. Johnson in the Development Office.

CORPORATE GIFT SUPPORT

The continued upturn in the economy last year helped to create a more favorable climate for solicitations of corporations. An increased number of major proposals was placed before leading corporations during the year, and prompt, favorable response was received from many of them.

C. Warren Smalzel assumed responsibility during the year for Energy Laboratory support, and several dozen visits were made to prospective donors throughout the country prior to Mr. Smalzel's retirement at the end of the year.

Corporate support, including memberships in the Industrial Liaison and Associates Programs, was \$8,602,568 compared with \$6,913,617 in 1975, and \$7,316,185 in 1974. This year's total reflects a 24 percent increase over 1975.

INDUSTRIAL LIAISON

Industrial Liaison Program

Support for the Industrial Liaison Program for 1976 was \$1,484,087, an increase of 15 percent over 1975's receipts of \$1,289,015. This is the second year that Industrial Liaison activities have been under the direction of Professor Goldblith. During the first year, particular attention was given to the Program's personnel and program objectives: increasing membership without concomitant increase in costs, furthering interaction with the intellectual life of the Institute, and improving the quality of service to member companies. The past year witnessed a marked increase in membership. This was due in large measure to the cooperation and activity of the senior officers, faculty, a number of alumni, and the Industrial Liaison Officers. The growth of the I. L. P. resulted not only in an increase in unrestricted income to the Institute but also provided the faculty with more interaction with industry and more research support.

Examples of greater participation in the intellectual life of M. I. T. include new symposia which have been videotaped by the Center for Advanced Engineering Study, close collaboration with the Sea Grant Program, and responsibility for an international symposium sponsored by Miles Laboratories, Inc., on "Impact of Recombinant Molecules on Science and Society." This timely symposium on a controversial subject attracted more than 400 scientists from all over the world.

During the past year, growth in membership occurred in American, European, and Japanese companies. Attempts to extend the Program into Mexico also have been initiated.

The faculty and administration have been most supportive of the Program. In looking ahead, one of the limiting factors to the growth of the I. L. P. is the limited amount of faculty time available for participation. Thus innovative and efficient means for utilizing faculty time must be realized. This was one of the main studies carried out during July and August 1976, by the Liaison Officers. Another study attempted to learn why companies have canceled membership and to learn ways of increasing services to member companies. The Liaison Officers also were responsible for gifts to the Leadership Campaign resulting from visits by I. L. P. member companies to M. I. T.

During January 1976, two successful one-week courses were presented in Zurich under the auspices of the Program. The courses covered "The Mighty Mini: A Close Look at Minicomputers/Microprocessors and Their Applications to Real World Problems," under the direction of Professor Hoo-Min D. Toong; and "Fermentation Technology," under Professor Daniel I. C. Wang's direction.

Institute Secretary

The improved economic climate of the past year provided a more favorable setting for solicitations of Industrial Liaison Program prospects and the results reflect this. Using the tested and proven procedure of encouraging campus visits by corporate representatives, 14 companies visited M. I. T. Five accepted membership, two declined, and seven decisions are pending. In addition, solicitations initiated in 1975-76 resulted in four new members in the past year.

Considerable effort was directed by Robert Hagopian toward utilizing the invaluable assistance of alumni both in identifying prospective companies and in making the initial solicitations. Of the nine new members noted above, four resulted directly from efforts by alumni. Increasing numbers of alumni view such activity as an attractive means of furthering the general objectives of the Leadership Campaign, and it is expected that this technique will receive intensified support in 1976-77.

M. I. T. ASSOCIATES PROGRAM

During the past year, many of the goals established in a planning process begun in 1974-75 by Director Jerome J. Schaufeld were realized. Mr. Schaufeld was ably supported by Assistant Directors David W. Dove and Thomas R. Henneberry. At year end the Program produced a level of revenue and number of participating companies that were unprecedented.

Receipts from the Program were \$204,000, an increase of 63 percent from the 1975 total of \$125,250. During the past year, 297 visitors from participating companies and from companies being solicited by the Program visited with 340 faculty members. From the solicitation effort, 12 firms joined the Associates Program. Total membership is now 42 companies. Faculty members who supported Program activities benefited from the revenue sharing plan that was initiated two years ago.

The Round Table luncheon sessions were continued during the past year. Response continues to be highly favorable, and plans are to continue this service. During the past year the Program sponsored the following sessions: "Industrial Marketing Strategy - How Many Dollars for Advertising?" with speaker Professor Gary L. Lilien; "International Marketing of Technology," with Professors Richard D. Robinson and William W. Seifert and Mr. Shing-Kwong Fung; and "Presidential Politics and the Economic Outlook," with Professor Robert E. Hall.

In summary, this year can best be characterized by the efforts to increase the base of company participation and the resulting revenue to the Institute. These Program endeavors were quite successful. During the next year, the Associates Program hopes to continue this basic strategy.

JAMES B. LAMPERT

Treasurer of the Corporation

Financial Statements

The need for simpler and more understandable reporting of college and university financial operations and financial condition is quickly apparent to anyone having an interest in this critically important area of an institution's activities. Only a few people can read the annual financial statements of a non-profit educational institution in a reasonable amount of time, and have confidence they really understand them. 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 by improving financial reports, and considerable progress has been made in recent years.

There are two major reasons why it is difficult for those knowledgeable in corporate accounting to understand university finances:

- 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."

M.I.T. has taken a major step in the past year, with the cooperation and help of its independent public accountants, Coopers & Lybrand, and the Chairman of the Auditing Committee of the Corporation, to revise its financial reporting to be more complete and comprehensive and, at the same time, to try to present the material in a simpler and more meaningful way.

The financial statements summarize the finances of the Institute during the fiscal year 1975-76, and at the close of the year on June 30, 1976. Figures shown for 1974-75 have been restated for comparative purposes with 1975-76 to conform to the new format and organization of the material.

Treasurer of the Corporation

Schedule A

The Statement of Revenues and Funds Used to Meet Expenses of Current Operations for the year ended June 30, 1976 with comparative totals for 1975, displays the expenses and the revenues or 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, 1976 with comparative totals for 1975, reports the year's investment income and other activity in that fund, and details the distributions to funds both in the general investments and in separately invested funds.

Schedule C

The Balance Sheet at June 30, 1976 with comparative totals at June 30, 1975, 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, 1976 with comparative totals for 1975, 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, 1976 with comparative totals for 1975, 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, 1976, summarizes the sources and uses of funds each year for the last decade.

Operations (Schedule A)

Total operating expenses in 1975-76 were \$269,250,000, an increase of 9 percent over the 1974-75 total of \$247,441,000. Total operating revenues and funds used to meet those expenses rose to \$262,757,000, an increase of 10 percent over the 1974-75 total of \$238,436,000. The additional need for unrestricted revenues and funds required to bring operations into balance was reduced from \$9,005,000 in 1974-75 to \$6,493,000 in 1975-76. This requirement in 1975-76 was met in part from current year revenues of \$1,220,000 from the Use of Facilities Allowances derived from sponsored research programs, \$457,000 from Patent Revenues, and \$2,216,000 from Unrestricted Gifts, Grants, and Bequests, including the Leadership Campaign, for a total of \$3,893,000. All amounts received in those categories were availed of except for \$310,000 of the Use of Facilities Allowances which was reserved for capital needs, primarily in the area of utility plant renewal and expansion of utility distribution lines, and a single, large bequest for general purposes which is being held for designation of use by the Executive Committee.

Another major source used to meet the remaining need for unrestricted funds was \$1,201,000 of Other Fund Balances which could be drawn upon to support specific activities. This amount included one-half of the 1975-76 investment income distributed to certain reserve funds, including the Research Reserve. The Institute was able to retain the other one-half of this income to add to these reserve funds to offset in part the effect of inflation.

The final resource used to balance operations for the year was \$1,399,000 of Funds Functioning as Endowment. While the total amount used in 1975-76 from the Use of Facilities Allowances, Patent Revenues, and Current Gifts, Grants, and Bequests of \$3,893,000 was approximately the same as the \$3,814,000 used from those same sources in 1974-75, the drawdown in 1975-76 of other fund balances and funds functioning as endowment was only about one-half of that which was necessary in 1974-75.

The substantial improvement in results in 1975-76 can be attributed to several significant factors. Budget reductions in operating expenses and other economies had taken effect and an attitude of general restraint prevailed, particularly in the support service areas of General and Administrative expenses, Plant, Libraries and Medical services. Research revenues increased by 11 percent in 1975-76, the first real growth in several years. Tuition and other related income was up by a substantial 15 percent, reflecting increases in tuition rates and fees, and in the number of students, both undergraduate and graduate. The Industrial Liaison Program grew at a rapid rate, and operations of the M.I.T. Press continued to show improvement.

An important part of the benefits program for the faculty, staff and employees of the Institute is the M.I.T. retirement plans. The plans are separately owned trusts provided from funds contributed by M.I.T. and, in some cases, the participants. Financial reports of the plans are distributed to the participants in the plans and to the M.I.T. Corporation. In fiscal 1976, actuarial

Treasurer of the Corporation

assumptions were revised in these plans to comply with the Cost Accounting Standards Board (CASB) and the Employee Retirement Income Security Act of 1974 (ERISA). The actuarial consultants have informed the Institute that at June 30, 1976 benefits earned have been fully funded in accordance with the actuarial assumptions of the plans, and there remains no unfunded past service liability. The retirement plans are for the benefit of the participants and are not a part of the financial assets of M.I.T.

Gifts

Gifts, grants and bequests in 1975-76 and in 1974-75 were as follows:

	1975-76	1974-75
Gifts for endowment	\$ 5,502,000	\$ 3,633,000
Gifts for buildings	3,196,000	4,703,000
Gifts for current and future use — invested	4,930,000	4,259,000
Other gifts for current use	4,900,000	4,187,000
Total gifts to funds	\$ 18,528,000	\$ 16,782,000
Grants-in aid	3,865,000	3,500,000
Total	\$ 22,393,000	\$ 20,282,000

The total of \$22,393,000 exceeded the results in each of the past five years. Because of the emphasis on increasing endowment in the M.I.T. Leadership Campaign, gifts for endowment reached the highest level in eight years. These gifts included both the initial and continuing funding for several endowed professorships, and substantial support for undergraduate scholarships.

Gifts for buildings included funding for the Ralph Landau Building for Chemical Engineering, the Sherman Fairchild Electrical Engineering and Electronics Complex, and a bequest from the estate of Ralph M. Parsons toward the funding of the Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics.

The gifts for current and future use — invested, included unrestricted gifts of \$2,690,000, of which \$1,220,000 were bequests. The largest of these bequests was \$652,000 received from the estate of William D. Coolidge. Gifts for future use include gifts to life income plans of \$514,000, of which \$310,000 was to the William Barton Rogers Pooled Income Fund, started in December of 1975. This Fund, and the other funds subject to life interests in income, provide for the income from these gifts to be paid to beneficiaries for life. When these income payments cease, the income and principal become available for the purposes of the Institute, which may be designated by the donor.

The gifts reported by the Alumni Fund totaled \$4,025,000, a new high, and are included in the various categories of gifts listed above as received. Grants-in-aid received during 1975-76 reached the highest level in the past five years and include private grants for support of designated sponsored research activities.

M.I.T. normally does not include in operating revenues and funds used to meet operating expenses the unrestricted gifts, grants and bequests received during the year. These resources are included in the unrestricted current fund revenues in the Statement of Changes in Financial Position (Schedule D-1) and, until recent years, were usually appropriated to the funds functioning as endowment to provide future investment income to the Institute. By following this policy, the Institute recognized the continuing need to add unrestricted gifts and bequests to the permanent resources of the Institute to assure its future growth and prosperity. In fiscal 1976, the unrestricted funds used to meet the expenses of current operations, including substantially all of the unrestricted gifts, grants and bequests received, are shown separately under the heading "Additional need for unrestricted revenues and funds" in Schedule A.

Funds

The book value of the funds was \$349,643,000 on June 30, 1976 as compared to \$344,907,000 on June 30, 1975.

	1975-76	1974-75
Endowment funds:		
For unrestricted purposes	\$ 75,365,000	\$ 76,351,000
For restricted purposes	127,355,000	121,754,000
Net realized gains from investments	38,472,000	41,143,000
Total endowment funds	\$241,192,000	\$239,248,000
Building and expendable funds	64,083,000	62,030,000
Other funds	44,368,000	43,629,000
Total funds	\$349,643,000	\$344,907,000

The increase of \$4,736,000 in funds resulted primarily from the \$5,601,000 increase in endowment funds for restricted purposes, particularly for endowed professorships and undergraduate scholarships.

Treasurer of the Corporation

There was a decline in cumulative net realized gains from investments as investment transactions resulted in more losses than gains relative to book values, although total market values increased during the year.

There was an increase in building and expendable funds for the first time in four years. This increase of \$2,053,000 resulted from the rising level of gifts, grants and bequests included in the M.I.T. Leadership Campaign combined with a reduction in the need to use unrestricted funds for operations and other Institute purposes.

The increase in other funds of \$739,000 resulted from an increase in student loan funds and funds subject to life interests in income. Both agency funds, held for affiliates, and the investment income for distribution to funds declined during the year.

Plant

The Ralph Landau Building for Chemical Engineering and the new undergraduate house on the West Campus were completed and occupied in 1975-76. Also, a substantial addition to the central chilled water system of the Institute was installed.

The funding of all major building construction commitments is now complete, with the new undergraduate house having been financed subsequent to June 30, 1976 through a \$6,300,000 bond issue of the Massachusetts Health and Educational Facilities Authority at an interest rate of 5.989 percent to be repaid over a thirty-year period. The sources of the repayments are to be rents and the investment income on an unrestricted fund which has been set aside for that purpose for the life of the bond issue. The financial statements at June 30, 1976 do not include the effect of this borrowing.

The book value of the educational plant was \$201,822,000 at June 30, 1976, up from \$197,513,000 on June 30, 1975.

Total mortgage indebtedness at June 30, 1976 was \$26,290,000 consisting of \$10,442,000 of Federal Government loans and \$15,848,000 of other loans.

Investments

The year-to-year change in the endowment and other investments is shown in the following table:³

	June 30, 1976		June 30, 1975	
	Book	Market	Book	Market
General investments				
Fixed income	\$144,237,000	\$125,847,000	\$146,272,000	\$125,961,000
Equities	114,164,000	212,041,000	107,968,000	189,384,000
Real estate				
For present or future use	13,439,000	13,439,000 ¹	12,777,000	12,777,000 ¹
Other real estate	29,258,000	30,997,000 ²	28,978,000	30,690,000 ²
Total	\$301,098,000	\$382,324,000	\$295,995,000	\$358,812,000
Separately invested	18,780,000	18,682,000	17,629,000	17,249,000
Total	\$319,878,000	\$401,006,000	\$313,624,000	\$376,061,000

¹ At cost

² At values determined by professional appraisers

³ This table excludes student notes receivable and due from Educational Plant Funds.

There was an increase of \$24,945,000 in the market value of the portfolio in 1975-76 caused by the higher market value of the common stocks and publicly traded bonds. This compares with an increase in 1974-75 of \$10,430,000.

During the year, portfolio transactions resulted in net realized losses relative to book values, primarily because of the sale of fixed income securities originally purchased during a period of lower interest rates and higher bond prices. The proceeds from these sales have been largely reinvested in other fixed income securities at higher coupon rates.

The total investment income received during the year was \$18,996,000 as compared with \$18,761,000 in 1974-75. After the deduction of administrative expenses, there remained \$18,532,000 of investment income for operating expenses and other purposes during 1975-76. M.I.T. makes available to operations and other Institute purposes only the income from dividends, interest and rents earned from investments, including internal advances. During both 1975-76 and 1974-75, the investment income distributed to funds exceeded the investment income actually earned, thus resulting in a drawdown of investment income for distribution to funds as shown in Schedule B. This drawdown was \$593,000 in 1975-76, and \$1,338,000 in 1974-75, including \$606,000 in 1974-75 to provide interest income on certain advances for internal purposes. The balance of investment income for distribution to funds was \$19,394,000 on June 30, 1976, and \$19,987,000 on June 30, 1975.

Treasurer of the Corporation

As stated above, M.I.T. allows only investment income to be distributed to funds. Net capital gains from investment transactions, and any appreciation in market values above cost are not spent, but continue to be invested to provide for future growth in investment income. By contrast, the total return spending formula applies a fixed percentage, often 5 percent, of an average of past market values to the needs of the operating budget. The use of a similar method by the Institute in recent years would have resulted in an increase in the amount available for distribution to funds. These additional resources, if spent, would have reduced the size of the investment portfolio available to produce income in the future. The Institute's policy of spending only earned income recognizes the vital need to maintain and increase the principal of the investment portfolio to assure the growth of investment income and assets in the future. The adverse effects of inflation on the need for income growth and on the market values of securities in recent years appear to support this policy. Although market gains are not included in investment income, the development of investment policies to maintain and increase market values over the long term is a primary concern of the investment management operation of the Institute.

General

The need for increased endowment and similar funds to strengthen the capital base of the Institute continues although the efforts of management resulted in a smaller deficit in 1975-76 over 1974-75. During the past year, the M.I.T. Leadership Campaign has increased the level of annual giving, and major commitments for future support have been received. Continued growth in this support is necessary if the financial resources are to keep pace with either the inflation in operating costs or the continued growth in real demand for the research and teaching services provided by the Institute.

M.I.T. succeeded in expending relatively little capital during the last few years of extreme financial pressure in relation to many other colleges and universities. Future results will depend upon continued success in controlling expenses and in the development of growing financial resources. The results during the past year support optimism that this will be achieved.

Respectfully submitted,
Stuart H. Cowen
Vice President for Financial Operations

Glenn P. Strehle
Treasurer

August 25, 1976

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Statement of Revenues and Funds Used to Meet Expenses of Current Operations
for the year ended June 30, 1976 with comparative totals for 1975
(in thousands of dollars)

	Schedule A			
	Unrestricted	Institute or Donor Restricted	Total 1976	Total 1975*
OPERATING EXPENSES:				
Instruction and unsponsored research	\$ 26,787	\$ 13,325	\$ 40,112	\$ 37,591
Sponsored research (Note A):				
Direct expenses:				
Departmental and interdepartmental	—	71,852	71,852	64,992
Lincoln Laboratory	—	81,737	81,737	72,922
Draper Laboratory	—	—	—	1,162
Research vacation expense	3,844	—	3,844	3,748
Research administration and general expenses	1,558	—	1,558	1,465
Total expenses directly attributable to instruction and research	32,189	166,914	199,103	181,880
Expenses jointly applicable to instruction and research:				
Libraries	3,154	122	3,276	3,089
Medical	3,376	14	3,390	3,186
Plant operations and maintenance	14,032	2,202	16,234	15,134
Administration	4,527	211	4,738	4,140
Fiscal, personnel and other Institute-wide services ...	8,871	495	9,366	8,708
General expenses	2,841	984	3,825	3,814
Other instruction and research support activities	1,232	103	1,335	1,862
Student services	4,243	1,762	6,005	5,230
Other expenses	2,679	—	2,679	2,085
Scholarships and fellowships:				
Undergraduate	581	4,001	4,582	3,906
Graduate	573	3,692	4,265	4,607
Dining and Housing	194	6,893	7,087	6,022
MIT Press	429	2,936	3,365	3,778
Total operating expenses (Schedule D)	<u>\$ 78,921</u>	<u>\$ 190,329</u>	<u>\$ 269,250</u>	<u>\$ 247,441</u>
REVENUES AND FUNDS USED:				
Tuition and other related income	\$ 34,473	—	\$ 34,473	\$ 29,950
Research revenues:				
Departmental and interdepartmental	21,201	\$ 71,852	93,053	85,083
Lincoln Laboratory	10,317	81,737	92,054	81,895
Draper Laboratory	—	—	—	1,314
Endowment income used for operations (Schedule B) ..	6,437	3,864	10,301	10,506
Gifts, investment income and other receipts for:				
Restricted purposes	—	15,406	15,406	13,476
Scholarships and fellowships	—	7,641	7,641	7,235
Dining and housing	—	6,893	6,893	5,844
M.I.T. Press	—	2,936	2,936	3,133
Total operating revenues and funds used	72,428	190,329	262,757	238,436
Additional need for unrestricted revenues and funds** .	6,493	—	6,493	9,005
Total revenues and funds used	<u>\$ 78,921</u>	<u>\$ 190,329</u>	<u>\$ 269,250</u>	<u>\$ 247,441</u>
**Additional need for unrestricted revenues and funds met from:				
Use of Facilities Allowances	\$ 1,220	—	\$ 1,220	\$ 1,351
Patent Revenues	457	—	457	431
Current gifts, grants, and bequests	2,216	—	2,216	2,032
Total additional current revenues	3,893	—	3,893	3,814
Other fund balances	1,201	—	1,201	2,581
Funds functioning as endowment	1,399	—	1,399	2,610
	<u>\$ 6,493</u>	<u>—</u>	<u>\$ 6,493</u>	<u>\$ 9,005</u>

The accompanying notes are an integral part of the financial statements.

*Reclassified for purposes of comparison.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
INVESTMENT INCOME FOR DISTRIBUTION TO FUNDS
for the year ended June 30, 1976
with comparative totals for 1975
(in thousands of dollars)

Schedule B

	<i>General Investments</i>	<i>Separately Invested Funds</i>	Total 1976	<i>Total 1975</i>
Investment income before distribution:				
Investment income for distribution to funds, balance beginning of year	\$ 19,987	—	\$ 19,987	\$ 21,325
Investment income, current year	<u>17,495</u>	<u>\$ 1,037</u>	<u>18,532</u>	<u>18,332</u>
Total before distribution	\$ 37,482	\$ 1,037	<u>38,519</u>	<u>39,657</u>
Distribution and Adjustment:				
Income distributed:				
From current year's earnings	\$ (17,495)	(1,037)	(18,532)	(18,332)
From prior years' earnings	<u>(593)</u>	<u>—</u>	<u>(593)</u>	<u>(732)</u>
*Total distribution to funds	(18,088)	(1,037)	(19,125)	(19,064)
Adjustment to provide interest income on certain advances for internal purposes	<u>—</u>	<u>—</u>	<u>—</u>	<u>(606)</u>
Total distribution and adjustment	<u>(18,088)</u>	<u>(1,037)</u>	<u>(19,125)</u>	<u>(19,670)</u>
Investment income for distribution to funds, balance end of year	<u>\$ 19,394</u>	<u>\$ —</u>	<u>\$ 19,394</u>	<u>\$ 19,987</u>
			(Schedule C)	(Schedule C)
*Total distribution to funds:				
Endowment funds:				
Used for operations (Schedule A)	\$ 10,270	\$ 31	\$ 10,301	\$ 10,506
Used for scholarships and fellowships	2,593	115	2,708	2,577
Used for other charges	5	—	5	964
Added to principal	9	68	77	89
Added to unexpended balances of endowment income	(133)	(33)	(166)	413
Transferred to other funds	<u>3,131</u>	<u>5</u>	<u>3,136</u>	<u>1,229</u>
	\$ 15,875	\$ 186	<u>16,061</u>	<u>15,778</u>
Other funds:				
Agency funds	31	—	31	43
Life income funds	18	290	308	318
Student loan funds	13	—	13	11
Building funds	315	—	315	273
Other expendable funds	<u>1,836</u>	<u>561</u>	<u>2,397</u>	<u>2,641</u>
Other funds	2,213	851	<u>3,064</u>	<u>3,286</u>
Total distribution to funds	<u>\$ 18,088</u>	<u>\$ 1,037</u>	<u>\$ 19,125</u>	<u>\$ 19,064</u>

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BALANCE SHEET

at June 30, 1976

with comparative totals at June 30, 1975

(in thousands of dollars)

Schedule C

	Current Operating Funds	Current Invested Funds	Student Loan Funds	Endowment and Similar Funds	Educational Plant Funds	Life Income and Agency Funds	Total 1976	Total* 1975
ASSETS								
Cash:								
Unrestricted	\$ 361	\$ —	\$ —	\$ —	\$ —	\$ —	\$ 361	\$ 399
Other	2,106	—	—	267	121	—	2,494	10,543
Accounts receivable	9,987	—	—	—	—	—	9,987	8,444
Students' notes receivable	—	—	21,666	—	—	—	21,666	19,215
Contracts in progress, principally U.S.								
Government	7,835	—	—	—	—	—	7,835	10,566
Deferred charges, inventories and other assets.	9,919	—	—	—	—	—	9,919	11,925
Investments, at cost (Notes B and C)	—	63,852	—	240,755	7,910	7,361	319,878	313,624
Receivables (payables) arising from								
investment transactions	—	—	—	614	—	—	614	686
Due from other M.I.T. funds	6,724	7,984	—	—	—	—	14,708	11,536
Land, buildings, and equipment, at cost	—	—	—	—	199,656	—	199,656	178,971
Construction in progress	—	—	—	—	2,046	—	2,046	17,101
Total assets	<u>\$36,932</u>	<u>\$71,836</u>	<u>\$21,666</u>	<u>\$241,636</u>	<u>\$209,733</u>	<u>\$7,361</u>	<u>\$589,164</u>	<u>\$583,010</u>
LIABILITIES AND FUND BALANCES								
Liabilities:								
Accounts payable and accruals	\$15,001	\$ —	\$ —	\$ —	\$ —	\$ —	\$ 15,001	\$ 15,151
Withholdings, deposits and other credits ...	6,228	—	—	—	—	—	6,228	5,629
Advances and unexpended grants for sponsored research:								
U.S. Government	5,101	—	—	—	—	—	5,101	11,822
Private sources	148	—	—	—	—	—	148	421
Due to other M.I.T. funds	—	6,724	267	—	7,717	—	14,708	11,536
Borrowings—Mortgage bonds and notes payable (Note F)								
—	—	—	3,786	444	26,290	—	30,520	30,122
Total liabilities	<u>\$26,478</u>	<u>\$ 6,724</u>	<u>\$ 4,053</u>	<u>\$ 444</u>	<u>\$ 34,007</u>	<u>—</u>	<u>\$ 71,706</u>	<u>\$ 74,681</u>
Fund Balances:								
Expendable:								
Unrestricted purposes	—	—	—	—	—	—	—	861
Restricted gifts and other receipts available								
for current expenses	10,454	—	—	—	—	—	10,454	10,743
Restricted purposes	—	41,204	—	—	—	—	41,204	39,826
Unexpended endowment income for restricted purposes								
—	—	4,514	—	—	—	—	4,514	4,680
Investment income for distribution to funds (Schedule B — Note D)								
—	—	19,394	—	—	—	—	19,394	19,987
Student loan funds (Note E)	—	—	17,613	—	—	—	17,613	16,472
Endowment and similar funds (Note C):								
Income for unrestricted purposes	—	—	—	75,365	—	—	75,365	76,351
Income for restricted purposes	—	—	—	127,355	—	—	127,355	121,754
Net realized gain from investments	—	—	—	38,472	—	—	38,472	41,143
Educational plant funds:								
Unexpended	—	—	—	—	7,911	—	7,911	5,920
Expended	—	—	—	—	167,815	—	167,815	163,422
Funds subject to life interests in income								
—	—	—	—	—	—	6,734	6,734	6,361
Agency funds	—	—	—	—	—	627	627	809
Total fund balances	<u>10,454</u>	<u>65,112</u>	<u>17,613</u>	<u>241,192</u>	<u>175,726</u>	<u>7,361</u>	<u>517,458</u>	<u>508,329</u>
Total liabilities and fund balances	<u>\$36,932</u>	<u>\$71,836</u>	<u>\$21,666</u>	<u>\$241,636</u>	<u>\$209,733</u>	<u>\$7,361</u>	<u>\$589,164</u>	<u>\$583,010</u>

*Reclassified for purposes of comparison.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CONDENSED STATEMENT OF CHANGES IN FINANCIAL POSITION
for the year ended June 30, 1976
with comparative totals for 1975
(in thousands of dollars)

Schedule D

	<i>Current Funds</i>		<i>Total Current Funds</i>	<i>Endowment, Plant, and Similar Funds</i>	Total 1976	<i>Total 1975</i>
	<i>Unrestricted</i>	<i>Institute or Donor Restricted</i>				
BALANCES, BEGINNING OF YEAR	\$ 861*	\$ 75,236	\$ 76,097	\$462,354	\$538,451	\$530,289
Current Year:						
Revenues, other additions, and borrowings	77,776	193,068	270,844	13,416	284,260	260,861
Operating expenses (Schedule A)	(78,921)	(190,329)	(269,250)	—	(269,250)	(247,441)
Other deductions and repayment of borrowings	—	(3,062)	(3,062)	(2,421)	(5,483)	(5,258)
Net increase (decrease) before appropriations	(1,145)	(323)	(1,468)	10,995	9,527	8,162
Appropriations among funds	284	653	937	(937)	—	—
NET INCREASE (DECREASE) FOR THE YEAR	<u>(861)</u>	<u>330</u>	<u>(531)</u>	<u>10,058</u>	<u>9,527</u>	<u>8,162</u>
BALANCES, END OF YEAR	<u>\$ —</u>	<u>\$ 75,566</u>	<u>\$ 75,566</u>	<u>\$472,412</u>	<u>\$547,978</u>	<u>\$538,451</u>

*Vannevar Bush bequest held for establishment of a professorship.

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, 1976
with comparative totals for 1975
(in thousands of dollars)

Schedule D-1

	<u>Current Funds</u>		<i>Total Current Funds</i>	<i>Student Loan Funds</i>
	<i>Unrestricted</i>	<i>Institute or Donor Restricted</i>		
BALANCES, BEGINNING OF YEAR	<u>\$ 861</u>	<u>\$ 75,236</u>	<u>\$ 76,097</u>	<u>\$ 18,964</u>
REVENUES, OTHER ADDITIONS AND BORROWINGS:				
Tuition and other related income	34,473	—	34,473	—
Research revenues	33,048	153,589	186,637	—
Fees, services and miscellaneous receipts	504	6,661	7,165	264
Investment income	6,608	11,257	17,865	13
Net realized gain or (loss) on investments	1	(1)	—	—
Student aid from foundations and agencies	—	5,315	5,315	1,173
Government support for construction	—	—	—	—
Dining and Housing	—	6,893	6,893	—
M.I.T. Press	—	2,936	2,936	—
Gifts, grants and bequests	2,690	6,415	9,105	207
Patent royalties received net of cost	452	3	455	—
Borrowings	—	—	—	2,430
Total revenues, other additions and borrowings	<u>77,776</u>	<u>193,068</u>	<u>270,844</u>	<u>4,087</u>
EXPENDITURES, OTHER DEDUCTIONS AND REPAYMENT OF BORROWINGS:				
Operating expenses (Schedule A)	78,921	190,329	269,250	—
Other deductions	—	3,062	3,062	57
Repayment of borrowings	—	—	—	1,137
Total expenditures, other deductions and repayment of borrowings	<u>78,921</u>	<u>193,391</u>	<u>272,312</u>	<u>1,194</u>
Net increase (decrease) before appropriations	<u>(1,145)</u>	<u>(323)</u>	<u>(1,468)</u>	<u>2,893</u>
APPROPRIATIONS AMONG FUNDS:				
Fund balances to unrestricted	789	(789)	—	—
Funds functioning as endowment to unrestricted (Schedule A)	1,399	—	1,399	—
Appropriations for buildings added to educational plant	(249)	(24)	(273)	—
Expendable funds used to support related expenses	—	1,448	1,448	(463)
Other appropriations	(1,655)	18	(1,637)	5
Total appropriations among funds	<u>284</u>	<u>653</u>	<u>937</u>	<u>(458)</u>
NET INCREASE (DECREASE) FOR THE YEAR	<u>(861)</u>	<u>330</u>	<u>(531)</u>	<u>2,435</u>
BALANCES, END OF YEAR	<u>\$ —</u>	<u>\$ 75,566</u>	<u>\$ 75,566</u>	<u>\$ 21,399</u>
 BALANCES, END OF YEAR INCLUDE:				
Fund balances	\$ —	\$ 75,566	\$ 75,566	\$ 17,613
Outstanding borrowings	—	—	—	3,786
Total	<u>\$ —</u>	<u>\$ 75,566</u>	<u>\$ 75,566</u>	<u>\$ 21,399</u>

*Reclassified for purposes of comparison.

Treasurer of the Corporation

<i>Endowment and Similar Funds</i>	<i>Educational Plant Funds</i>	<i>Life Income and Agency Funds</i>	Total 1976	<i>Total* 1975</i>
<u>\$239,986</u>	<u>\$196,234</u>	<u>\$ 7,170</u>	<u>\$538,451</u>	<u>\$530,289</u>
—	—	—	34,473	29,950
—	—	—	186,637	169,757
—	2,035	30	9,494	7,231
—	314	340	18,532	18,332
(2,663)	—	53	(2,610)	443
—	—	—	6,488	6,227
—	—	—	—	499
—	—	—	6,893	5,844
—	—	—	2,936	3,133
5,503	3,196	517	18,528	16,782
3	—	1	459	455
—	—	—	2,430	2,208
<u>2,843</u>	<u>5,545</u>	<u>941</u>	<u>284,260</u>	<u>260,861</u>
—	—	—	269,250	247,441
4	15	312	3,450	3,803
294	602	—	2,033	1,455
<u>298</u>	<u>617</u>	<u>312</u>	<u>274,733</u>	<u>252,699</u>
<u>2,545</u>	<u>4,928</u>	<u>629</u>	<u>9,527</u>	<u>8,162</u>
—	—	—	—	—
(1,399)	—	—	—	—
—	273	—	—	—
—	(978)	(7)	—	—
504	1,559	(431)	—	—
(895)	854	(438)	—	—
<u>1,650</u>	<u>5,782</u>	<u>191</u>	<u>9,527</u>	<u>8,162</u>
<u>\$241,636</u>	<u>\$202,016</u>	<u>\$ 7,361</u>	<u>\$547,978</u>	<u>\$538,451</u>
\$241,192	\$175,726	\$ 7,361	\$517,458	\$508,329
444	26,290	—	30,520	30,122
<u>\$241,636</u>	<u>\$202,016</u>	<u>\$ 7,361</u>	<u>\$547,978</u>	<u>\$538,451</u>

SUMMARY OF CHANGES IN INVESTED FUND BALANCES*
for the ten years ended June 30, 1976
(In thousands of dollars)

Schedule E

	1976	1975	1974
Fund balances at beginning of year	\$344,907	\$343,964	\$342,058
Sources of funds:			
Gifts and bequests (Note A)	\$ 18,528	\$ 16,782	\$ 19,475
Investment income (Note D)	18,532	18,332	19,099
Net gain or (loss) on sales or exchanges of investments ..	(2,610)	443	712
Royalties received net of related costs	459	455	953
Receipts from foundations and agencies for student aid	5,315	5,252	4,321
Appropriations from research contract allowances ..	1,830	1,465	1,426
Government construction grants	—	499	3,024
Government grant for student loans	1,173	975	946
Fees, services and other receipts	9,884	6,636	2,406
	\$ 53,111	\$ 50,839	\$ 52,362
Use of funds:			
Used to meet expenses of current operation:			
Endowment investment income (Note D)	\$ 10,301	\$ 10,506	9,681
Gifts, investment income and other receipts	21,503	18,602	17,357
Scholarship and fellowship awards for tuition and stipends	8,550	8,285	7,711
Additions to educational plant	3,729	5,867	10,129
Operating expenses recorded in direct expenses of the Office of Sponsored Programs	1,093	673	983
Other charges to funds not related to current operation	3,199	5,963	4,595
	48,375	49,896	50,456
Net increase in funds	4,736	943	1,906
Fund balances at end of year	349,643	344,907	343,964
Less gifts and other receipts available for current expenses	10,454	10,743	9,660
Total invested funds	\$339,189	\$334,164	\$334,304

*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)

<i>1973</i>	<i>1972</i>	<i>1971</i>	<i>1970</i>	<i>1969</i>	<i>1968</i>	<i>1967</i>
\$335,318	\$328,247	\$302,901	\$290,598	\$259,882	\$239,902	\$229,119
\$ 18,407	\$ 18,440	\$ 35,591	\$ 15,878	\$ 25,069	\$ 22,147	\$ 16,019
18,321	16,942	15,498	15,523	14,579	13,502	12,788
2,429	1,931	7,598	6,768	14,068	9,221	3,008
1,310	978	1,058	963	1,772	698	709
3,999	4,280	4,787	4,441	4,624	4,698	4,881
1,457	1,383	1,209	1,698	1,405	1,627	1,921
651	776	—	92	2,188	2,028	1,793
816	923	874	556	639	699	677
2,490	2,778	2,781	3,141	2,921	3,007	1,276
<u>\$ 49,880</u>	<u>\$ 48,431</u>	<u>\$ 69,396</u>	<u>\$ 49,060</u>	<u>\$ 67,265</u>	<u>\$ 57,627</u>	<u>\$ 43,072</u>
\$ 9,794	\$ 9,602	\$ 8,435	\$ 7,354	\$ 7,351	\$ 6,865	\$ 4,859
9,193	9,471	14,529	13,704	10,344	11,113	9,970
7,965	8,162	7,999	7,533	7,279	7,566	6,879
11,969	9,151	6,513	4,283	7,067	10,076	8,509
1,640	2,246	2,869	2,627	1,957	1,062	1,241
2,579	2,728	3,705	1,256	2,551	965	831
<u>43,140</u>	<u>41,360</u>	<u>44,050</u>	<u>36,757</u>	<u>36,549</u>	<u>37,647</u>	<u>32,289</u>
<u>6,740</u>	<u>7,071</u>	<u>25,346</u>	<u>12,303</u>	<u>30,716</u>	<u>19,980</u>	<u>10,783</u>
342,058	335,318	328,247	302,901	290,598	259,882	239,902
8,927	7,680	6,893	8,900	7,775	6,441	6,939
\$333,131	\$327,638	\$321,354	\$294,001	\$282,823	\$253,441	\$232,963

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 rate for the fiscal year ended June 30, 1976, which is subject to final negotiation after Government audit.

LAND, BUILDINGS, AND EQUIPMENT

Land, Buildings and Equipment, is 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 \$621,000 as well as \$7,096,000 of borrowings from current invested funds (at 5% and 6% interest) related to the temporary funding of certain buildings.

B. INVESTMENTS

Total market value of investments approximated \$401,006,000 and \$376,061,000 at June 30, 1976 and 1975 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. ENDOWMENT AND SIMILAR FUNDS

The Institute is reviewing the source of designation of its funds in order to classify the funds between Corporation Designated (quasi endowment) funds and Donor Designated (true endowment) funds. The Institute has accounted for the fund and the income thereon in accordance with the restrictions designated by the donor or by the Corporation. Preliminary results of the review indicate that a substantial portion of the endowment funds are in the nature of quasi endowment. A similar portion of the income for distribution to funds is in the nature of income applicable to quasi endowment funds upon distribution. The final results of the review will be set forth in the financial statements upon completion.

D. INVESTMENT INCOME FOR DISTRIBUTION TO FUNDS

At June 30, 1976, the Institute has reserved \$19,394,000 (captioned "Investment Income for Distribution to Funds") representing endowment fund income in excess of amounts distributed to funds in 1975 and prior years. This Reserve was reduced by \$593,000 and \$1,338,000 in 1976 and 1975 respectively (see Schedule B).

E. STUDENT LOAN FUNDS

National Direct Student Loan Funds of \$9,987,000 and \$8,814,000 at June 30, 1976 and 1975, respectively, are ultimately refundable to the United States Government.

F. BORROWINGS — MORTGAGE BONDS AND NOTES PAYABLE

Borrowings — Mortgage Bonds and Notes Payable consist of the following at June 30, 1976 and 1975:

M.I.T. Construction and Consolidation Bonds of 1968:	1976	1975
Series A, 3 ½ %, due 1976-2003	\$ 4,853,000	\$ 4,968,000
Series B, 3 ¾ %, due 1976-2015	3,696,000	3,736,000
Series C, 3%, due 1976-2018	1,590,000	1,610,000
	<u>\$10,139,000</u>	<u>\$10,314,000</u>
Dining facilities bonds, 3 ⅛ %, due 1976-1999	303,000	311,000
Mortgage notes payable, 5 ¼ %, due 1976-1978	282,000	385,000
Mortgage notes payable, 5 ¼ %, due 1976-1981	376,000	452,000
Residential facility lease purchase obligation (note G)	5,225,000**	5,310,000**
Mortgage notes payable, 5-6 ½ %, due 1976-2003	9,965,000	10,120,000
	<u>\$26,290,000*</u>	<u>\$26,892,000*</u>
Total related to educational plant	—	93,000
Notes payable, 6%, due 1976	395,000	547,000
Notes payable, 6%, due 1976-1978	49,000	98,000
Notes payable, non interest-bearing due 1977	<u>—</u>	<u>—</u>
Total related to investment real estate	\$ 444,000	\$ 738,000
Notes payable to bank, 6 ¾ %-7 ¼ % due 1976-77 for student loans	2,200,000	1,050,000
Notes payable to Student Loan Marketing Association, 9 ¾ %, due 1976	1,000,000	1,000,000
Notes payable to bank, 7 ¼ %, due 1976 for Faculty and Staff Educational Loan Fund	100,000	50,000
Notes payable to U.S. Government, 6 ⅛ %-8 ½ %, due 1976-1991, for student loans	486,000	392,000

*At June 30, 1976 the Institute had pledged securities with a market value of \$4,492,000 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.

G. COMMITMENTS

1. Subsequent to June 30, the Massachusetts Health and Educational Facilities Authority financed the retirement of advances previously made by the Institute in connection with the construction of the West Campus Housing residence facilities. Project costs of approximately \$6,125,000 have been met by an issue of Authority Bonds, Massachusetts Institute of Technology, Series C, of \$6,300,000 which are supported by a mortgage given by the Institute on the project land and facilities. These bonds mature serially through 2006 and bear interest at the rates of 5% to 7%.
2. 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 \$900,000 and are being charged to plant operations as incurred.
3. The Institute is committed under real estate leases to a gross annual payment of \$1,102,000 in 1977. Certain leases expiring in 1977 are subject to renewal or may be renewed.
4. The Institute is committed under a lease for certain computer equipment to a gross annual payment of \$922,000 in fiscal 1977, 1978, 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.

H. RETIREMENTS 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; prior service costs have been fully funded at June 30, 1976. Pension expense charged to operations was \$9,029,000 and \$7,453,000 in fiscal 1976 and 1975 respectively.

AUDITOR'S REPORT

TO THE AUDITING COMMITTEE OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY:

We have examined the following financial statements of the Massachusetts Institute of Technology:

Schedule A—Statement of Revenues and Funds Used to Meet Expenses of Current Operations for the Year Ended June 30, 1976 with Comparative Totals for 1975.

Schedule B—Investment Income for Distribution to Funds for the Year Ended June 30, 1976 with Comparative Totals for 1975.

Schedule C—Balance Sheet as of June 30, 1976 with Comparative Totals for 1975.

Schedule D—Condensed Statement of Changes in Financial Position for the Year Ended June 30, 1976 with Comparative Totals for 1975.

Schedule D-1—Statement of Changes in Financial Position for the Year Ended June 30, 1976 with Comparative Totals for 1975.

Schedule E—Summary of Changes in Invested Fund Balances for the Ten Years Ended June 30, 1976.

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 made a similar examination for the year ended June 30, 1975. Totals for 1975 have been reclassified to conform to the 1976 format and are presented for comparative purposes.

In our opinion, the aforementioned financial statements present fairly the financial position of the Massachusetts Institute of Technology at June 30, 1976, 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, 1976 in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

COOPERS & LYBRAND

Boston, Massachusetts, September 13, 1976

Secretary of the Institute

The Secretary of the Institute is responsible for the provision of support services to the Corporation, its officers, and 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 total of 90 members of the Corporation included 74 active members, 15 life members emeriti, and one member-elect due to assume office as a representative from recent classes at the October 1, 1976 annual meeting of the Corporation. During 1975-76, an active year for the Membership Committee, 22 individuals' membership status changed.

The Corporation lost through death on August 11, 1975 its eldest member, Alfred L. Loomis, at the age of 87, life member emeritus and former President of the Loomis Institute for Scientific Research, Inc., who had served for 44 years; on September 16, 1975 its life member emeritus, Uncas A. Whitaker '23, founder and Chairman of the Board, AMP Incorporated, who had served for 14 years; and on March 29, 1976 its life member, Marshall B. Dalton '15, Honorary Chairman of the Board, Arkwright-Boston Manufacturers Mutual Insurance Company. At the age of 83, Mr. Dalton was the senior active life member and had served for 39 years in the Institute's governing body and for more than 60 years in the committees and councils of M. I. T. and its Alumni Association.

At its annual meeting on October 3, 1975, the Corporation elected Joseph J. Snyder, Treasurer Emeritus, to life membership. At the same meeting, Dr. Shirley A. Jackson '68, Research Associate at the Fermi National Accelerator Laboratory, assumed office as a representative from recent classes.

In January 1976, The Honorable Edward F. Hennessey succeeded The Honorable G. Joseph Tauro as Chief Justice of the Supreme Judicial Court of the Commonwealth and thus became one of the three representatives of the Commonwealth in the Corporation. Also in January, Gregory C. Chisholm '73, Member of the Technical Staff of the Transportation Systems Center of the US Department of Transportation, resigned in order to enroll as a special graduate student in the Department of Mechanical Engineering. He was succeeded by David R. Wilson '73, Control Engineer at the Corning Glass Works, who was elected at the March 5, 1976 meeting to complete the balance of Mr. Chisholm's term to 1979 as a representative from recent classes.

As its May 28, 1976 meeting, the Corporation elected the following to life membership effective July 1, 1976: Paul M. Cook '47, Raychem Corporation; Dr. Ralph Landau '41, Chairman and Chief Executive Officer, Halcon International, Inc.; and Carl M. Mueller '41, Managing Partner, Loeb, Rhoades & Co.

At its May 28, 1976 meeting, the Corporation further elected the following to five-year terms, effective July 1, 1976: Ellis C. Littmann '33, President and Chairman of the Board,

Nixdorff-Krein Manufacturing Co.; William H. Mills '34, founder and President, Mills & Jones Construction Co.; Kenneth H. Olsen '50, founder and President, Digital Equipment Corporation; Howard L. Richardson '31, Consultant and Corporate Director; and Helen F. Whitaker, Trustee, The Health Sciences Fund. James A. Moody '75, student, Georgetown University Law Center, was elected a representative from recent classes, for five years, to assume office on October 1, 1976. In addition, our Corporation member, Edward O. Vetter '42, former Executive Vice President, Texas Instruments Incorporated and now Undersecretary of Commerce, assumed an additional ex-officio position in the Corporation by virtue of his election as the 1976-77 President of the Alumni Association. In that post he succeeded Mr. Richardson.

Messrs. Littmann, Mills, and Richardson were the first alumni nominees to be selected under a new nominating procedure of the National Selection Committee of the Alumni Association, of which D. Reid Weedon, Jr. served as chairman.

Four life members transferred to emeritus status successively at the October, December, March, and May meetings. They were: Cecil H. Green '23, Honorary Lecturer in the Department of Earth and Planetary Sciences, Co-founder, former President and now Honorary Director of Texas Instruments Incorporated, with 17 years of service; Donald F. Carpenter '22, former General Manager, Film Department, E.I. du Pont de Nemours & Company, Inc., with 32 years of service; William A. Coolidge, Corporate Director, with 28 years of service; and Dr. Julius A. Stratton '23, President Emeritus, with 25 years of service. Together, these retiring life members account for more than a century of service in the Institute's governing body.

Expiration of term membership has cost the Corporation the formal services of William S. Edgerly '49, President, State Street Boston Financial Corporation; and Pamela T. Whitman '70, of Radiation Monitoring Devices Incorporated. These retiring 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. For several years the Institute's representative has been Howard W. Johnson. During the past year, Dr. Johnson was elected President of the Board of the Museum of Fine Arts in another splendid tribute to his leadership and public service.

M. I. T. LEADERSHIP CAMPAIGN

At each successive meeting of the Corporation, the reported totals of gifts, grants, and pledges to the M.I.T. Leadership Campaign rose to nearly a doubling of the \$43 million nucleus fund originally reported at the April 22, 1975 public announcement of the \$225 million, five-year Campaign. By the May 28, 1976 meeting, nearly \$78 million -- or one-third of the total sought -- was in hand or pledged.

The pattern of positive responses from individuals, corporations, and foundations in the first public year of the Campaign was a source of great encouragement to the Campaign Steering Committee under the Co-chairmanship of Howard W. Johnson and Paul F. Hellmuth. Other members of the Campaign Steering Committee, in addition to Dr. Killian, President Wiesner, and Chancellor Gray, are: Paul M. Cook '47, Luis A. Ferre '24, Robert C. Guinness '34, Cecil H. Green '23, Kenneth Jamieson '31, Breene M. Kerr '51, Paul V. Keyser '29, Ralph Landau '41, Carl M. Mueller '41, Clint W. Murchison, Jr. '44, William B. Murphy,

D. Reid Weedon, Jr. '41, and John J. Wilson '29. During the year the Committee lost the devoted services of Marshall B. Dalton '15 and Uncas A. Whitaker '23.

The report by Vice President James B. Lampert, who heads 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 members of the Campaign Steering Committee, Corporation Development Committee, Alumni Fund Board, and as area chairmen. In addition, many members of the Corporation have headed or are heading National Sponsoring Committees for particular projects, and have made historic gifts of their own. For example, Mr. Murchison is chairman of the \$6 million drive for a new athletics and special events center. In record time, Mr. Cook raised \$1 million from Course X alumni to endow the Edwin R. Gilliland Professorship of Chemical Engineering. As this report is being written, Mr. and Mrs. Green have established three new Cecil and Ida Green Professorships, each fully endowed at \$1 million, bringing to six the number of endowed chairs they have contributed to M.I.T. 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. For the first time, former members of the Corporation were invited to join the annual meeting held in October, 1975; 14 former members participated. 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 fiscal 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, again served as secretary to the Committee on Shareholder Responsibility.

Additional thanks are due the Corporation Screening Committee, under the chairmanship of Pamela T. Whitman, 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, representatives from recent classes. The continuing decline of alumni participation in this special election has resulted in a study of possible Bylaw revisions to simplify the nominations procedure.

In notable actions, the Corporation approved the recommendation of the faculty for a reorganization in the School of Humanities and Social Science which resulted in the dissolution of the Department of Foreign Literatures and Linguistics, the merger of Linguistics with Philosophy as a new Department of Linguistics and Philosophy, and the establishment of a new Section in the Department of Humanities comprising Foreign Languages and Literatures. Also approved were the establishment of several new joint degree programs with Woods Hole Oceanographic Institute leading to new joint Engineer and Doctoral degrees in Chemical

Engineering, Civil Engineering, Mechanical Engineering, Materials Engineering, Metallurgical Engineering, and Electrical Engineering. A new S.M. in Neural and Endocrine Regulation also was approved as part of the establishment of a fifth graduate field of specialization in the Department of Nutrition and Food Science.

Two additional actions relating to real estate were noteworthy; the establishment of a new subcommittee of the Investment Committee on Real Estate, chaired by Carl M. Mueller, and the renewed authorization to proceed with borrowing and revenue bonds to finance the construction of an undergraduate residence on Memorial Drive adjacent to Tang Hall.

The Corporation also adopted a formal archival policy to clarify the responsibilities of faculty, staff, and officers of the Corporation for the preservation of historical materials, Dr. Stratton playing a leading role in formulating this policy.

CORPORATION JOINT ADVISORY COMMITTEE ON INSTITUTE-WIDE AFFAIRS (C.J.A.C.)

Under the chairmanship of Gregory Smith, C.J.A.C. completed its seventh year of operation. As in 1974-75, the Committee held six regular open sessions with various senior officers and the heads of administrative offices, plus a private meeting with the Ad Hoc Committee on International Institutional Commitments chaired by Professor C.P. Kindleberger. The year was mainly given over to searching for suitable agenda topics. Topics given special attention by C.J.A.C. included international institutional commitments, calendar reform to establish year-round operation, financial aid, student-related issues, and the purposes of C.J.A.C. Thanks are due a student subcommittee headed by Max Donath, Bonnie J. Buratti, Vice President Kenneth R. Wadleigh, Professor Charles P. Kindleberger, Chairman Howard W. Johnson, and Financial Aid Director Jack H. Frailey for their presentations to C.J.A.C. on these and related subjects. The writer wishes to acknowledge 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 able staff support of Robert D. Blake, until February 1976. He was then succeeded by Leena Kiirats, of the Alumni Association.

DEDICATIONS AND SPECIAL FUNCTIONS

The Corporation continued to carry prime responsibility for dedications of major facilities. Notable ceremonies this year included the dedication of the Ralph Landau Building for the Department of Chemical Engineering on March 5, 1976, in conjunction with a convocation commemorating the event. Several hundred alumni and friends of Chemical Engineering attended. J. Kenneth Jamieson, who had served as chairman of the National Sponsoring Committee for the Building, was the principal speaker. He was joined by Dr. Landau. John C. Haas served as chairman of the Chemical Engineering Convocation, and Maurice F. Granville and Dr. Landau were among the distinguished panelists who presented papers on the future of chemical engineering. Dr. Johnson presided at the dedication, and presented Dr. Landau with a bound copy of the Corporation Resolutions naming the building in his honor. In December 1975, "Transparent Horizon," a major contemporary work by noted sculptor Louise Nevelson, was dedicated in conjunction with the Ralph Landau Building.

Within this new facility a number of special named memorial rooms and facilities also were dedicated on March 5, 1976. These were the Edwin R. Gilliland Auditorium, gift of the Milliken Corporation; a new Warren K. Lewis Conference Room; a new William L. Walker Lounge; a School of Chemical Engineering Practice Lounge, gift of alumni of the Practice School; and the M. I. T. Fuels Research Laboratory, gift of the Pew Memorial Trust.

On October 30, 1975, the Center for Cancer Research took responsibility for the dedication of the Grover Higdon Laboratories in the Seeley G. Mudd Building. The new laboratories were made possible by a gift of the Fund for Higher Education (in Israel). In addition, Provost Walter A. Rosenblith represented the Institute on November 15, 1975, at the dedication of the McGraw-Hill Observatory at Kitt Peak, Arizona, a jointly owned and operated facility of Dartmouth College, University of Michigan, and M. I. T., made possible by gifts of McGraw-Hill Publishing Company and the Alfred P. Sloan Foundation. Additional special functions were held during the year to continue the periodic meetings with the Ida M. Green Fellows and Health Sciences Fellows; an evening on October 2, 1975, with Dr. Clark Kerr serving as Corporation dinner speaker, and an afternoon colloquium on October 3, 1975, honoring M. I. T. faculty members who hold named and endowed professorships. Institute Professors Manson Benedict, Philip Morrison, Walle J. H. Nauta, and Paul A. Samuelson were the colloquium speakers in Huntington Hall, Room 10-250, on October 3, 1975. Although these were not Corporation activities, it is appropriate to note that Drs. Johnson and Wiesner and members of the faculty played major roles in the 1976 annual meeting of the American Association for the Advancement of Science (AAAS) held in Boston, and in a Convocation held at M. I. T. as part of the Centennial Celebration of the invention of the telephone by Alexander Graham Bell. At the AAAS meeting, Dr. Johnson served as co-chairman, and some 50 M. I. T. faculty and staff members presented papers. The Telephone Convocation was organized by the Institute in cooperation with American Telephone and Telegraph Company. At that Convocation, the Postmaster General introduced a special commemorative stamp.

CORPORATION VISITING COMMITTEES

1975-76 was a busy and productive year for the Corporation Visiting Committees, with 18 meetings attended by more than 200 members, or about half of the total Visiting Committee membership. In early fall, the Visiting Committee Chairmen for the School of Engineering met with Dean Keil and his associates to discuss the outlook of the School of Engineering and the recent Task Force Report. The Visiting Committees for Mathematics and Economics met for the first time in several years.

The Corporation continued the Visiting Committee procedure involving the election of the Chairman of the Committees at the March meeting of the Corporation. This change promotes better academic-year scheduling of meetings by providing more working time in the spring to plan effectively for the fall. The results to date lend continuing strong support to this move; six Committees already have requested meetings for this coming fall, while several are actively planning for January and the winter months.

Several features of the meetings which have proved successful in the past were continued by the Committees this year. All of the meetings 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. The Student Affairs Visiting Committee dispersed its members to have dinner in several student residences. Also, the Committees made effective use of sessions with students, 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. One Visiting Committee devoted much of its agenda to the criteria which should be used as the basis for selecting a new department head.

An illustration of particularly timely and effective Visiting Committee experience was the scheduling of simultaneous meetings of the Foreign Literatures and Linguistics Visiting Committee, under the chairmanship of Gregory Smith, and the Philosophy Visiting Committee, under the chairmanship of Rebecca A. Donnellan. These two Committees met at M.I.T. on February 4 and 5, 1976, in nearby spaces, and also held plenary sessions to discuss departmental recommendations for a reorganization of the several academic disciplines and three departments involved. The availability and presence on campus of these two interested advocacy groups of Corporation advisors was of great assistance in facilitating the subsequent reorganization which will become effective July 1, 1976. As part of this change, the Foreign Literatures and Linguistics Visiting Committee was disbanded, and selected members are being transferred to the Humanities Visiting Committee or the Linguistics and Philosophy Visiting Committee.

Attendance by members of the Visiting Committees has been excellent this year, with an average of more than 12 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 enhances the interchange between the committee and the department, and often provides a welcome catalytic effect which contributes to the success of the meeting. Provost Walter A. Rosenblith deserves warm thanks for his energetic participation both in the meetings and in the selection of new Committee members. The more than 300 faculty members who participated in the sessions of the Visiting Committees also deserve credit.

The Corporation has received both oral and written reports from the chairmen of all 18 Committees meeting in the 1974-75 year. These reports 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. In keeping with prior year's discussions in the Corporation about the need for improved feedback to the Institute, 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.

In keeping with discussions held at the March 5, 1976 meeting of the Corporation, the frequency of certain Visiting Committees which have come to establish an annual pattern of meetings has been slowed somewhat. This change was introduced to maintain the quality of participation in meetings and to improve the formal reporting, and to hold to a more manageable schedule the total Visiting Committee activity during the period of intense off-campus activity of the senior officers in connection with the M.I.T. Leadership Campaign.

To conclude this report of the 1975-76 year, I wish to express appreciation to several individuals who were associated with the Office of the Secretary of the Institute. At mid-year, Robert D. Blake transferred to the staff of the Alumni Association after five years of round-the-clock service in this Office. He has made a lasting contribution to the Institute through his quiet competence in providing staff support to C.J.A.C. and the Corporation Visiting Committees. We wish him continued success in his new post. Under normal circumstances his departure would have been sorely felt. The elimination of his position, as part of the Institute's budget reduction, has opened a void which we are attempting to fill with part-time

volunteers. During the spring semester Leena Kiirats of the Alumni Association served as a volunteer Secretary of C. J. A. C. With Ms. Kiirats' departure from the Institute at year's end, Patricia M. Maroni of the Editorial Staff of the Resource Planning Office offered her services as Secretary of C. J. A. C. during 1976-77. These generous acts on the part of full-time M. I. T. staff members give this Office a timely lift and a heightened sense of determination to handle its recurring schedule of meetings and activities relating to the governance of the Institute. We are deeply grateful to Ms. Kiirats and Ms. Maroni. Our search for volunteer assistance with Visiting Committee arrangements continues.

Finally, in this period of reduced support services throughout M. I. T., I wish to thank Carolyn B. Cox, Director of the Registry of Guests since 1963, longtime M. I. T. standard bearer and cherished friend, for her brilliant support of the May 28 Commencement Exercises. The smooth operation of our Commencements have in no small way been due to her dedicated service as Executive Secretary of the Commencement Committee. She gave her whole self to the orchestration of M. I. T. Commencements over the years, and she gave permanent joy to all who had the privilege of working with her.

V. A. FULMER

Alumni Association

1976-77 was a year of considerable change for the Alumni Association. James A. Champy, '63, completed his first full year as the Association's Executive Vice President and Publisher of Technology Review. Major effort was devoted to the establishment of a new staff organization, described below. The new organizational format, which required several staff changes, is able to support the activities of M.I.T. alumni with increased scope and vitality.

Besides the major activities of the Alumni Fund and M.I.T. clubs, the Association directed substantial attention to regional conferences, the Technology Review, and the development of new programs for 1976-77. Progress also was made in the operational areas of data processing, records, and accounting.

Considerable effort was devoted to the Association's communications program with the experimental introduction of a tabloid, MIT 76, sent to all alumni three times a year. In 1976-77, a new section of Technology Review will include those parts of the Review previously grouped under the "Institute Review" section. On three occasions during 1976-77, this new section will be sent to all alumni not receiving Technology Review.

Howard L. Richardson, '31, served his last year as President of the Association in 1975-76. Mr. Richardson's guidance and advice were invaluable during the Association's staff reorganization and as the Association began new program development.

On June 4, 1976, Edward O. Vetter, '42, assumed the presidency. Formerly Executive Vice President of Texas Instruments, Inc. and now Undersecretary of Commerce of the United States, Mr. Vetter has served M.I.T. and the Association in many capacities, including membership on the M.I.T. Corporation and its Executive Committee and the Alumni Fund Board.

ALUMNI RELATIONS

1975-76 was a year of transition and progress. The staff reorganized from functionally oriented fund and club field personnel to regional directors responsible for coordinating all alumni activities in a given area, and reporting directly to the Executive Vice President. The number of volunteers and the number of programs increased this year. Local alumni leadership indicate that the new field organization is working well.

The Board of Directors, the Fund Board, the Club Advisory Board, the Alumni Advisory Council Program and Membership Committee, and the Alumni Day Committee also reconsidered their roles and functions, particularly as they relate to long- and short-term goals and planning cycles. The planning cycles that evolved were based on two assumptions: first, the programs of the Association will generally require more than a year to accomplish goals and, therefore, the Association should have both a short-term (one-year) plan and a rolling long-term (five-year) plan; second, during any given year, the attention of the Board

should be directed toward future programs and goals (except at an early evaluation meeting) since the Association programs generally require long range planning for effective implementation. Mid-year redirection of programs may be counterproductive other than in exceptional cases. The proposed planning cycle also assumes that the Board will continue to meet quarterly and that the Alumni Fund Board and Club Advisory Board will hold at least two regularly scheduled meetings each year. The new planning cycle has been discussed and approved by all Boards and will be implemented in the coming year.

As a result of the 1975 Alumni Officers' Conference, Mr. Richardson announced in January the appointment of Claude W. Brenner, '47, as Chairman of an ad hoc committee of the Alumni Association to assist in developing and coordinating Institute programs which involve alumni as a resource. At that time there were three other members in addition to Mr. Brenner and as of June 30 the Committee grew to 11 members, divided into two groups (School and department liaison officers and program officers).

It is the purpose of this committee, now named the Committee to Strengthen Alumni Involvement with the Institute, to: serve the Institute; develop the Alumni Association and the body of alumni as a resource to support Institute programs; bridge Institute needs and alumni capabilities; respond to initiatives from specific School or department activities; and work with Institute agencies to develop new programs to which alumni may contribute.

Following is a table of attendance at events over the past four years:

<u>Event</u>	<u>1975-76</u>	<u>1974-75</u>	<u>1973-74</u>	<u>1972-73</u>
Alumni Day and Reunions	2,344	2,325	1,968	2,132
Alumni Officers' Conference	590	745	525	342
Alumni Advisory Council	806	802	589	621
Club Programs	10,765	9,800	7,400	8,600
Conferences and Seminars (includes Chemical Engineering Convocation)	<u>1,359</u>	<u>700</u>	<u>1,400</u>	<u>1,160</u>
Total	15,864	14,372	11,882	12,855

There were 146 club programs held during the year. Highlights of these programs included Princeton (newly formed) with Senator Clifford P. Case and Representative Millicent Fenwick; Fairfield County with Halsey Herreshoff (newly activated, attracted 125); New York City, a Job Clinic Program (attracted 150) and a Planetarium Show (attracted 350); a number of meetings with Regional Directors, many in areas where there had been no meetings for some time; A Boston meeting with Robert Seamans (attracted 155) and lunch with Governor Dukakis (attracted 175); in Washington, D.C. a Nuclear Energy Session with Congressman Mike McCormack (attracted 120); and Dean Pounds attended an Annual Meeting at Wilmington, Delaware (attracted 75). There were 8 meetings at foreign clubs attended by approximately 300 alumni.

The Association sponsored three highly successful regional conferences: one in San Francisco on natural resources, one in Mexico City which addressed the management decision-making process, and one in Washington, D.C. which examined the issues of US technological innovation and economic development.

A Chemical Engineering Convocation was held at M.I.T. on March 4 and 5, 1976, in conjunction with the dedication of the Ralph Landau Chemical Engineering Building. For a day and a half, technical workshops detailed many new processes in the field of chemical engineering. Fifty members of the M.I.T. Corporation attended the Dedication luncheon along with 475 department alumni and guests.

The 1975 Alumni Officers' Conference, held on September 12 and 13, 1975, had the second highest attendance of 590 alumni officers, faculty, and guests. Thirteen Bronze Beaver Awards and three Presidential Citations were given to alumni and organizations in recognition of distinguished service to the Institute through Association programs.

The 1976 Alumni Day (renamed Technology Day) and the class and course Reunions also had a record attendance -- 2,344 alumni and their guests visited M.I.T. over a four-day period this past June. All of the quinquennial reunion classes held at least a portion of their reunion on campus, while many reunion classes convened exclusively at M.I.T. Additionally, the Departments of Aeronautics and Astronautics, Chemical Engineering, Civil Engineering, Economics, Materials Science and Engineering, Mechanical Engineering, and Nuclear Engineering hosted departmental reunions, consisting of cocktail parties and dinners held in conjunction with the regular program. Besides the panels offered by the reunioning departments, over 13 lectures, symposia, and tours offered by a cross section of M.I.T.'s departments were presented on Technology Day to visiting alumni and the M.I.T. community.

Alumni Records and Data Processing

As of June 30, 1976, the rolls of living alumni included 63,054 names, resulting from the addition of 251 from the Class of 1975 and 1,694 from the Class of 1976, and the removal of 517 alumni reported deceased during the academic year 1975-76.

The 1975 Alumni Register, the Centennial Edition, was produced and distributed in November to 5,195 alumni. This was the first register produced since 1967 and was the first in the history of the Association to be produced directly from an electronic data base. By procuring information on business positions and addresses, we were able for the first time to include this data in our electronic file and to use it effectively in various programs. During the year, a computer program was also designed and implemented for generating a complete directory of our nearly 4,000 officers directly from the data base.

During the year, an effort was made, with assistance from the M.I.T. Audit Division, to develop an accounting and budget control system that would: make maximum use of the M.I.T. system; provide uniform classification of expenses for all of our cost centers; separate cost centers by management function and by individual responsibility; and provide for a system of reporting monthly to both individual managers and to our Executive Committee in a consistent and understandable manner.

The new system was used this year for our budget presentation to the Executive Committee and to our Board of Directors and was well received. Starting July 1, 1976, all income, expenses, and certain balance sheet items will be reported on a monthly basis using the new format.

Nominations and Elections

For the first time this year, the three nominees for five-year appointments to the Corporation, the President, two Vice Presidents, and four Directors of the Alumni Association were selected directly by the National Selection Committee. Election by ballot process to all alumni was delayed this year due to problems with the final edition of MIT 76 of which the ballot was a part. The response, which last year represented only 4.6 percent of our alumni, dropped to 1 percent. The balloting for Representatives for Recent Classes to the Corporation was also disappointingly low, 6.5 percent compared to 8.6 percent a year ago (compared to a high in 1971 of 22.2 percent) even though this process was timely.

A total of 62 alumni were nominated to fill vacancies on the Corporation Visiting Committees and 34 were elected to serve on the national boards and committees of the Association.

ALUMNI FUND

The 1975-76 Alumni Fund received a total of \$4,025,073 from 21,350 alumni donors. This total was up \$697,621 (21 percent) from 1974-75 and represents another record high performance for the Fund. The number of donors was up slightly from the previous year's performance to achieve the third highest record for donors in the history of the Fund.

The 25th, 40th, and 50th reunion classes reported five-year reunion gifts of \$1,451,311, \$480,994, and \$902,779, respectively. The 60th reunion class continued a tradition begun by last year's 60th reunion class, by reporting a 10-year total of gifts to M.I.T. of \$1,603,318.

Of the \$4 million reported above, the sum of \$130,950 was designated by 1,350 donors for the Independent Residence Development Fund, (I.R.D.F.), part of a 10-year effort to bring the I.R.D.F. to a total of \$12 million. The two-year drive to provide renovation funds for the M.I.T. Sailing Pavilion and a new fleet was completed with cash and pledges totaling \$303,000 from 1,400 alumni donors. The drive, under the able chairmanship of George Warren Smith, '26, exceeded its \$211,000 goal by \$92,000. A special appeal by President Jerome Wiesner and Chancellor Paul Gray for expendable scholarship funds produced \$92,100 from 1,400 alumni donors. The Sailing Pavilion Drive and the Scholarship Appeal were both successful in persuading previous non-donors or donors of nominal amounts to increase their gifts to amounts between \$500 and \$5,000. A total of \$1,398,500 (35 percent) of the \$4 million was undesignated.

The above results are in the context of the five-year plan for the Alumni Fund which seeks to achieve a goal of 35,000 contributors and \$6.4 million for the 1979-80 Fund year. The number of geographical regions organized for personal solicitation in 1975-76 was 199, up from 161 for the previous year. There were 62 area and class special gift chairmen, up from 45.

1975-76 marked the first full year of operation under a new staff organization plan whereby each of five regional directors of the Alumni Association has responsibility for staff support for all Alumni Association programs in that person's geographic territory. Each regional director also assumes class and departmental program responsibilities. The benefits accruing from this new organization plan include a closer identification of each staff person with alumni in that person's area and clearer understanding on the part of alumni of the various components of the Alumni Association programs and how they relate to one another. This

new organizational format has required substantial attention to detail, and we have, as a result, allowed several programs to continue without the support they deserve during this organizational period.

The Alumni Fund has continued during 1975-76 to pursue its goals in the context of the M.I.T. Leadership Campaign announced in April 1975. The Alumni Fund continues with expanded activities during the period of the Campaign in an effort to provide a substantial stream of growing annual support for M.I.T. that will continue even after the completion of the Campaign.

TECHNOLOGY REVIEW

By any standard, Technology Review had a good year in 1975-76. There were no major changes in the format, organization, or scope of the magazine in Volume 78. We continued to provide -- for alumni and non-alumni paid subscribers -- a professional journal of new developments in technology and their implications for human affairs; and a comprehensive review of events at M.I.T. and of the Association's and classmates' activities.

The March/April issue attracted wide attention through "Search for the Loch Ness Monster," by Robert H. Rines, '42; Charles W. Wyckoff, '41; Harold E. Edgerton, '27; and Martin Klein, '62. The article represented a summary of findings by this group and others during recent decades, together with a review of the methods used and the environmental situation at the Loch which makes possible speculation on the existence of a large unidentified creature.

Unique in our history was the June issue, a special issue dedicated to Philip Morrison, Institute Professor of Physics, containing articles commissioned in Professor Morrison's honor by Professor Kenneth Brecher, '64, and Mrs. Morrison. No issue of the Review has ever had a more distinguished list of authors and contributors: Charles Eames, Frank Drake, Frank Oppenheimer, Cyril S. Smith, '26, Martin Gardner, Jerome Y. Lettvin, Hans A. Bethe, and Victor F. Weisskopf.

There is only one blemish on the record, resulting from a misunderstanding between the Editor and one member of the faculty who finally took serious exception to the Review's interpretation of his research results published in the form of an article.

Two new contributors joined the roster of Technology Review's columnists -- David F. Salisbury, Science Writer at the Christian Science Monitor and Colin Norman, Washington correspondent for the British journal Nature.

We gave special attention this year to improving the content of "Institute Review," the report to alumni of current events at the Institute. There were articles by students in almost every issue, and topics of concern in the M.I.T. community were covered fully. We remain challenged by the need to represent controversial developments in a form which will be of interest to alumni, and to give adequate display to matters of special importance and appeal without sacrificing our coverage of affairs which are important to fewer graduates. Also included must be information on course and departmental activities.

Class Secretaries continued to report regularly on classes' and classmates' activities, performing an invaluable function for the Review and for the Alumni Association.

Circulation

Non-alumni paid circulation provides an important measure of the appeal of Technology Review and of its success as a professional journal. Both response and renewal rates advanced slightly -- the response rate measuring the number of orders received from direct-mail advertising, the renewal rate measuring the number of current subscribers who elect to renew their subscriptions at expiration.

The increase in subscription rate (\$12 to \$15 per year, effective with Volume 78) had little if any measurable effect on either of these parameters; as a result, non-alumni subscription income covered a slightly increased share of total expenses than in previous years.

Anticipating popular interest in the article on the Loch Ness monster, we entered a contract for a modest test of newsstand sale of Technology Review in March 1976. Even now, four months later, it is essentially impossible to report on results.

Our circulation efforts were substantially aided this year by the work of the Review's new Circulation Manager, Kitty Potter. Ms. Potter's organizational skills have substantially increased our ability to maintain accurate records and reach new markets.

Advertising

Advertising volume remained essentially unchanged in Volume 78. Travel advertising declined, but we obtained orders from several new accounts which suggests that future promotional efforts may yield better results in corporate and recruiting advertising. Professor J. Herbert Hollomon, '40, appeared on behalf of Technology Review at a small meeting to cultivate present and potential future advertisers on the West Coast in September 1975.

JAMES A. CHAMPY