

Massachusetts Institute of Technology
Bulletin

Report of the President and the Chancellor Issue
1973-1974

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President and Chancellor

Introduction

The annual Report of the President and the Chancellor has, by our third year, become part of the measured pace of the year. It is that occasion on which we assess where we have come, take notice of the achievements of many throughout the Institute, assess our shortcomings and problems, and consider the trajectory of the Institute into the future. Our major perception of the past year at M. I. T. is of a quickening of pace -- a focusing of energies, consolidation of efforts, and progress toward the achievement of reaffirmed long-term goals.

The last few years have been ones of uncertainty and deep searching, as every sector of our society has taken stock of the complexities and incongruities of the contemporary world, and reassessed its goals and its effectiveness. M. I. T., too, has been engaged in such an examination. We faced a society uncertain of its goals and seriously questioning the role of technology, a political mood less understanding and supportive of basic research than before, and a government policy designed to cut back graduate education in science and engineering. As a consequence, many young people were hesitant to choose careers in engineering and science, and many educational institutions elected to cut back their graduate programs.

At M. I. T., we regarded these moves as serious errors, and chose to exert our leadership through support of a continuing high level of research and a scientifically based education. As the world's leading Institute of Technology, we felt a very special responsibility to identify the continuing value of engineering and technology in our society. At the same time, we felt an important obligation to maintain a major visible commitment to fundamental research, the creation of knowledge for its own sake. We took as our institutional obligation the support of these two propositions in a time of challenge.

In many ways this meant simply doing what we had been doing, in a new context and with strong determination. The challenge was to continue and intensify our efforts in the face of widespread skepticism and even antagonism, to relate our efforts to the problems of society and industry created by the forward sweep of technology, and to address people's growing concerns about whether the resulting world truly serves them well.

This year we are pleased to report some positive results of the planning and hard work of our colleagues throughout the Institute. The problems by no means have disappeared, nor are they likely to do so in our lifetime. However, we believe that we are going in the right direction. During the past year, we have seen a variety of activities develop beyond their formative stages, assuming more mature and integrated roles in the life of the Institute. We are pleased that these newer efforts are holding their own and are beginning to make substantial contributions to M. I. T. 's educational programs, to our understanding of the complexities of modern life, and to the improved management of our society. We are equally pleased that these new activities have been built, in large measure, through initiatives that stem from M. I. T. 's established departments and Schools. At the same time, the core

programs are in a healthy state of flux, as exciting new research is undertaken and teaching programs are adapted to current intellectual interests. These achievements are documented in detail in the reports of our colleagues, the Provost, the deans and department heads, the vice presidents, and the laboratory and center directors. We will note the highlights in later pages of this Report, but wish to express here our appreciation of the efforts of all those at the Institute who have made those achievements possible.

This Report is, in effect, a snapshot of the year past, in which we present a summary of some of the major events of 1973-74. We wish at the same time to convey a sense of continuity within change -- to examine the links of the past and future in the present. For this purpose, we have devoted a portion of this Report to an extensive discussion of the evolution of undergraduate education at M. I. T. during the past 15 years. To provide an even broader frame of reference, we have included an appendix prepared by the Provost and several of his associates. This appendix, containing a series of charts, indicates some patterns of growth and change at M. I. T. over the past 30 years -- in physical size, in population, and in the number and range of activities. As we feel a quickening of the stride of the Institute into the seventies, we recognize our deep indebtedness to those who have built this institution and made it strong.

* * * * *

M. I. T. always has been a remarkably timely institution. Throughout its history, the intellectual problems it has addressed, the style of its education, and its mix of theoretical and applied arts have been at the cutting edge of our society's most pressing contemporary issues. One sign of the timeliness an M. I. T. education offers is the strength of undergraduate and graduate applications to the Institute. Both the number and the quality of applications remained high during the recent period in which other colleges, and especially schools of engineering, reported declining applications. They remain strong today. Last year, for example, we had 4,417 final applications, a 20 percent increase over 1972-73. Although we intended to hold the size of each class to approximately 1,000, primarily because of limitations in our ability to provide adequate dormitory space, significantly more students in the Class of 1978 accepted our offer of admission than we had anticipated. This will create some over-crowding in the residential system during the next year, but it also bears witness to the attractiveness of an M. I. T. education for both young men and young women. Graduate applications also have risen, although the number of students we can admit and the number who can come continue to be affected by the difficulty of obtaining financial support.

After several months of extensive discussions, this year the faculty approved a new form for the undergraduate humanities requirement, which is now called the Institute Requirement in the Humanities, Arts, and Social Sciences. The new Requirement still consists of eight term subjects, but now includes a distribution requirement in a range of areas, a small core of concentration in one aspect of humanities, the arts, or social sciences, and several electives. The overall objective is to engage students in important ways of thinking and modes of expression not commonly encountered in science and engineering subjects, and to foster that integration of perspectives on which effective, responsible work in science and technology depends. The depth and spirit of the discussions which led to a new requirement to help meet this goal bear witness to the importance of its role in an M. I. T. education.

The contemporary nature of an M. I. T. education, as well as its interrelation with research and industry, is illustrated by new developments in the School of Engineering. That School has just received a major grant from the Alfred P. Sloan Foundation to identify new and different subject offerings and degree programs, to support different kinds of problem oriented research, and to develop continuously new areas of social concern. These new

research efforts and the related educational programs are aimed at understanding the complex operations of a technological society. They will build on engineering science and will emphasize technology in relation to the social, economic, and value systems of the society, with special emphasis on major functional sectors such as construction, transportation, manufacturing, and the delivery of a variety of essential services. The undergraduate program will bridge the humanities, the social sciences, and engineering, and will draw support from all the Schools of the Institute.

Similar interdepartmental and inter-School collaborations have developed around a number of timely issues in health related fields, the sciences, nutrition planning, and the inter-connected problems of energy and environment. Because of the close connections between these research and educational programs and the concerns of a wide range of industries, government agencies, and service providers, existing avenues for collaboration are being strengthened and imaginative new ones are being developed. For example, undergraduate participation in cooperative programs, in which the student spends several terms working in a company or agency on successively more sophisticated research, is increasing. Applications to the cooperative program in the Department of Electrical Engineering, for example, were up to 116 this year, from 39 four years ago. During the same period, the number of spaces available for new students in participating private companies and government agencies has grown from 29 (in 1970) to approximately 65 (in 1974). The similar growth in other departments' cooperative programs and the success of the Undergraduate Research Opportunities Program's off-campus placements also attest to the continuing viability and mutual benefit of this mode of education.

M.I.T.'s efforts to combine intellectual work, public service, and education in the fields of energy and technology policy have been consolidated and strengthened by the development of two new laboratories in these areas. The Energy Laboratory has three broad goals: to identify and work toward short-term and long-range solutions to energy related problems, emphasizing those requiring broad interdisciplinary capabilities; to provide comprehensive and objective assessments which can become the basis for public policy; and to strengthen research and educational opportunities in energy related areas at M.I.T. The Laboratory was in a very good position to respond to a suddenly increased need for analysis when fuel problems became critical last fall. Several M.I.T. faculty members associated with the Energy Laboratory worked intensively on short-range studies to help the Federal Energy Office develop supply and allocation policies for dealing with the immediate crisis; in addition, they have done a somewhat longer-range policy study exploring means to assure growing and continuing energy supplies, particularly of petroleum, for the nation.

Research in the Energy Laboratory has been sponsored in special areas by contributions from industrial supporters and utilities, as well as by foundations and the government. These contributions include substantial longer-term funding that enables us to build a national facility capable of carrying out large-scale studies, which the nation desperately needs and to which we believe M.I.T. should contribute.

The Center for Policy Alternatives, established within the School of Engineering in 1972, has a comparable responsibility. The Center's primary function is to identify the major technology related issues facing society, to assess the consequences of present policies and practices, and to develop alternative actions which will improve society. In its two years of existence, the Center's annual research support has grown from \$60,000 to approximately \$1.5 million; its staff has grown from three people in 1972 to providing partial support for over 15 faculty members and 30 graduate students from throughout the Institute, as well as supporting its own professional staff. Among the wide spectrum of the Center's studies, one on the hidden costs of consumer appliances received major attention during the past year.

Another new and promising effort is the Division for Study and Research in Education. Through this new Division, we are building a group of people who will work on the extremely difficult, fundamental questions of learning and behavior, which up to now have proven quite intractable. By the end of its first year, the Division had made significant progress in identifying those aspects of learning, and those contexts in which learning occurs, which seem to provide the most promising avenues for investigation. A major hypothesis which the Division is investigating is that the effectiveness of a learning process -- whether in a person, an institution, or a computer -- has much to do with how information and procedures are represented, retrieved from memory, and modified. If this is true to a significant degree, then studies of these very different learning situations should be mutually enhancing. Such investigations are rich in connections to the educational concerns of faculty and students throughout the Institute, and the Division offers the potential for a variety of collaborative arrangements which could influence the effectiveness of our educational programs -- all too rare an occurrence in the intellectual life of most universities.

While M. I. T.'s faculty and students in interdisciplinary groups, new and old, are addressing themselves with some success to major functional issues in our society (with the indispensable collaboration and support of government agencies, private foundations, and the relevant and affected industries), basic research in a variety of fields has been equally productive.

For example, fundamental breakthroughs have been made in our understanding of the biological substrates of life. In August, 1973, M. I. T. scientists announced the synthesis of a 126-unit gene, the first ever synthesized with the potential for functioning detectably in a living cell. Although the code by which genetic information is transcribed into working molecules is well known, only now is it possible, by synthesizing chemical start and stop signals and attaching them to the synthetic gene, to explore how this transcription is controlled by the cell.

Work which builds on already strong research groups in biology, chemistry, and biochemistry is under way in the new Center for Cancer Research. In the past few years, it has been discovered that chemical changes take place on the surface of cells when they become cancerous, and the changed chemicals have been identified. Immunologists at the Center have established that once the surface substances have been identified, one can make an animal reject its own cancer cells. Finally, an enzyme has been discovered that acts as a catalyst, converting the genetic material of a virus into DNA which can enter the genetic material of a cell and make it cancerous. While the Center for Cancer Research is currently a relatively small facility, its fundamental theoretical work is producing increased knowledge of how cells become cancerous, what goes wrong in cancer cells, and what abnormalities are due to the action of viruses.

Just as significant breakthroughs in molecular biology have been made possible by the discovery of the double-helix structure of DNA, so the development of plate tectonics has provided significant impetus in the geological sciences. According to this theory, the earth's outer surface is composed of 12 plates, each roughly 100 kilometers thick. These plates, on which the continents float, are in constant motion, sliding by each other, colliding, and separating. Most large-scale geological phenomena -- earthquakes, volcanos, and large mineral deposits, including oil -- occur at the boundaries of these plates; some are caused by their motion. For a number of years, M. I. T. scientists, in collaboration with the Woods Hole Oceanographic Institution, have been exploring the details of plate motion and investigating its practical consequences for earthquake prediction, the discovery of mineral deposits, and the study of other phenomena.

In the field of radio astronomy, M. I. T. scientists discovered this past spring a new and completely unexpected celestial source of radio emissions. This source, imperceptible

by optical methods, is detectable only in the 0.1 to 1 millimeter range of wavelengths. It emits a signal one-tenth as strong as the moon's, indicating the presence of a class of significant and previously unknown phenomena outside our solar system. This discovery is an interesting repetition of the history of modern astronomy, when opening a new band of observation revealed unsuspected phenomena. At longer radio wavelengths, quasars, pulsars, and radio galaxies were dramatic examples of objects completely different from familiar ones; when X-ray detectors were carried above the Earth's atmosphere, X-ray stars were discovered, posing entirely new astronomical questions. The nature of the new class of source is a complete mystery so far, but history gives one confidence that interesting and important physical phenomena will be revealed.

A final example of ground-breaking scholarship is in mathematics, and concerns one of that field's most famous unsolved problems -- the so-called Riemann hypothesis. Certain unproved mathematical conjectures of long standing have played a major role in the development of the discipline, because they are rooted in fundamental questions, are tantalizingly difficult to prove, and because the attempt to prove them generates new and exciting mathematical concepts and tools. The Riemann hypothesis is just such a conjecture within the field of analytic number theory. Since 1859, an uninterrupted string of mathematical giants has attempted to prove the Riemann hypothesis, and, while unsuccessful, their attempts have generated an enormous amount of new and interesting mathematics. During this past year, Professor Norman Levinson has made the greatest progress to date toward proving this famous hypothesis, showing that more than one-third of the zeroes of the Riemann zeta function lie on the line $\text{Re}(z) = 1/2$.

A very different but equally important contributor to the liveliness and contemporary flavor of M.I.T. has been the work of the Council for the Arts. Just completing its second year, the Council now has established itself as a fully functioning unit of the M.I.T. community, having developed an operating staff and a modus operandi which should see it through many years to come. The Council's role is to some degree that of magnifier -- providing grants and helping to find support for a variety of faculty and student projects throughout the Institute, as well as initiating its own activities. Through its efforts, we envision a decade of growth and development in one of humanity's oldest, yet newest, endeavors. Worldwide, the arts are moving out of an era of private patronage and into an era in which increasingly they are practiced and appreciated in many parts of our lives. We are by now quite familiar with the ideas of economic and social development. However, it is becoming possible to speak also of cultural development, and to do so in terms that have the sort of clarity demanded by interdisciplinary problems. If society is beginning to become serious about cultural development, it will need models as the precondition for knowing how to proceed. It is precisely here that M.I.T. can make its unique contribution. Not only is participation in the arts an especially appropriate, lively, and popular part of the lives of many of our students, but M.I.T. is also in the process of developing active, broadly based, participatory programs in the arts. These programs, which are founded solidly on teaching, practice, and research, may help our society to invent a process for melding cultural developments with its social and technological progress.

We at M.I.T. remain committed to the proposition that education, science, technology, and art, broadly conceived and used in the service of a free, democratic society, remain basic ingredients of genuine human progress and happiness. We see ahead a new era of understanding and caring in the relationships among people, their environment, and their society -- an era in which technology is responsive to broad social and environmental needs, as well as to individual material needs. M.I.T. has important contributions to make, and is in a strong position to do so. However, our most important contribution will be our ability to foster the best in our students. The most important resource of the future will be these young people -- intelligent, concerned, alerted to the nature of the issues at hand, and equipped with the best

intellectual tools available.

* * * * *

Undergraduate education at M. I. T. is an inseparable part of a large, complex, and exciting system composed of teaching at both the graduate and undergraduate levels, research, and a variety of relationships with society at large. In this dynamic environment new research programs, such as those in energy and biomedical engineering, markedly broaden the opportunities and choices available to the undergraduate student. Moreover, reconceptualization of a field at an advanced research level can have at M. I. T. immediate and beneficial consequences for related undergraduate programs; conversely, new developments and patterns in undergraduate education can influence graduate education and research activities deeply. To consider undergraduate education as a separate topic, as we do here, is clearly an oversimplification. However, the past 15 years have been a time of heightened change and ferment in undergraduate education at M. I. T., a time of experiment and response to an evolving world, and it is now appropriate to focus specifically on the extent and nature of these changes, tracing their origins and exploring probable future directions.

Several major influences on the evolution of undergraduate education at M. I. T. during the past 15 years are especially striking. Since the late 1950s, we have witnessed significantly improved and more intensive preparation in many secondary schools. (M. I. T. itself played a major role in this national development.) This has made for greater diversity of preparation among students entering M. I. T. At the present time, for example, approximately one-half of the entering freshman class already has had a year of calculus in secondary school, which produces a range of appropriate "starting points" in the mathematics program. Similar differences in level of preparation and area of student interest occur in the sciences and in the humanities. Furthermore, M. I. T. appears to draw an increasing fraction of its entering students from a group of applicants that it shares with major liberal arts universities. These young people, highly capable in mathematics and the sciences, look to us for a first-rate education which can help them develop a wide range of interests.

In addition, faculty members' and students' perceptions of students' future career patterns have been changing. Increasing numbers of students go on to graduate or professional school, yet at the same time, fewer undergraduate students wish to make an early exclusive commitment to a single career path. As a consequence, both faculty and students value the opportunity for sampling career possibilities. For many students, such experience also provides the motivation that comes only from genuine involvement with real problems.

Finally, fields and disciplines have continued to evolve, both as knowledge has developed and as patterns of external problems and needs have changed. In particular, increased concern with problems generated by technology itself has been a notable influence on our educational programs.

In the presence of these and related influences, faculty members in all fields at the Institute have provided vigorous and imaginative leadership in a continuous evolution of the undergraduate program. This leadership has been evident in ongoing debate and formulation of policy in faculty meetings and by faculty committees such as the Committee on Educational Policy (C. E. P.); it has been evident in special studies of education such as the Committee on Curriculum Content Planning, the Commission on M. I. T. Education, and the Special Task Force on Education; and most important, it has been evident in the evolution of departmental programs, in the teaching of individual subjects by individual faculty members. Students, as members of faculty committees and participants in faculty meetings, have made increasingly significant and effective contributions to these developments. We believe that throughout this recent period, the M. I. T. faculty has been second to no other university faculty in the energy,

creativity, discrimination, and commitment they have brought to the exploration of new approaches and directions in undergraduate education.

Through it all, a sense of continuity with the past has remained strong. The Institute maintains and indeed cherishes its distinctive character and atmosphere as a university of "science, engineering, and the arts." The commitment to excellence, to hard work, to learning by doing, is as evident at M. I. T. today as it ever has been in the past. The early exhortation of William Barton Rogers to maintain the highest intellectual quality while seeking useful knowledge remains a guiding principle in the formulation of our educational programs. Undergraduate programs continue to be departmental and "professional" in format. The general balance of student interests is as before -- traditional disciplines in science and engineering continue to draw a major share of undergraduate students -- although the balance of interests and emphasis among these disciplines has changed in important ways. The most significant of these may be the great interest in the life sciences and in societally related aspects of science and engineering. Perhaps most important of all, both students and faculty continue to find inherent satisfaction and reward in the intellectual activity of learning and research.

However, changes have been made -- changes which translate M. I. T.'s traditional educational values into modern terms, capable of engaging and challenging today's students. As an overall pattern, these changes have added considerable variety and flexibility to the undergraduate program. The form and structure of the Institute core requirements have been modified to permit increasingly varied paths and programs, while retaining an emphasis on basic principles and on experience in science, technology, and the humanities. For example, it is possible to take a version of freshman physics that is oriented toward the biological sciences or one that is highly theoretical, instead of the regular one. Similarly, in introductory mathematics and chemistry the student has several choices, and some of the subjects can be studied in a variety of styles -- self-paced, in a seminar-tutorial mode, or in the familiar lecture-recitation mode. Pass/fail grading has been introduced in the freshman year to facilitate adaptation of new students to the Institute, and to provide a less competitive atmosphere for them to stretch their minds freely and explore new subjects. (A limited form of pass/fail also exists in the upperclass years.)

In a similar vein, flexibility in upperclass departmental and interdisciplinary programs has been increased significantly. The Interdisciplinary Science Program (Course XXV) was introduced several years ago in the School of Science; it leads to a bachelor's degree without specification of professional field. Students in this program, in consultation with faculty, can design individual courses of study in science that have a wide variety of forms and emphases. Several departments across the Institute also offer programs leading to degrees that do not specify a major field. These programs permit the student to arrange rather general courses of study within the setting of a department. At the same time, departmental programs leading to a degree that specifies a major field also give an increased measure of elective freedom to students, who may take subjects both within and outside their major field. One measure of increased upperclass flexibility is that at the present time, almost one-fifth of all undergraduates choose to select a major field of study later than the beginning of the sophomore year.

New and welcomed flexibility for both faculty and students also has been achieved through the shift of the academic calendar so that the first term ends before Christmas vacation, making possible the three-and-one-half-week Independent Activities Period in January. Into this short period is crowded an aggregation of some 600 mini-courses, problem focused seminars, intensive versions of regular academic offerings, and imaginative exotica which provide engaging opportunities (such as building the world's largest yo-yo). I. A. P. provides an exciting change of pace, a midwinter rejuvenation which is good for the mind and the soul.

In keeping with the strong professional orientation of M. I. T., the faculty has been exploring a variety of new ways to provide an early introduction to professional atmosphere and to problem oriented experience. Laboratory work now emphasizes longer-term projects; a variety of fieldwork opportunities are available as part of regular departmental programs; the Undergraduate Seminar Program provides elective introductory subjects in informal, small-group settings; cooperative programs continue to give intensive field experience in an off-campus setting; and the Undergraduate Research Opportunities Program (U. R. O. P.) provides a framework within which the student who wishes to can participate (in any given term) in a research experience, on- or off-campus, that will stand as the equivalent of one or more subjects taken in that term. Such collaborative work provides the undergraduate student with a close association with a faculty member, a situation we have been most anxious to achieve. At the present time, in any given term, approximately one-half of the faculty and approximately one-half of all undergraduate students are engaged in activities under this latter Program.

The diversity of interests among our students also has suggested the usefulness of educational collaboration with other institutions. One example is the Wellesley-M. I. T. Exchange Program, which began in 1967. Under this program, undergraduates at each institution may take subjects at the other, and participation this year included 337 M. I. T. students and 446 Wellesley College students. The program offers a richer and more varied educational atmosphere to students at both institutions, including opportunities for increased joint participation in such extracurricular activities as the M. I. T. Symphony and the Wellesley Chamber Singers. It is hoped that an increased amount of faculty collaboration also will become possible. A cross-registration program, more limited in scope, also exists between M. I. T. and Harvard University for undergraduate and graduate students at both institutions. Finally, the Program in Health Sciences and Technology, sponsored jointly by M. I. T. and the Harvard Medical School, provides the first two years of professional medical education for students who seek a program with special scientific and technological emphasis. This program accepts approximately 25 students each year. M. I. T. students may apply for admission at the end of their junior year. After the two-year joint program, students take their final two years of medical education at Harvard Medical School and receive the Doctor of Medicine.

Throughout recent years, both faculty and students have given continued attention to the vital role (both formal and informal) of humanities, social sciences, and the arts in undergraduate education. Earlier in this Report, we described the new Institute Requirement in Humanities, Arts, and Social Sciences. The change in formal requirement is a reflection of increased concern on the part of both faculty and students for the development of new and more varied ways in which to become engaged with social and humane issues. Another symptom of this interest is the burgeoning of activities in drama, music, creative writing, and the visual arts. All bespeak the vital connections among science, technology, society, and culture.

Our survey of recent changes in M. I. T.'s undergraduate education is nearly complete. However, it has not conveyed yet one of the more important but subtle changes in educational atmosphere that has occurred -- the increasingly collegial role that students have come to play in the educational and research life of the Institute. This has been a wholly beneficial development. It provides an educational atmosphere that is highly favorable and that holds potentials we are only beginning to explore.

In addition to continuous efforts to modify the academic program so that it retains the unique strengths of M. I. T. -- equal dedication to excellence and to contemporary issues -- we also have kept in mind that for undergraduates, M. I. T. is a home, a 24-hour-a-day community. Some aspects of this community should lend themselves to rest, play, and congenial company. Others should supplement the intellectual activity which is represented by formal course work, problem sets, and exams. The peer community in which a student lives and works is particularly important in these respects, and we regard the housemaster-tutor system, begun in

1951 and well under way by the late 1950s, as a particularly valuable bridge between life in student living groups and the academic enterprise. Similarly, recent alternative programs for freshmen, such as the Experimental Study Group (E.S.G.) and Concourse, have given ample demonstration of the potential and value of small peer groups based on shared intellectual interests and experiences.

While providing a supportive milieu which enhances educational experiences is a general goal for the Institute, it is of particular importance to the minorities and women who study here. M.I.T. is striving to become more nearly a community where no preconceived bounds are set on the capabilities or potential contributions of its members. The Class of 1978 includes 20 percent women and 5 percent minority students, and we look forward to significant increases in these groups in the future.

Most of the recent developments in undergraduate education had their origins in the early and middle 1960s. In the late sixties, the time of student unrest across the nation, the flux of experiment and innovation continued at M.I.T. In the past two or three years, as we engaged in a more general stocktaking and sorting-out, many of the new educational efforts were judged to be of enduring worth, and consequently have been kept. We have mentioned the most valuable of these. Others were judged not to be of long-range value, and have been phased out.

It will be no surprise that many vexing questions remain. Exploration of new approaches and directions, of course, will go on. Such work is a major part of the continuing process by which each generation of faculty and students renews itself and its commitment to the educational mission of the Institute. We hope to be guided in these efforts by our recent experience, and expect that some of the issues before us will be natural projections of concerns and issues which are emerging from that experience. For example, are there other ways in which the Institute, within the present general framework of educational programs and research interests, can provide an undergraduate student with an early introduction to professional atmosphere and research experience? Are there ways in which the Institute can acquaint a student with a variety of possible areas of career choice? The success of the Undergraduate Research Opportunities Program and of the Independent Activities Period may provide helpful guides.

The change in the humanities requirement doubtless will result in many new subjects becoming available to students. During the period in which the logistics of its operations are being worked out and the range of distribution and concentration subjects is being refined, how can we best take advantage of the opportunity to help our students grasp not just the letter of the requirement, but also its spirit -- the development of a deep commitment to nonquantitative ways of thinking, and to an understanding of humanity? In particular, how can we foster those writing skills on which communication in all fields depends?

How can we continue to ensure that undergraduate programs keep pace with the reconceptualization of academic fields? Such reorganization, often along problem oriented lines, is an important academic concern of the Institute at the present time. A related question is the extent to which interdisciplinary programs for the individual student should be encouraged and formalized. We are most enthusiastic about the School of Engineering's current exploration of this range of issues in undergraduate engineering education.

Given the diversity of students and the diversity of possible careers, what is the best possible form for academic advising and counseling? Advising and counseling at M.I.T. occur under a variety of circumstances at a variety of places and times, as they should. At present, we judge our efforts to be inadequate. How can we tap better the human resources of faculty and staff in support of the advising process? Can we understand better the nature and extent of the academically related advisory needs of minority students, women students, and prelaw

and premedical students? What is the role of peer groups and small learning groups in providing support, a sense of collegiality, and a source of continuing advice in a relatively large and increasingly diverse university?

Finally, the formal structure of academic requirements and procedures are not the body and substance of education, but they are the skeleton upon which the body takes its shape. They remain a major subject of faculty and student deliberations. Among such formal issues are the following questions: What is the meaning of the general escalation of grades? Should M.I.T.'s current grading systems be revised or modified? (A special faculty-student committee on grades will report this fall.) What parts of a student's educational life at M.I.T. merit formal academic credit, and how should such credit be measured? To what extent should exchanges or joint programs with other institutions be fostered? Can the present balance of prescription and elective choice within our undergraduate program be improved?

We anticipate further discussion of these concerns and issues during the coming year, and most likely will discover new ones. Our ability to maintain an Institute-wide perspective on these issues will be enhanced by the establishment of the position of Associate Provost, and particularly through the talents and experience of its incumbent, Professor Hartley Rogers, Jr., who has been involved deeply in helping the faculty to consider continually the effectiveness of its efforts. We believe that M.I.T. now has undergraduate programs of outstanding quality, substance, and value. The developments of the past 15 years have brought much of enduring value, and the past year has seen a consolidation and a sorting-out of substantial proportions in our programs. Much remains to be learned and done, however. Both the Institute and its students must continue to explore and grow.

* * * * *

It seems fair to say that investments in M.I.T.'s intellectual and educational future made over the course of the past few years were extremely worthwhile. However, these investments, in the form of time, energy, new materials, equipment, and space, and most importantly people, have been made in the context of increasing financial stringency for the Institute. In financial terms, the year was a difficult one. The relentless pressure of inflation on the cost of operations increased dramatically, and our planned efforts at cost control proved insufficient to preserve the delicate balance that has held for the past several years.

The effect of inflation on expenses was compounded by unusual restrictions on the recovery of indirect costs from Federal research sponsors. These restrictions, which were agreed to in 1972 as part of the plan for the divestment of the Draper Laboratory, applied only during 1973-74, when they produced a shortfall of approximately \$2.8 million in indirect cost recovery. As a result of these factors, a large operating loss experienced by The M.I.T. Press, a loss associated with the Turnkey project in housing for the elderly in Cambridge, and a modest decline for the year in the flow of unrestricted gifts, the operating budget showed a deficit (after application of current unrestricted gifts and income) of approximately \$1.5 million, or approximately 0.8 percent of the expense budget for the year. Both this deficit and the shortfall in indirect cost recovery were funded by drawing on unrestricted reserves of the Institute.

The impact of inflation, and the form of our response to it, are illustrated well by the effect of the "energy crisis" of last winter on M.I.T. operations. The Institute is an intensive user of energy, in the forms of electricity and of oil and natural gas, which are used for heating and air conditioning. Since October, 1973, the unit cost of electricity has nearly doubled, while the unit cost of oil has tripled. As a result, the cost of utilities for the year

exceeded the budget by approximately \$0.9 million, or 27 percent. Because of the limitations on indirect cost rates for the year, none of this increase in cost could be recovered from research sponsors. The increase would be even larger were it not for heroic efforts at energy conservation throughout the Institute. Such measures allowed the Institute to operate normally under a 75 percent allocation for fuel oil, and reduced the operating deficit for the year by approximately \$0.8 million from what would have resulted had energy utilization not been curtailed.

The energy budget for 1974-75 is, in spite of effective conservation measures, nearly twice that of 1972-73. This enormous cost inflation, coupled with the possibility of future oil and gas shortages, requires that we continue to give attention to ways of reducing the use of energy at the Institute.

Our current budget plans include a small deficit for 1974-75 as well, although the return to full rates for the recovery of a share of indirect costs will prevent a repetition of the shortfall experienced in the year just ended. It had been our intention to have a balanced budget in the current year, but it appeared unwise to exert the degree of cost control which would have been necessary to absorb the sizable cost increases caused by the extraordinary escalation of inflation and energy costs. We begin preparation for the budget process for 1975-76 with the intent of developing those processes which will restore the budget to balance, and of making available for capital purposes a significant portion of the annual flow of unrestricted gifts.

Despite financial difficulties of the moment, the Institute is financially sound, and will remain so if we take strong measures now. It is intellectually and educationally first-rate. Our future contributions will depend on insightful development of our intellectual and educational resources, coupled with determined efforts to protect our financial strength. We can invest in the intellectual future and simultaneously strengthen our financial base in several ways, expanding the capacity of the Institute to contribute to new areas of research activity and making M. I. T.'s unique education available to more young people. To this end, we are considering seriously a variety of new options: expanded cooperative programs, a new master's-level program in applied science, and expanding enrollments to the extent that undergraduate housing and graduate-level financial aid permit. We must renew our efforts at cost control and cost reduction, eliminating those activities which are no longer central to our educational purpose and supporting the academic activities of the Institute as efficiently as possible. In support areas, we will focus on the purpose of each activity, consider alternatives, and with our colleagues in each area, take a hard look at priorities. In academic areas, we will encourage reexamination of the present utilization patterns of money, people, and space, with the recognition that we must consciously redirect existing resources.

Finally, we must redouble our efforts to seek new levels of private gift support, which is crucial in securing the future independence and vitality of the Institute. We plan to undertake a broadly based appeal for capital funds, similar to the Second Century Fund of the early 1960s, but focused on increasing M. I. T.'s endowment and on ensuring adequate support for those research and educational programs for which we are uniquely suited.

We believe that M. I. T. is in a unique position to help a society plagued with interrelated energy and environmental problems, the challenge of controlling technology, and unprecedented inflation rates which wreak havoc on all sectors of the economy. We emerge from our years of searching with a sense of optimism. This optimism is based in part on the successes of the past few years, on the opportunities in research and education which our efforts have opened up, and on the spirit and quality of the young people we live and work with.

As we close our remarks for this year, we would like to pay special tribute to two men whose unique contributions to M. I. T. were noted on two occasions during the past year.

The first was an occasion of celebration -- the Corporation's Resolution to name M. I. T. 's Great Court in permanent honor of Dr. James R. Killian. As noted in the Resolution and affirmed by the warmth of the ceremony held in the Court, for 25 years M. I. T. has "looked to him for exceptional poise, unity, and sense of direction which have enabled M. I. T. to move forward with giant strides and high confidence." The Great Court has existed for slightly more than the 50 years of Jim Killian's association with the Institute, waiting for a felicitous name. Jim Killian and the Great Court, with its serenity, beauty, and affirmation of life, appropriately honor each other.

The second occasion was one of sadness -- the death of Dr. Vannevar Bush. Much was written at the time of his death late in June, 1974, and we cannot hope to equal, in eloquence or feeling, the many tributes already paid. Suffice it to say that Van Bush carried with him an enormous vision of the role of science in the life of modern humanity; in his words:

Science by itself provides no panacea for individual, social, and economic ills. It can be effective in the national welfare only as a member of a team, whether the conditions be peace or war. But without scientific progress, no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world. . . .

M. I. T. owes much to each of these men. We find in their long and varied careers the essence of the Institute -- reborn with each generation, changing in some ways with each decade, but preserving an essential spirit, a dedication to excellence, to inquiry, and to renewed efforts on the side of humanity. As we have noted achievements of the past year, as we evaluate our attempts to define a first-rate contemporary education, and as we come to a fuller realization of the necessity of protecting the quality of M. I. T. 's life by putting it on a firmer financial foundation, we are impressed continually with the legacy of strength that has been given to those at M. I. T. today, and we are determined that it shall be continued.

* * * * *

In Special Recognition

The individual efforts and distinctions of faculty members at M. I. T. have been many during the past year, and cannot be enumerated in full here. We do wish to take note of the election of six members of the faculty to the National Academy of Sciences, six to the National Academy of Engineering, and 11 to the American Academy of Arts and Sciences. These elections, and numerous other honors and awards, attest to the continued high quality of the M. I. T. faculty and to the dedication of its individual members to scholarship of the highest order.

Of special note during the year were the appointments of three members of the faculty to the distinguished rank of Institute Professor: Dr. Philip Morrison, Professor of Physics; Dr. Walle J. H. Nauta, Professor of Neuroanatomy in the Department of Psychology; and Dr. Robert M. Solow, Professor of Economics. Also of special note was the second presentation of the James R. Killian, Jr. Faculty Achievement Award, to Institute Professor Victor F. Weisskopf. Special honor was paid several faculty members through their appointment to newly established distinguished professorships. Dr. John S. Waugh is the first Arthur Amos Noyes Professor of Chemistry; Dr. Hermann A. Haus, the first Elihu Thomson Professor of Electrical Engineering; Pierre Raoul Aigrain, the first Henry R. Luce Professor of Environment and Public Policy; Dr. Francois M. M. Morel, the first Henry L. Doherty Assistant Professor of Ocean Utilization; Dr. Seymour A. Papert, the first Cecil and Ida Green Professor of Education; Dr. Robert W. Mann, the first Uncas Whitaker Professor of Biomedical Engineering; and Dr. John G. King, the first Francis Friedman Professor of

Physics. The initial incumbent of such a distinguished chair is especially honored for outstanding achievements to date; in turn, through his or her continued achievements, the incumbent honors the name of the chair itself.

The past year saw several appointments to senior posts that should receive special mention. Professor Wilbur B. Davenport was appointed Head of the Department of Electrical Engineering; Professor Jule G. Charney, Head of the Department of Meteorology; Professor Myron Weiner, Head of the Department of Political Science; Professor Herbert H. Richardson, Head of the Department of Mechanical Engineering; Professor Langley C. Keyes, Head of the Department of Urban Studies and Planning; and Professor Michael L. Dertouzos, Director of Project MAC. Dr. Hartley Rogers, Jr., Professor of Mathematics and past chairman of the faculty, was appointed Associate Provost.

The past year also marked the retirement of 12 members of the faculty. Their long and dedicated service to M. I. T. will be remembered by their students and colleagues alike.

Of particular sadness to us during the year were the untimely deaths of three active and beloved members of the faculty. Lan Jen Chu, Webster Professor of Electrical Engineering, died after a brief illness in July, 1973. We honor him as a pioneer in the understanding of theoretical radiation problems and as a teacher who left an indelible impression on all those who had the privilege to be his students.

Arthur T. Ippen, Institute Professor Emeritus, died suddenly in April, 1974. A scholar of worldwide renown, Professor Ippen had been associated with M. I. T. for 29 years, and was personally responsible for developing a leading center of education and research in the field of water resources and environmental engineering related to water problems.

Samuel J. Mason, Cecil H. Green Professor of Electrical Engineering, died suddenly in March, 1974. He had come to M. I. T. in 1942, joining the Radiation Laboratory to work on microwave systems. Throughout his career at M. I. T., he was respected widely both for his scholarly attainments and for his deep-seated interest in young people.

These men have been outstanding examples of strength and dedication to our educational programs; they will be remembered and honored long by generations of their students, friends, and associates.

JEROME B. WIESNER, President
PAUL E. GRAY, Chancellor

October 4, 1974

Patterns of Growth and Change — 1940 to 1973

During the summer and fall of 1973, several of us tried to explore whether the ways in which the Institute had evolved during the past third of a century could help us to understand in a more than superficial manner how it might change in the quarter-century ahead of us. To make meaningful predictions obviously was difficult; during the time under consideration, the problems of our society, the conditions of science and technology, the structure of human knowledge, and humanity's expectations all have undergone profound changes. The widespread belief in progress which had accompanied the end of World War II seemed at times to have been replaced by a quasi-apocalyptic feeling that things were out of control, and that the improvident use of technology had been a major contributor to unhealthy growth and waste. We at the Institute were neither immune nor insensitive to these perturbations in the intellectual climate. The Institute's traditional Rogerian philosophy was a strong foundation on which to build, when many curricula elsewhere were blown away by the single word relevance. We tried to deepen our understanding -- and that of M. I. T. students -- of the nation's and of humanity's problems, in the firm conviction that more science and technology would lead to wiser management through responsible use of the opportunities which both basic and applied research provide.

Since 1940, M. I. T. obviously has both grown and changed. Some of the dimensions of this growth are fairly easy to document and even to quantify; however, most of the patterns of change, of increased complexity, are much harder to grasp, let alone to describe numerically.

Let us begin with the number of students attending M. I. T., which has increased by a factor of 2.5 between 1940 and 1973; among the total of students, undergraduates have barely doubled, while the graduate population has increased by a factor of five. We have no figures for the postdoctoral student population before World War II; today there are approximately 500 "postdocs" on campus. The percentage of women students has increased significantly, especially since the opening of McCormick Hall in 1963.

STUDENT ENROLLMENT

Including special students

	<u>1940</u>	<u>1950</u>	<u>1960</u>	<u>1970</u>	<u>1973</u>
Total Students	3,100	5,458	6,270	8,024	7,850
Undergraduate	2,379	3,856	3,580	4,074	4,183
Percentage of Women	1%	1%	2%	6%	11%
Graduate	721	1,602	2,690	3,950	3,667
Percentage of Women	3%	2%	3%	8%	10%

If we look for more meaningful detail in the growth of the student body by examining the distribution of undergraduate and graduate students by Schools, we find the following. The combined percentage of the Schools of Engineering and Science has hardly changed (from

Patterns of Growth and Change

81 to 76 percent), but the mix between the two has; in 1940, the ratio of undergraduate engineering majors to science majors was 3:1, while in 1973 it was 1:1. However, in absolute numbers there were approximately 1,100 engineering majors in 1940, and approximately 1,200 in 1973. It would be informative, of course, to examine intra-School trends and shifts more closely, and to study (for instance) the relative stability of enrollment in the Department of Electrical Engineering compared to the dramatic increase in biology majors within the last decade. (This increase was preceded by the rise of molecular biology and by a career shift toward the health professions -- for example, roughly 10 percent of the Class of 1974 entered medical school, compared with 1 percent of the Class of 1940.)

UNDERGRADUATE ENROLLMENT -- by School

Freshmen excluded; special students included

	<u>1940</u>	<u>1950</u>	<u>1960</u>	<u>1970</u>	<u>1973</u>
Total Undergraduates (freshmen excluded)	1,774	3,112	2,644	3,107	3,137
Engineering	61%	65%	56%	40%	38%
Science	20%	18%	28%	31%	38%
Management	11%	11%	8%	4%	4%
Humanities and Social Science	---	2%	4%	11%	6%
Architecture and Planning	4%	4%	4%	5%	6%
Undesignated	4%	---	---	9%	8%

The number of graduate students has increased almost fourfold in the School of Engineering, and by slightly more than fourfold in the School of Science. However, the combined percentage of these two Schools drops from 94 to 74 percent. We see substantial increases in the graduate student population of the three smaller Schools: the Sloan School of Management, the School of Humanities and Social Science (where only programs in the social sciences have graduate students), and the School of Architecture and Planning. Two of these Schools came into existence in the immediate postwar period (Humanities in 1950, and Sloan in 1951).

GRADUATE ENROLLMENT -- by School

Excluding special students

	<u>1940</u>	<u>1950</u>	<u>1960</u>	<u>1970</u>	<u>1973</u>
Total Graduate Students	689	1,450	2,258	3,395	3,328
Engineering	427	889	1,257	1,555	1,522
(percentages)	62%	61%	56%	46%	46%

Science	222	444	669	1,046	938
(percentage)	32%	31%	30%	31%	28%
Management	19	32	164	329	360
(percentage)	3%	2%	7%	10%	11%
Humanities and Social Science	---	43	103	282	274
(percentage)	---	3%	4%	8%	8%
Architecture and Planning	21	42	65	183	234
(percentage)	3%	3%	3%	5%	7%

Given the above figures, the table reflecting degrees granted should present little surprise. The total number of degrees granted annually has almost tripled; today there are roughly as many master's and engineer's degrees as there are bachelor's. The number of doctorates is 6 to 7 times what it was in 1940, when the Graduate School was just a few years old.

DEGREES GRANTED

	<u>1940</u>	<u>1950</u>	<u>1960</u>	<u>1970</u>	<u>1973</u>
Bachelor's	509	1,052	824	873	1,038
Master's and Engineer's	301	504	781	874	945
Doctorates	64	166	199	439	396
TOTAL	874	1,722	1,804	2,186	2,379

The next table summarizes quite a few economic data: tuition, student costs, and beginning salary. Though each of these quantities approximately triples during the time interval considered, the ratios of tuition to salary (and budget to salary) remain amazingly stable. Without entering into the kind of detail which would be necessary to understand the complex nature of student aid, let us mention just two figures: undergraduate student aid climbed from \$200,000 in 1940 to roughly \$5 million in 1973!

FOUR-YEAR TUITION AND STUDENT COSTS AS RATIOS OF S. B. STARTING SALARY

	<u>1951</u>	<u>1960</u>	<u>1970</u>	<u>1973</u>
Four-Year Tuition	\$3,100	\$4,800	\$8,100	\$10,200
Four-Year Student Budget	6,825	10,050	15,400	18,800

Patterns of Growth and Change

Median Annual Starting Salary Offer (S. B.)	3,804	6,432	10,500	11,280
Tuition/Salary *	.815	.745	.771	.904
Budget/Salary **	1.76	1.565	1.47	1.67

* Ratio of four-year M. I. T. undergraduate tuition costs upon graduation to graduate's median starting annual salary.

** Ratio of four-year M. I. T. undergraduate student budget costs upon graduation to graduate's median starting annual salary.

The expansion of the student body and the related expansion in research¹ have been accompanied by an increase in the number of employees, which is depicted in the following table. Here the category of teaching staff includes faculty, instructors, and teaching assistants, while the category of research staff currently includes approximately 1,000 graduate students who are research assistants, as well as postdoctoral fellows, staff members of sponsored research projects, and so forth.

ON-CAMPUS EMPLOYEES -- by function

Lincoln and Draper Laboratories excluded

	<u>1940</u>	<u>1950</u>	<u>1961</u>	<u>1970</u>	<u>1973</u>
Teaching Staff	538	865	1,187	1,727	1,703
Nonfaculty Research Staff	185	940	1,177	2,213	2,467
Administration	75	114	249	533	582
Library, Medical, and M. I. T. Press Staff	9	38	69	135	155
Support Staff	583	1,695	2,029	3,090	2,891
TOTAL	1,390	3,652	4,711	7,698	7,788

If we focus on faculty members only, we see that the total number has increased a little more than threefold since 1940. The tenured faculty has increased continuously in number, but in the period of greatest faculty expansion -- the late fifties and early sixties -- the percentage of tenured faculty decreased, when most of the new faculty members were brought in as assistant professors. In recent years, many of these assistant professors have been promoted to higher rank and tenure, while the overall number of faculty members has stopped growing. Thus during the last five years, the faculty size has remained

¹ All research projects and programs are directed by members of the faculty, and practically all research involves graduate students; many research projects include the active participation of undergraduates, especially since U. R. O. P. -- the Undergraduate Research Opportunities Program -- came into being.

essentially constant, while the age and rank distribution have been changing. During this period, the number of assistant professors has decreased by about 60.

TENURED FACULTY

Excludes visiting faculty, emeriti faculty

Includes administrative, faculty on leave, medical, and athletic faculty

	<u>1940</u>	<u>1946</u>	<u>1950</u>	<u>1955</u>	<u>1960</u>	<u>1965</u>	<u>1970</u>	<u>1973</u>
Number Faculty	274	315	425	498	621	793	881	881
Number Tenured	NA	192	255	279	298	365	475	525
Percent Tenured	---	61%	60%	56%	48%	46%	54%	60%

The next table shows the sources of funds and revenues for all M.I.T. operations (including the Lincoln and Draper Laboratories) for the period 1940-1973. All of the component sources increased substantially (in part because of inflation), but none as much as the funds for sponsored research. These funds include overhead allowances, which increased from roughly \$3 million in 1950 to over \$30 million in 1973.

SOURCES OF FUNDS AND REVENUES FOR OPERATIONS

(In millions of dollars)

	<u>1940</u>	<u>1950</u>	<u>1960</u>	<u>1970</u>	<u>1973</u>
Tuition and Fees	\$1.8	\$4.2	\$7.9	\$18.5	\$24.6
Investment	1.2	1.3	2.2	7.3	9.8
Gifts	0.1	2.1	6.1	9.1	8.4
Auxiliaries*	0.4	1.4	1.9	6.9	7.9
Sponsored Research** (including on-campus)	0.2 (0.2)	12.0 (9.2)	65.4 (20.1)	169.9 (56.5)	218.1 (71.8)
Unrestricted Funds Used for Operating Expenses	---	0.1	---	4.6	0.8
TOTAL	\$3.7	\$21.1	\$83.5	\$216.3	\$269.6

* Housing, Dining, M.I.T. Press

** Does not include the Use of Facilities Allowance

During the period 1950-1973, the mix of governmental and private agency contribution to the funds for on-campus sponsored research (i. e. excluding the Lincoln and Draper Laboratories) changed appreciably, as the following table indicates. This table contains a good deal of information, perhaps as much about how in the last 25 years Federal agencies

have divided among themselves the support for academic research as about the growth of research in the life and health sciences to a point where it comprises roughly one-third of all research done at M. I. T. Three further comments are in order: 1) the passing of the Mansfield Act accounts for the rather sudden shifts between Department of Defense and National Science Foundation support between 1970 and 1973; 2) the category labeled "industry" hardly conveys an accurate picture of the several ways (Industrial Liaison Program, annual gifts, and so forth) in which industry supports the Institute -- furthermore, industry's percentage of support for sponsored research for the fiscal years 1974 and 1975 is substantially higher than for 1973; and 3) in recent years, the annual rise in total research support has not kept pace with inflation.

This is an appropriate point at which to put into brief perspective the change in Federal policy regarding graduate fellowships and traineeships. Throughout the late 1950s and the 1960s, the number of these fellowships increased. In fiscal years 1969 and 1970, M. I. T. graduate students held approximately 700 such Federal fellowships and traineeships. Since then, the number of awards to M. I. T. students has been cut in half, although M. I. T. students (and M. I. T. as an institution) are among the most successful competitors for the much smaller fellowship pie.

ON-CAMPUS SPONSORED RESEARCH -- SOURCES OF FUNDING

	<u>1950</u>	<u>1960</u>	<u>1970</u>	<u>1973</u>
Department of Defense	81%	47%	27%	18%
National Science Foundation	--	8	11	21
Atomic Energy Commission	12	21	15	11
National Aeronautics and Space Administration	1	2	11	11
National Institutes of Health *	--	6	15	18
Other Federal Government	<u>2</u>	<u>2</u>	<u>5</u>	<u>6</u>
TOTAL Federal Government	96%	86%	84%	85%
Foundations, Education, and Other Nonprofit	--	4	11	10
Industry	4	6	3	3
Other **	<u>--</u>	<u>4</u>	<u>2</u>	<u>2</u>
TOTAL	100%	100%	100%	100%
On-Campus Sponsored Research Revenues (in millions)	\$9.2	\$20.1	\$56.5	\$71.8

* Includes Public Health

** Approximately one-half state and local government and one-half Lincoln and Draper Laboratories

The growth in students, staff, and research support which we have documented obviously needed to be matched by an enlarged physical plant. The next table depicts the various components of this growth. The Support, Administration, and Services category includes such items as libraries, parking garages, and the chilled water plant. The expansion of residential space has made it possible to house 2,000 undergraduates in on-campus dormitories, in addition to the 1,200 who live in nearby fraternities. These figures, which reflect the outcome of the Second Century Fund drive, do not give us details on the age distribution of our buildings. M. I. T. 's physical plant has a book value of close to \$200 million. At current building costs, we must maintain and renovate the plant to keep it efficient, since we cannot think of replacing it. However, maintenance and renovation also are costly, especially for buildings full of sophisticated equipment which requires air conditioning. The recent rise in the cost of utilities is common knowledge; what is perhaps less obvious is that the "intensity of use" (here defined as the number of kilowatt hours per square foot of academic space) has on the average quadrupled since 1940.

BUILDING AREA

(In millions of gross square feet)

	<u>1940</u>	<u>1950</u>	<u>1960</u>	<u>1970</u>	<u>1974</u> [*]
Academic	1.2	1.5	2.1	3.6	3.9
Academic Support, Administration, and Services	0.1	0.2	0.4	1.4	1.5
SUBTOTAL	1.3	1.7	2.5	5.0	5.4
Athletic and Residential	0.5	0.9	1.0	1.5	2.0
TOTAL	1.8	2.6	3.5	6.5	7.4

* Estimated -- includes Center for Cancer Research and Electrical Engineering buildings

As we conclude this statistical bird's-eye view of the Institute's recent past, we must be aware of what we have not encompassed; any attempt to describe a complex institution suffers from a kind of Gresham's Law, in that the quantifiable drives out the significant. There is little in these data that captures the quality of distinctive excellence which the Institute has achieved in this third of a century, a level of excellence for which Drs. Compton, Killian, Stratton, and Johnson have laid the foundations. We could cite statistics on the number of faculty members who are members of academies, or who have won awards and prizes (including the Nobel prize); on the high ratings that departments and Schools obtain from their professional peers; and equally importantly, on the number of top students from the U. S. and other countries who choose M. I. T. over other universities; but all of these still might fail to convey the essence of the reputation which M. I. T. enjoys throughout the world.

We also have not addressed ourselves to the substantive evolution of disciplines and fields. (Physics)₁₉₄₀ clearly is different from (physics)₁₉₇₃,² and to be able to do first-rate physics in 1973 demands different facilities, resources, and talents from those required a

² A fact that is underlined by the number of departments that have changed names during the period under consideration.

third of a century ago. Some of these facilities, resources, and talents have been assembled in interdepartmental laboratories, a new institutional form that came into being after World War II. The Research Laboratory of Electronics, founded in 1946 (as the successor to the famed Radiation Laboratory of World War II), has been the forerunner of close to two dozen interdepartmental laboratories, centers, and programs. These range from space research to international studies, from nuclear science to the Sea Grant Program, from artificial intelligence to transportation, and from materials science and engineering to cancer research.

Many of these laboratories and centers have become incubators of new fields, while others represent problem or mission oriented units in which engineers, natural scientists, and sometimes social scientists collaborate across departmental boundaries. Outside agencies may find it easier to "resonate" with such units than with departments organized along strictly disciplinary lines. The fact that approximately one-half of the Institute's research support comes through these interdepartmental laboratories supports such an assumption.

Finally, we have not dealt with changes in educational patterns, which are at the core of the Institute's commitment. An earlier section of this Report deals with these very issues. What we present in this appendix, then, documents some but clearly not all of the patterns of growth and change which illuminate our institutional history, and which may help us to understand more fully the foundation on which we build our future.

WALTER A. ROSENBLITH, Provost

Statistics for the Year

The following paragraphs report briefly on the various aspects of the Institute's activities and operations during 1973-74.

Registration

In 1973-74, student enrollment was 7,888, an increase of 38 over the 7,850 enrolled in 1972-73. This total was comprised of 4,113 undergraduate and 3,775 graduate students.

Graduate students who entered M.I.T. last year held degrees from 357 colleges and universities, 210 American and 147 foreign. The foreign student population was 1,429, representing 18 percent of the total enrolled. The foreign students were citizens of 93 different countries.

Degrees awarded by the Institute in 1973-74 included 1,065 bachelor's degrees, 832 master's degrees, 102 engineer's degrees, and 378 doctoral degrees -- a total of 2,377.

The number of women at M.I.T., both graduate and undergraduate, has increased continuously. In 1973-74, 921 women students were at the Institute, compared with 816 in 1972-73. In September, 1973, 122 first-year women entered M.I.T. In 1973-74, 194 degrees were awarded to women.

Student Financial Aid

During 1973-74, the student financial aid program again was characterized by increases in total awards, in loans made, and in the amount of scholarship assistance. There was again a decrease in the number of individuals assisted.

A total of 1,671 undergraduates who demonstrated the need for assistance (42 percent of

FIGURE 1

FINANCIAL AID TO UNDERGRADUATE STUDENTS
FROM ALL SOURCES, 1964-1974

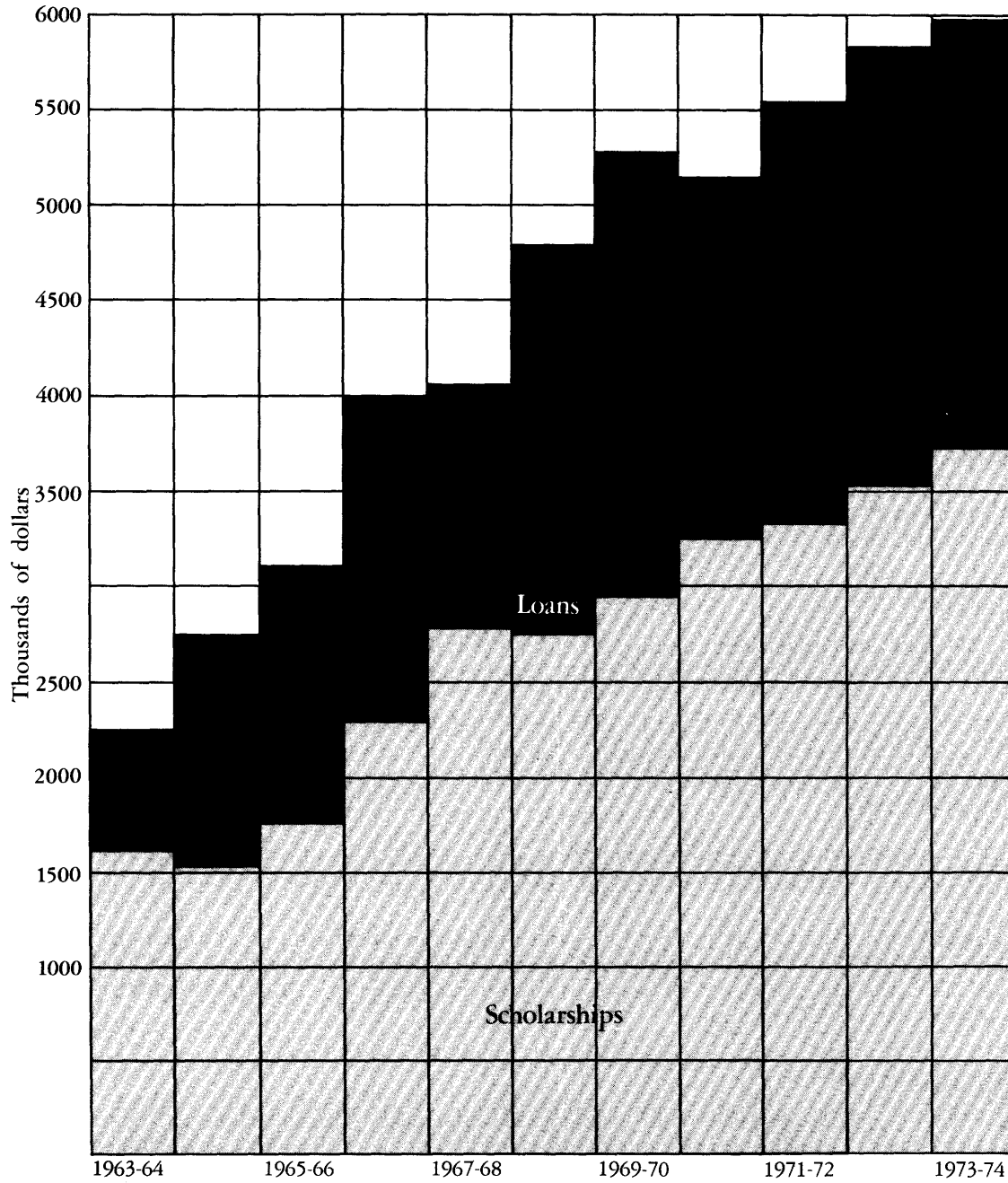
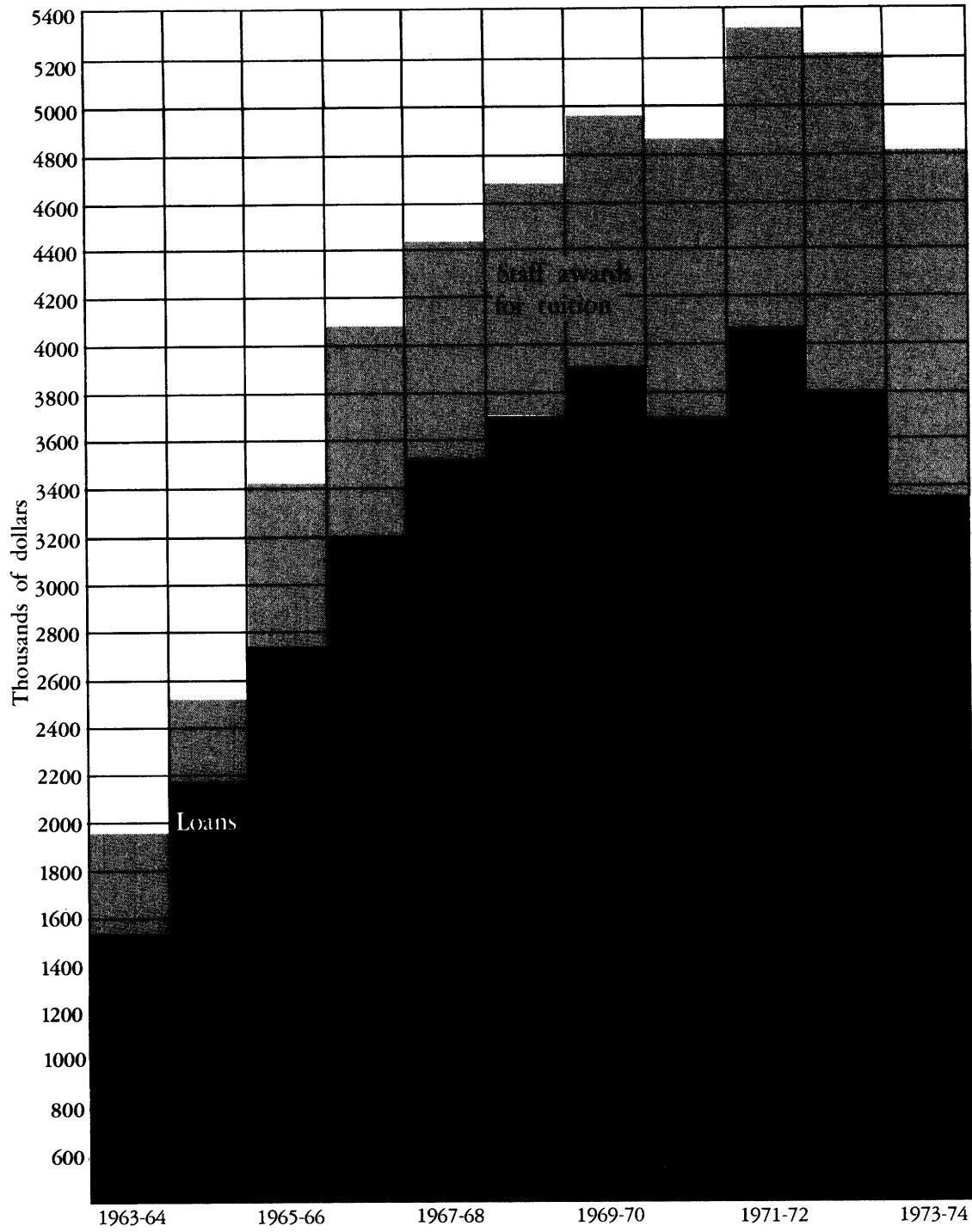


FIGURE 2
FINANCIAL AID TO GRADUATE STUDENTS
AWARDED BY M.I.T. 1964-1974



the enrollment) received \$3,014,426 in scholarship aid and \$1,884,323 in loans. The total of \$4,898,749 represented a small increase in direct aid over last year.

Scholarship assistance was provided by the scholarship endowment in the amount of \$1,746,194, by outside gifts for scholarships in the amount of \$654,447, and by direct grants to needy students totaling \$524,310. Scholarship assistance from M.I.T.'s own operating funds was not used during the year. The special program of scholarship aid to minority group students represented an additional \$89,475 from specially designated funds. An additional 360 students received direct grants from outside agencies, irrespective of need, in the amount of \$708,653. Outside scholarship support thus totaled \$1,887,410, a substantial increase over last year's total. A significant portion of the increase was due to increased funding of the Federal government's grant-aid program. The undergraduate scholarship endowment was aided by the addition of \$410,639 in new funds, which raised the principal of the endowment to \$20,983,707.

Loans totaling \$1,884,323 were made to needy undergraduates. Of this amount, \$572,555 came from the Technology Loan Fund, \$1,309,268 from the National Defense Loan Fund, and the remainder from other M.I.T. loan funds. An additional \$377,269 was obtained by undergraduates from state administered Guaranteed Loan Programs and other outside sources.

Graduate students obtained \$852,010 from the Technology Loan Fund. Of this total, \$331,730 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 \$2,736,333, an increase of \$103,117 over last year's total.

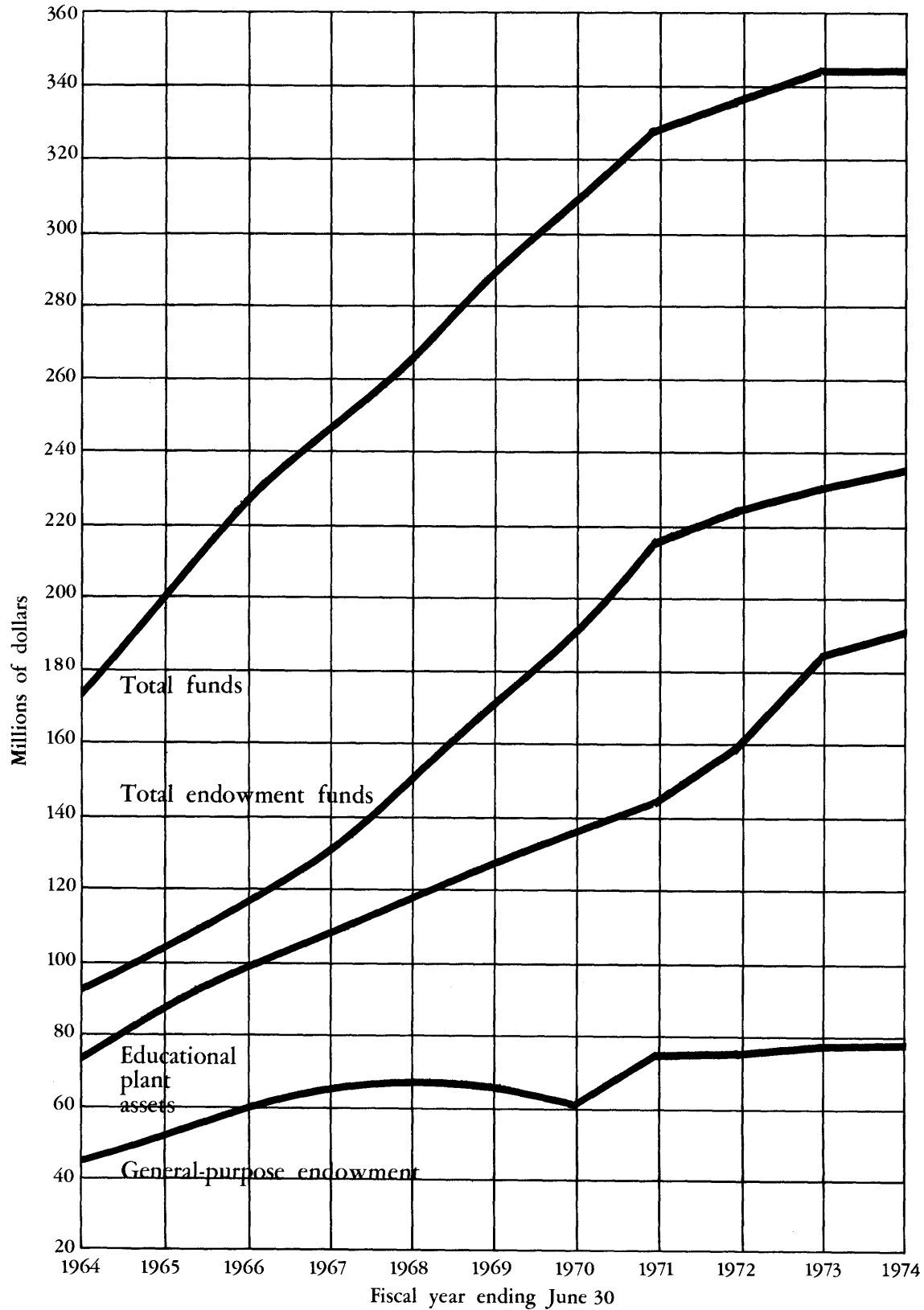
Career Planning and Placement

The past year saw a continued upswing in the demand for M.I.T. graduates in most fields of study. More companies and government agencies came in search of engineers and scientists than in any of the previous three years. Mindful that national enrollments in engineering have decreased sharply, many employers made an extra effort to attract their share of candidates. The demand for master's degree candidates in management remained strong, but it was less than the demand for engineers. The number of employers recruiting at the Sloan School of Management dropped slightly, and salary offers increased hardly at all. In contrast, the employment outlook in architecture was grim indeed. On the last day of classes in May, 1974, no one on the graduate degree list in this area had found a job. By the end of June, a few students had better things to report, but a large number still were unemployed.

Starting salaries moved upward in keeping with the market, although not as steeply as the consumer price index. Graduating students joined that large section of the population which has suffered from the prevailing inflation more than it has contributed to it.

An important event during the year was the move of the Career Planning and Placement Office from the fourth floor of the Ford Building to new quarters on the first floor of Building 10. As a result, the number of students using the Office has increased considerably, perhaps as much as 30 percent. Activity also increased in the area of alumni placement. The number of alumni registering with the Office rose to over 500, from 403 the previous year. In January, 1974, the Office began publication of a four-page job listing (the M.I.T. Alumni Placement Gazette) which is sent approximately once every two weeks to all alumni who maintain current registration. Each issue described 25 to 30 of the most attractive jobs reported to the Office since the previous issue went to press. The Gazette has been received very well by alumni.

FIGURE 3
THE GROWTH OF M.I.T.'S FUNDS AND PLANT ASSETS, 1964-1974



Finances

As reported by the Treasurer, the total financial operations of the Institute, including sponsored research, decreased from the level of 1972-73. Educational and general expenses -- excluding the direct expenses of departmental and interdepartmental research, the Lincoln Laboratory, and the Charles Stark Draper Laboratory -- amounted to \$82,432,000 during 1973-74, compared to \$75,297,000 in 1972-73. Reflected in the finances of the Institute was the increase in the use in operations of unrestricted funds to \$2,528,000, compared with \$757,000 in the preceding year. In addition, the Research Reserve was drawn on for the first time, in the amount of \$2,781,000.

The direct expenses of general departmental and interdepartmental sponsored research increased from \$58,704,000 to \$59,436,000, and the direct expenses of major laboratories and special departmental research decreased from \$129,613,000 to \$76,989,000, largely as a result of the Draper Laboratory divestment.

The construction program of the Institute continued to make progress in 1973-74, with the book value of educational plant facilities increasing from \$182,063,000 to \$190,029,000.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, had a book value of \$340,866,000 and a market value of \$388,176,000. This compares to book and market totals of \$339,333,000 and \$440,924,000 last year.

Gifts

Gifts, grants, and bequests to M. I. T. from private donors increased from \$21,664,000 in fiscal year 1972-73 to \$22,666,000 in fiscal year 1973-74. The latter figure includes unrestricted direct gifts to the Alumni Fund of \$864,000, which constituted part of the total of \$2,917,000 reported by the Alumni Fund in 1973-74.

Physical Plant and Campus Environment

Construction continued during the year on two academic and research projects -- the Chemical Engineering Building, which is located to the east of the Whitaker Building, and the Seeley G. Mudd Building adjacent to the Ford Building. In the spring of 1974, the two basement foundations of the Chemical Engineering Building were completed; work has begun on the building's superstructure.

The fifth floor of the Seeley G. Mudd Building was completed in December, 1973, just nine months after the start of construction. The staff of the Center for Cancer Research moved into that floor immediately and initiated their research programs, while construction continued on the remaining floors. The Arteriosclerosis Center, located on the fourth floor, was completed and occupied in May, 1974, and the headquarters of the Center for Cancer Research on the first floor were completed in June. The remainder of this building was substantially complete by the summer of 1974.

Major construction was initiated during the year on the West Campus Undergraduate House and the Geophysical Underground Laboratory. The West Campus Undergraduate House, a reinforced concrete residence for 300 students, will be located on Memorial Drive adjacent to MacGregor House. Foundation work on this structure was begun in April, 1974; the building is scheduled to be occupied in the fall of 1975. The Geophysical Laboratory, located near the Wallace Astrophysical Observatory in Westford, Massachusetts, will be devoted to seismic research.

Personnel Changes

In the housing area, the renovation of the west wing of Ashdown House was completed in November, 1973; students moved into the new spaces in December. Renovations began immediately on the east wing of the building, and this work is now substantially complete.

Two other projects involving changes in dormitory spaces were completed this year. Since an office and desk area were built on the first floor of its Ware entryway, Senior House has functioned independently of the East Campus Houses. Also, the west lounge on the fourth floor of Baker House underwent a renovation which incorporated new furnishings, lighting, and carpeting.

On May 30, 1974, the Institute received a Special Award of Merit from the Massachusetts Horticultural Society "for the use of trees and plants around a great university." One of only five such awards made for the year 1973 by this prestigious horticultural organization, the merit award was the first such honor presented to an entire university campus.

* * * * *

Personnel Changes from October 1, 1973, to September 30, 1974

Corporation

DEATHS

James M. Barker
Life Member

Vannevar Bush
Life Member

H. I. Romnes
Member

CHANGE OF APPOINTMENT

Lloyd D. Brace
Life Member Emeritus

ELECTIONS

Louis W. Cabot
Member

Frank T. Cary
Member

Gregory A. Chisholm
Representative from
Recent Classes

Thomas F. Creamer
Member

Edward E. David, Jr.
Member

Luis A. Ferré
President of the Alumni
Association

Charles E. Reed
Member

Cecily C. Selby
Member

REELECTIONS

James A. Champy
Member

Jerome H. Holland
Member

Breene M. Kerr
Member

Carl M. Mueller
Member

Jeptha H. Wade
Member

RESIGNATIONS

William R. Hawthorne
Member

TERMS EXPIRED

William S. Edgerly
President of the Alumni
Association

Elisha Gray II Member	George P. Wadsworth Professor in Mathematics	James E. Potter Aeronautics and Astronautics
Christina H. Jansen Representative from Recent Classes	Minor White Professor in Architecture	Myron S. Scholes Sloan School of Management
Harold E. Thayer Member	RESIGNATIONS	Ronald C. Shank Nutrition and Food Science
Faculty	<u>Professors:</u>	Pin Tong Aeronautics and Astronautics
DEATHS	Edward H. Bowman Sloan School of Management	Frederick Y. M. Wan Mathematics
Arthur I. Ippen Institute Professor Emeritus	P. L. Thibaut Brian Chemical Engineering	Luther S. Williams Biology
Samuel J. Mason Professor in Electrical Engineering	Frederick W. Frey Political Science	<u>Assistant Professors:</u>
RETIREMENTS	Eugene Goodheart Humanities	James E. Annable Sloan School of Management
Douglas P. Adams Professor in Mechanical Engineering	G. Hubert Matthews Foreign Literatures and Linguistics	James D. Callen Aeronautics and Astronautics
Lynwood S. Bryant Professor in Humanities	Vincent V. McRae Civil Engineering	James F. Drummond Nutrition and Food Science
Margaret Z. Freeman Associate Professor in Foreign Literatures and Linguistics	Norman A. Phillips Meteorology	Samuel M. Fleming Chemical Engineering
Shih-Ying Lee Professor in Mechanical Engineering	Steven Weinberg Physics	Charles T. Grant Physics
William N. Locke Professor in Foreign Liter- atures and Linguistics, and Foreign Study Advisor	<u>Associate Professors:</u>	Richard C. Lanza Physics
Myle J. Holly Professor in Civil Engineering	John J. Deyst Aeronautics and Astronautics	Joseph B. Lassiter Ocean Engineering
Victor P. Starr Professor in Meteorology	Jean-Pierre Flatt Nutrition and Food Science	Thomas R. McGetchin Earth and Planetary Sciences
George E. Valley Professor in Physics	John Graves Philosophy	John W. Morgan Mathematics
	Michel Y. Jaffrin Mechanical Engineering	Gary J. Powers Chemical Engineering
	Ralph L. Keeney Sloan School of Management	Jorgen Randers Sloan School of Management
	Thomas J. Lardner Mechanical Engineering	Christopher Schaefer Political Science

Personnel Changes

John B. See
Metallurgy and Materials
Science

Murat R. Sertel
Sloan School of Management

Guillermo J. Vicens
Civil Engineering

PROMOTIONS

To Professor:

Thomas J. Allen
Sloan School of Management

Sow-Hsin Chen
Nuclear Engineering

C. Allin Cornell
Civil Engineering

Alan Davison
Chemistry

Robert E. Hall
Economics

Willard R. Johnson
Political Science

Robert S. Kennedy
Electrical Engineering

Langley C. Keyes
Urban Studies and Planning

James L. Kinsey
Chemistry

Daniel Kleppner
Physics

Walter Lewin
Physics

Chiang C. Mei
Civil Engineering

Robert C. Merton
Sloan School of Management

Borivoje B. Mikic
Mechanical Engineering

Steven A. Orszag
Mathematics

Robert I. Rotberg
Humanities

Alvin J. Silk
Sloan School of Management

Ain Sonin
Mechanical Engineering

Steven R. Tannenbaum
Nutrition and Food Science

Daniel I. C. Wang
Nutrition and Food Science

Martin L. Weitzman
Economics

Sheila E. Widnall
Aeronautics and Astronautics

Bernhardt J. Wuensch
Metallurgy and Materials
Science

To Associate Professor:

Barry A. Blesser
Electrical Engineering

H. Kent Bowen
Metallurgy and Materials
Science

Chryssostomos Chryssostomidis
Ocean Engineering

Catherine V. Chvany
Foreign Literatures and
Linguistics

Harry S. Colburn
Electrical Engineering

Charles C. Counselman
Earth and Planetary Sciences

Renwick E. Curry
Aeronautics and Astronautics

Robert F. Engle
Economics

Stephen Erdely
Humanities

Michael J. Fischer
Electrical Engineering

Clifton G. Fonstad
Electrical Engineering

E. Victor George
Physics

Jochen Heinsenber
Physics

Joel A. Huberman
Biology

Gordon V. Kelly
Athletics

Jonathan A. King
Biology

Heather N. Lechtman
Humanities

Margaret L. A. MacVicar
Physics

William H. Matthews
Civil Engineering

John W. Morgan
Mathematics

Amedeo R. Odoni
Aeronautics and Astronautics

Wayne M. Pecknold
Civil Engineering

William M. Rand
Nutrition and Food Science

David G. Schaeffer
Mathematics

William J. Shack
Mechanical Engineering

Lawrence Susskind
Urban Studies and Planning

Robert J. Taylor
Physics

President and Chancellor

Ian D. Terner
Urban Studies and Planning

Philip Thullen
Mechanical Engineering

Richard C. Tremaglio
Architecture

Barry L. Vercoe
Humanities

Judith G. Wechsler
Architecture

James H. Williams
Mechanical Engineering

To Assistant Professor:

Elizabeth C. Altman
Humanities

Arnold I. Barnett
Sloan School of Management

Robert C. Channon
Foreign Literatures and
Linguistics

Michael L. Fredman
Mathematics

Peter Herman
Humanities

James Howe
Humanities

Miles Morgan
Philosophy

Lorenzo Morris
Political Science

Paul S. Wang
Mathematics

CHANGES OF APPOINTMENT

Richard B. Adler
Cecil H. Green Professor in
Electrical Engineering

Alan Altshuler
Senior Lecturer in Political
Science

Michael M. Athans
Professor in Electrical
Engineering and Director
of the Electronic Systems
Laboratory

Raymond F. Baddour
Lamot du Pont Professor
and Head of Department of
Chemical Engineering

Jeanne S. Bamberger
Associate Professor of
Education and Music in
Humanities and Division
for Study and Research in
Education

Julian Beinart
Professor in Architecture

Claude R. Canizares
Assistant Professor in Physics

Jule G. Charney
Sloan Professor and Head of
Department of Meteorology

Fernando J. Corbato
Professor and Associate Head
of Department of Electrical
Engineering

Robert W. Crandall
Research Associate in
Economics

Charles K. Crawford
Research Affiliate in
Electrical Engineering

Wilbur B. Davenport, Jr.
Professor of Engineering and
Education in School of Engi-
neering and Division for
Study and Research in Edu-
cation, Acting Director of
Center for Advanced Engi-
neering Study and Head of
Department of Electrical
Engineering

Michael L. Dertouzos
Director of Project MAC and
Professor in Electrical
Engineering

Peter Elias
Edwin S. Webster Professor
in Electrical Engineering

Joseph Ferreira, Jr.
Class of 1922 Career De-
velopment Assistant
Professor in Urban Studies
and Planning

Samuel A. Goldblith
Underwood-Prescott Pro-
fessor of Food Science in
Nutrition and Food Science
and Director of Industrial
Liaison

Ted R. I. Greenwood
Assistant Professor in
Political Science

Imre Halasz
Professor in Architecture

Robert L. Halfman
Professor in Aeronautics
and Astronautics and
Visiting Associate Dean
for Student Affairs

Sandra C. Howell
Associate Professor in
Architecture

Robert L. Jaffe
Assistant Professor in
Physics

Marcus Karel
Professor of Food Engineer-
ing and Deputy Head in
Department of Nutrition
and Food Science

Edward C. Kern
Assistant Professor in
Ocean Engineering

John G. King
Francis Friedman Pro-
fessor in Physics

Personnel Changes

Stephen G. Kukolich
Visiting Scientist in
Chemistry

Donald R. Lessard
Assistant Professor in Sloan
School of Management

Paul W. MacAvoy
Henry R. Luce Professor of
Environment and Public
Policy in Sloan School of
Management

Manuel Martinez-Sanchez
Assistant Professor in Aero-
nautics and Astronautics

Bruce Mazlish
Acting Head of Department of
Humanities and Professor of
History

Robert W. Mann
Uncas A. Whitaker Professor
of Biomedical Engineering in
Department of Mechanical
Engineering

Roger G. Mark
Hermann von Helmholtz
Associate Professor of
Electrical Engineering and
Health Sciences and Tech-
nology

William H. Matthews
Arthur D. Little Assistant
Professor of Environment
Sciences and Engineering
in Civil Engineering

Ronald P. McCaffrey
Visiting Assistant Professor
in Biology

John F. McCarthy
Director of Center for Space
Research and Professor in
Aeronautics and Astronautics

Edward W. Merrill
Carbon P. Dubbs Professor in
Chemical Engineering

Marvin L. Minsky
Donner Professor of Science
in Department of Electrical
Engineering and Co-Direc-
tor of Artificial Intelligence
Laboratory

Francois M. M. Morel
Henry L. Doherty Assistant
Professor of Ocean Utili-
zation in Ocean Engineer-
ing

Joel Moses
Associate Director of
Project MAC and
Associate Professor
of Electrical Engineering

Richard S. Naylor
Research Affiliate in Earth
and Planetary Sciences

Seymour A. Papert
Cecil and Ida Green Professor
of Education in Division for
Study and Research in Edu-
cation, and Professor in
Mathematics

Bryan R. Pearce
Assistant Professor in
Civil Engineering

Paul L. Penfield, Jr.
Professor and Associate Head
of Department of Electrical
Engineering

Frank E. Perkins
Professor in Civil Engineer-
ing and Special Assistant to
the Dean of Engineering for
Educational Programs

Otto Piene
Professor in Architecture
and Director of the Center
for Advanced Visual Studies

Stephen A. Raymond
DSR Staff Member

Herbert H. Richardson
Professor and Head of
Department of Mechanical
Engineering

John F. Rockart
Senior Lecturer in Sloan
School of Management

Hartley Rogers, Jr.
Associate Provost and
Professor in Mathematics

John C. Schaake
Visiting Associate Professor
in Civil Engineering

Donald A. Schon
Ford Professor of Urban
Studies and Education in
Urban Studies and Planning
and Division for Study and
Research in Education

Campbell L. Searle
Senior Lecturer in
Electrical Engineering

Louis D. Smullin
Dugald Caleb Jackson
Professor in Electrical
Engineering

Albert Solbes
Research Associate in
Aeronautics and Astro-
nautics

H. Eugene Stanley
Hermann von Helmholtz
Associate Professor of
Physics and Health
Sciences and Technology

Peter H. Stone
Professor in Meteorology

Lawrence Susskind
Associate Professor and
Assistant Department
Head in Urban Studies
and Planning

William P. Thurston
Sloan Fellow in Mathematics

President and Chancellor

Erik H. Vanmarcke Gilbert W. Winslow Associate Professor in Civil Engineering	Ann F. Friedlaender Civil Engineering and Economics	Klaus J. Bathe Mechanical Engineering
Joseph F. Vittek, Jr. Assistant Professor in Aeronautics and Astronautics	Lance J. Taylor Nutrition and Food Science and Economics	James M. Becker Civil Engineering
Myron Weiner Professor and Head of Department of Political Science	Myron Tribus School of Engineering and Director of Center for Advanced Engineering Study	John R. Bennett Earth and Planetary Sciences
Richard W. Wertz Lecturer in Humanities	Charles Weiner School of Humanities	George W. Brandenburg Physics
Daniel E. Whitney Lecturer in Mechanical Engineering	<u>Associate Professors:</u> Steven Dubowsky Mechanical Engineering	Leonard G. Buckle Urban Studies and Planning
Alan S. Willsky Assistant Director of Electronic Systems Laboratory and Assistant Professor in Electrical Engineering	John E. Hart Meteorology	Suzann T. Buckle Urban Studies and Planning
Carroll L. Wilson Mitsui Professor in Problems of Contemporary Technology in Sloan School of Management	Ronald M. Latanision Metallurgy and Materials Science	Peter Pin-Shan Chen Sloan School of Management
Joel Yellin Associate Professor in School of Humanities and Social Science	Cho K. Rha Nutrition and Food Science	James D. Felske Mechanical Engineering
Ronald W. Yeung Assistant Professor in Ocean Engineering	Philip A. Sharp Biology	Robert W. Field Chemistry
<u>NEW FACULTY APPOINTMENTS</u>	Robert Suskind Nutrition and Food Science and Associate Director of Clinical Research Center	Edward M. Graham Sloan School of Management
<u>Professors:</u> Herman Chernoff Mathematics	<u>Assistant Professors:</u> Donald B. Anthony Chemical Engineering	Alan J. Grodzinsky Electrical Engineering
Mac V. Edds Nutrition and Food Science and Executive Director of Neurosciences Research Program	F. Christopher Arterton Political Science	Michael M. Hammer Electrical Engineering
	Tanya M. Atwater Earth and Planetary Sciences	Reuben T. Harris, Jr. Sloan School of Management
	Raymond M. Baker Biology	Ellen J. Henderson Chemistry
		John Joannopoulos Physics
		John Kassakian Electrical Engineering
		Stephen J. Kobrin Sloan School of Management
		James P. Kostman Philosophy
		Roberto L. Lenton Civil Engineering

Personnel Changes

James M. Lyneis
Sloan School of Management

Sitikantha Mahapatra
Sloan School of Management

Kenneth R. Manning
School of Humanities and
Social Science

Jeffrey A. Meldman
Sloan School of Management

Peter Molnar
Earth and Planetary Sciences

Thomas E. Nutt
Urban Studies and Planning

Owen H. Oakley, Jr.
Ocean Engineering

Ronald L. Rivest
Electrical Engineering

Nils R. Sandell
Electrical Engineering

Prabha Sridharan
Mechanical Engineering

Keith Stolzenbach
Civil Engineering

Hoo-Min D. Toong
Electrical Engineering

Daniele Veneziano
Civil Engineering

Guillermo J. Vicens
Civil Engineering

Stephen A. Ward
Electrical Engineering

Stanley A. West
Civil Engineering

John L. Wilson
Civil Engineering

Langdon Winner
School of Humanities and
Social Science

VISITING FACULTY

Visiting Professors:

Pierre Aigrain
Henry B. Luce Professor of
Environment and Public
Policy

Turner Alfrey
Metallurgy and Materials
Science

Ilhan A. Birkan
Mechanical Engineering

Jerome S. Bruner
Division for Study and Re-
search in Education

Lennart A. E. Carleson
Mathematics

Pierre Cartier
Mathematics

Ming M. Chen
Aeronautics and Astronautics

Arnold Collery
Economics

Charles S. Davidson
Nutrition and Food Science
and Program Director of
Clinical Research Center

Murray A. Geisler
Sloan School of Management

Jeffrey Goldstone
Physics

G. Robert Greenberg
Chemistry

James M. Ham
Electrical Engineering

Leif M. Hambræus
Nutrition and Food Science

William R. Hawthorne
School of Engineering

James S. Hekimian
Sloan School of Management

Thomas A. Jaeger
Nuclear Engineering

Thomas F. Jones
School of Engineering and
Division for Study and
Research in Education

John S. Kark
Military Science

Fritz Klein
Chemistry

Kai Kroger
Metallurgy and Materials
Science

Harold D. Lasswell
Political Science

Henryk J. Leskiewicz
Mechanical Engineering

Alvin Liberman
Psychology

Richard S. Lindzen
Meteorology

John P. Longwell
Chemical Engineering

James E. Mark
Chemical Engineering

Alva R. Myrdal
Political Science

Christian Norbert-Schulz
Architecture

Uwe Pape
Electrical Engineering

John R. A. Pearson
Chemical Engineering

Paul F. Rempp
Chemical Engineering

Helmut Schnelle
Foreign Literatures and
Linguistics

William B. Schwartz
Electrical Engineering

Larry Schwartzman
Aerospace Studies

Gian-Carlo Setti
Physics

Milton Shaw
Nuclear Engineering

George L. Siscoe
Physics

Evgueni N. Sokolov
Psychology

Abraham Szoke
Electrical Engineering

Pravin Varaiya
Electrical Engineering

Hian P. Yap
Mathematics

Visiting Associate Professors:

Yvan Allaire
Sloan School of Management

Dennis D. Buss
Electrical Engineering

E. Eugene Carter
Sloan School of Management

Siegmund Fischer
Biology

Goesta H. Granlund
Electrical Engineering

J. Karl Hedrick
Mechanical Engineering

J. Morgan Jones
Sloan School of Management

Julius Kuti
Physics

Claudio Rebbi
Physics

Peter L. Rogers
Nutrition and Food Science

Erik Sandewall
Electrical Engineering

Warren D. Seider
Chemical Engineering

William Simon
Electrical Engineering

Shin Takeuchi
Mechanical Engineering

Koichi Yazaki
Physics

Visiting Assistant Professors:

Marie J. Adams
Humanities

Thomas H. Brylawski
Mathematics

Gabriel Y. Handler
Civil Engineering

Allan S. Jacobson
Biology

John D. Malcolm
Mechanical Engineering

David S. McClain
Sloan School of Management

Margaret D. McDuff
Mathematics

Hideo Okamura
Mechanical Engineering

Ezio Tarantelli
Sloan School of Management

Herbert Weber
Electrical Engineering

Michael E. Werner
Sloan School of Management

Lothar Wolf
Nuclear Engineering

AWARD:

Morris Cohen
Killian Award Lecturer for
the Academic Year 1974-75

Administration

DEATHS

James G. Cronin
Administrative Staff
Comptroller's Accounting
Office

RETIREMENTS

Jules J. Sherman
Grants Accountant
Comptroller's Accounting
Office

Donald Whiston
Deputy Director
Physical Plant

RESIGNATIONS

James C. Allison, Jr.
Assistant for Minority Affairs
Office of the President and
Chancellor

Cora H. Bartholow
Programming Analyst
Information Processing Center

Nancy J. Beckley
Systems Programmer
Planning Office

Donna D. Berman
Special Assistant
Institute Real Estate Office

Sheila B. Beyer
Associate Director
Institute Real Estate Office

Personnel Changes

Vera R. Borum Employee Instructor Office of Personnel Development	Edward T. Hester Assistant Manager Systems Development Office of Administrative Infor- mation Systems	Ronald W. Regan Administrative Staff Lincoln Fiscal Office
Barbara A. Breazeale Systems Analyst Office of Administrative Information Systems	Paul E. Johnson Associate Director Institute Information Services	Lauri E. Rosser Assistant Design Manager M. I. T. Press
Ellen C. Burbank Associate Director Council for the Arts at M. I. T.	Charles F. Kiefer Assistant Director Office of Sponsored Programs	Ralph Segman Managing Editor, Technology Review Alumni Association
Edwin F. Butters Administrative Staff Comptroller's Accounting Office	Rebecca M. McGovern Marketing Director M. I. T. Press	Lawrence W. Speck Researcher Office of the Vice President, Operations
Jordan D. Carter Associate Director M. I. T. Associates Program	Benjamin F. Moultrie Assistant Director Student Financial Aid Office	James F. Steuert Subsystems Programmer Programming Development Office
Peter Clark Acting Marketing Director M. I. T. Press	Janice O. Morgan Employee Instructor Office of Personnel Development	Paul Tamulynas Grant and Contract Accountant Comptroller's Accounting Office
Gerald Edwardsen Assistant Sales Manager M. I. T. Press	John D. O'Connor Staff Accountant Comptroller's Accounting Office	Richard Tilden System Programmer Programming Development Office
Martha N. Fateman Applications Analyst Information Processing Services	Richard C. Pippen Application Programmer Office of Administrative Infor- mation Systems	Tekle A. Tomlinson Assistant Director Admissions Office
Margaret W. Foote Photojournalist, News Office Institute Information Services	Cornelius F. Provost Application Programmer Office of Administrative Infor- mation Systems	Arnold C. Tovell Editorial Director M. I. T. Press
Judith H. Gimple Assistant Production Manager M. I. T. Press	Ronald Rakip Programmer Programming Development Office	Carla J. VanHoesen Applications Analyst Information Processing Center
Charles W. Goodell Staff Editor M. I. T. Press	Rosemary Ralph Placement Counselor Office of the Vice President, Administration and Personnel	Howard Webber Director M. I. T. Press
Ina M. Harmon Staff Accountant Comptroller's Accounting Office	Robert Rebello Programming Analyst Information Processing Center	Deborah Weinstein Advertising and Promotion Manager M. I. T. Press

Leigh Woodward
Associate Director
Institute Real Estate Office

APPOINTMENTS AND
CHANGES

E. Annette Anderson
Assistant Director
Council for the Arts at
M. I. T.

Gene F. Armstrong
Systems Analyst
Office of Administrative
Information Systems

Mary L. Atkinson
Assistant to the Director
Office of Sponsored Programs

Anne Aylward
Administrative Assistant in
Urban Studies and Planning

Stephen E. Barnes
Director of Special Events for
Alumni Association

Harvey Baumel
Assistant to the Director
Programming Development
Office

Doris C. Berizzi
Architect, Programming and
Design Review
Planning Office

John B. Bidwell
Applications Guidance
Coordinator
Planning Office

Laurence H. Bishoff
Associate Director for
Administration
Medical Department

Carol M. Bostick
Staff Accountant
Comptroller's Accounting
Office

Andrew J. Brown
Staff Accountant
Comptroller's Accounting
Office

Barbara V. Buchan
Assistant to the Director
Office of the Vice President for
Resource Development

Allan S. Bufferd
Institute Secretary
Institute Estate Secretary

Robert M. Byers
Director, News Office and
Acting Director of Institute
Information Services

Calvin D. Campbell
Assistant Director, News
Office (Photojournalist)
Institute Information Services

Daniel A. Carrier
Administrative Officer in
Psychology

Richard J. Cerrato
Administrative Assistant
Information Processing Center

Gerald L. Clarke
Manager, Administrative and
Data Systems Planning
Programming Development
Office

Deborah Cohen
Assistant Staff Writer/
Researcher
Resource Planning

Allen M. Commeau
Staff Accountant
Comptroller's Accounting Office

Muriel Cooper
Media/Design/Production
Director
M. I. T. Press

Meredith E. Copeland
Applications Programmer
Office of Administrative
Information Systems

John A. Currie
Director of Finance

Raymond M. Diffley
Associate Director
Safety Office

Thomas E. Donnelly
Applications Guidance
Coordinator
Planning Office

James P. Donohue
Assistant Director
Programming Development
Office

Alice Drake
Documentation Support
Specialist
Office of Administrative
Information Systems

Richard C. Driscoll
Captain
Campus Patrol

James H. Eacker
Assistant to the Vice President
Office of Vice President

Margaret E. Fahey
Assistant Supervisor,
Computer Operations
Lincoln Fiscal Office

Barbara M. Farquhar
Senior Application Programmer
Office of Administrative
Information Systems

Brenda L. Ferriero
Computer Services Coordinator
Information Processing Center

Jacquelyn M. Findlay
Assistant Director of the
Alumni Fund
Alumni Association

William J. Fitzgerald
Operations Support Coordinator
Office of Administrative
Information Systems

Personnel Changes

Peter H. Flagg Project Manager Office of Administrative Information Systems	Alan E. Harrington Control Supervisor Comptroller's Accounting Office	Donald B. Johnson Assistant Director Development Office
John M. Flynn Assistant Auditor Audit Division	Noel P. Hart Technical Assistant to Oper- ations Manager Office of Administrative Infor- mation Systems	Dexter J. Kamilewicz Assistant Director Housing and Food Services
Winston E. Flynn Assistant Registrar Registrar's Office	Rachel L. Hayes Programming Analyst Information Processing Center	Emily Hui-Sun Kao Application Programmer Office of Administrative Infor- mation Systems
Nancy R. Foti Staff Accountant Comptroller's Accounting Office	Lyman R. Hazelton, Jr. Programming Analyst Information Processing Center	Peter B. Kelley Programmer Programming Development Office
John M. Fresina Director Safety Office	Betty L. Hendricks Supervisor, Academic Staff Records Office	Philip J. Keohan Comptroller
Ruth S. Goodwin Assistant to the Registrar Registrar's Office	Office of the Vice President, Administration and Personnel	Susan C. Knight Associate Director Council for the Arts at M. I. T.
Ann B. Gordon Assistant Dean for Academic Administration in the School of Architecture and Planning	James L. Homan Programmer Information Processing Center	Jane Kosut Assistant to the Director Office of Sponsored Programs
Robert P. Greene Program Officer Office of Sponsored Programs	Susan Haigh Houpt Advisor on Preprofessional Education Office of the Dean for Student Affairs	Robert W. Krieg Project Manager Office of Administrative Infor- mation Systems
Carol J. Greenough System Programmer Programming Development Office	Michael K. Hubner Assistant Staff Writer/ Researcher Resource Planning	Roberta F. J. Kurland Assistant Director Student Financial Aid Office
Carl W. Hagge Environmental Engineer Physical Plant	Leslie Clift Hruby Director of Placement and Assistant to the Dean Sloan School of Management	John P. Leonard Assistant Comptroller Comptroller's Accounting Office
Robert Hagopian Institute Secretary Office of the Vice President for Resource Development	Daryl Hymoff Senior Application Programmer Office of Administrative Information Systems	S. Edward Leonard, Jr. General Manager -- Food Services Housing and Food Services
David J. Harrigan Project Officer Office of Sponsored Programs	Phyllis Lou Jackson Assistant to the Director Career Planning and Placement	Grace A. Lewis System Programmer Programming Development Office

President and Chancellor

Thomas E. Lightburn Assistant Director Office of Sponsored Programs	Philip A. McMahon Supervisor, Computer Operations Lincoln Fiscal Office	John D. O'Sullivan Accounting Officer Comptroller's Accounting Office
Kathryn Lombardi Associate, Analytical Studies and Planning Group and Manager, Campus Information Services	John T. McNeil Manager, Student Center Food Services Housing and Food Services	Martha M. Pennell Systems Programmer/Analyst Planning Office
Michael F. Luck Assistant Director Development Office	Elaine B. Medverd Administrative Officer in Division for Study and Research in Education	Merry Peterson Programmer/Analyst Resource Planning
Judith Lugas Facilities Data Manager Planning Office	Frank O. Melanson Systems Analyst Office of Administrative Information Systems	Michael G. Petruzzello Project Manager Office of Administrative Information Systems
Marilyn Lynch Assistant Auditor Audit Division	Louis Menand Special Assistant to the Provost and Senior Lecturer in Political Science	Carol H. Pettyjohn Program Secretary Information Processing Center
William R. MacDonald System Programmer Programming Development Office	Dennis L. Meredith Managing Editor, Technology Review Alumni Association	Philip L. Philips Systems Analyst Office of Administrative Information Systems
John L. Mack Staff Recruiter Office of Personnel Services	Stanton I. Moody System Planner Programming Development Office	Felicia Pleuthner Area Coordinator Office of Administrative Information Systems
Mary J. Manning Assistant to the Director Educational Council	Mary L. Morrissey Director, Information Center Institute Information Services	Nancy C. Pokross Graphic Designer Institute Information Services
Patricia Maroni Assistant Director, News Office Institute Information Services	Thomas E. Mullen Accounting Officer Comptroller's Accounting Office	Paul C. Powell Assistant Director Office of Sponsored Programs
Victor Maslov Manager, Resource/Alumni Data Systems Resource Planning	Pamela L. Northridge Programming Analyst Information Processing Center	George E. Pratt Area Coordinator/Financial Office of Administrative Information Systems
Robert F. Matson Systems Analyst Resource Planning	N. Leo Rasmussen Acting Director of Center for Information Systems Research in Sloan School of Management	James F. Purtell Assistant Programming Coordinator Office of Administrative Information Systems
Richard May Assistant Comptroller Comptroller's Accounting Office		Thomas D. Quirk Designer/Draftsman Planning Office
Catherine R. McDonald Application Programmer Office of Administrative Information Systems		

Personnel Changes

Robert R. Ragusa Staff Accountant Comptroller's Accounting Office	John C. Sears Assistant Comptroller Comptroller's Accounting Office	Richard M. Stetson Senior System Programmer Programming Development Office
Wayne Richards Assistant Manager of Operations Office of Administrative Information Systems	Alex L. Seid Assistant Project Planner Planning Office	Sarah A. Sumner Assistant to the Wage and Salary Administrator Office of Personnel Relations
James J. Righi System Programmer Programming Development Office	Robert M. Shaw Systems Analyst Office of Administrative Information Systems	James H. Sussbauer Programming Coordinator Office of Administrative Information Systems
William O. Risinger, Jr. Senior System Programmer Programming Development Office	Robert Shillington Application Programmer Office of Administrative Information Systems	Peter Talbert-Hall Sales Manager M. I. T. Press
Roger A. Roach Manager of System Programming Programming Development Office	Rosalita Sicherman Employee Instructor Office of Personnel Development	Reynolds W. Thompson Planner Planning Office
Patience P. Rochester System Programmer Programming Development Office	William Simmons MODE, Executive Officer Department of Meteorology	Ralph H. Thuftedal Application Programmer Office of Administrative Information Systems
Paul J. Saia, Jr. Assistant Manager of Systems Development Office of Administrative Information Systems	Victoria V. Sirianni Interior Designer Purchasing Office	John B. Turner Assistant Dean Office of the Graduate School
Christine A. Salmon Journals Department Manager M. I. T. Press	Franklin C. Smith System Programmer Programming Development Office	Lamar Washington General Manager of Innovation Co-op
Christine C. Santos Assistant Editor, Technology Review Alumni Association	Mary C. Smith Administrative Assistant Housing and Food Services	Suzanne Weinberg Coordinator, Lobby 7 Committee Office of the Vice President, Administration and Personnel
Kathleen B. Sayre Production Manager Alumni Association	Ena C. Squires Assistant to the Director of the Alumni Fund Alumni Association	Bruce Wheeler Application Programmer Office of Administrative Information Systems
Harry A. Schade Staff Accountant Comptroller's Accounting Office	Paul N. Stanton Associate Director of the Alumni Fund Alumni Association	Clarence G. Williams Special Assistant to the President and Chancellor for Minority Affairs
	Sylvia Steiner Media Designer M. I. T. Press	George T. Williams Programming Analyst Information Processing Center

President and Chancellor

Maureen M. Yagodka
Co-Director
Office of Personnel
Development

F. Adam Yagodka
Co-Director
Office of Personnel
Development

Dean for Student Affairs

This report will begin with an updating of the issues considered in last year's report. The success of the major effort for staff recruitment and the continued solid performance of incumbents resulted in personnel stability, as novices and old hands learned to work effectively with each other. One major vacancy remains unfilled; the Dean and her colleagues continued to share the role while they considered how best to restructure the Office.

Dean Eisenberg's campaign to develop direct and personal relations with students has continued, with the addition of an Open House during Residence/Orientation Week, the development of a new Independent Activities Period (I. A. P.) seminar on health careers, and the maintenance of sherry-and-cheese hours for groups of students invited from the various houses, fraternities, and organizations on campus.

Student concern about the disciplinary role of the Office of the Dean for Student Affairs resulted in proposals from this Office and meetings to permit direct student input into the deliberations of the ad hoc group from the Committee on Educational Policy, which this spring submitted to the faculty proposals for a revision of the judicial process. This ad hoc group will continue its work in the next academic year.

The climate on campus was marked by the increased participation of most students in academic and extracurricular activities. Though the role of undergraduate student government continued to be problematic, there was a vigorous campaign for offices and the election of responsible officers with prior experience in campus affairs.

Major efforts were devoted to promoting communication between faculty and graduate residents, staff, and ancillary services in order to formulate common house policies. Monthly dinner meetings for faculty residents and deans; weekly luncheons for house personnel, Dean's Office staff, and a psychiatric liaison representative (Dr. Peter Jenney); and a bi-weekly meeting among Chief James Olivieri of Campus Patrol, Psychiatrist in Chief Dr. Merton Kahne, and Dean Eisenberg -- all contributed to the establishment of a more effective network for sharing information and ideas on student life. In part, this development was spurred by the previous year's tragic occurrence of four suicides. Whether or not related to the new policy, this year was marred by only one possible suicide -- a tragedy that occurred despite the mobilization of resources to arrange for the student's care.

The one major item of unfinished business is the Dean's Office's inability to progress toward the creation of an Office for Minority Education (O. M. E.). Serious differences of opinion remain between some minority students and this Office over such issues as the placement of O. M. E. in the administrative structure of the Institute. It is to be regretted greatly that another year has gone by without the establishment of O. M. E., and that the integration of some minority students continues to be a problem. It is urgent that the groups involved come to some resolution of their differences, in order that O. M. E. may become a functioning unit within the coming academic year.

New activities included a series of evening get-togethers for women premedical students in the Boston area. Also, the Dean was invited to sit for the first time on the Academic

Appointments Subgroup of the Academic Council; her personal goal is to bring information on faculty participation in housing and extracurricular affairs to the committee's deliberations.

Plans to move the Foreign Study Office into the Office of the Dean for Student Affairs were completed, an event of particular significance in view of Professor William Locke's retirement as Foreign Study Advisor at the end of this academic year. His devoted efforts will be missed sorely; it will be up to the staff of the Dean's Office to expand this area, with its promise for enlarging the educational and experimental horizons of M. I. T. students.

During the coming year, Mary Hope will take a one-term leave of absence to complete her tenure in the New York City school system, and Anne Ellison will work three-fifths time in order to complete her doctorate in philosophy. Temporary arrangements will be made to cover their absences. Further, the new assignment of Associate Dean William Speer to the task of compiling an oral history of part of the Institute deprives this Office of its oldest and wisest member.

The Dean for Student Affairs gratefully acknowledges the importance of her weekly meetings with Chancellor Paul E. Gray. For all the stresses and continuing problems associated with the Office of the Dean for Student Affairs, the nature of which guarantees new issues and challenges each year, the Dean confesses to a continuing sense of excitement and fulfillment.

CAROLA B. EISENBERG

Freshman Advisory Council

Approximately 220 faculty and staff members served as advisors to the 895 freshmen who entered M. I. T. in September, 1973. Over 150 of the advisors had upperclass men and women working with them as associate advisors. For the first time since 1969, when the Freshman Advisory Council (F. A. C.) first sought only volunteers as advisors, it achieved its goal of assigning to each advisor no more than the number of advisees he or she preferred. This resulted primarily from the fact that the Class of 1977 was 140 students smaller than the previous class, while the number of advisors remained almost the same.

As in 1972-73, about one-half of the volunteers were faculty members and one-half were staff members. The broad base from which the diverse group of advisors comes and the generally positive feedback that was received at small-group luncheons throughout the year suggest that freshman advising continues to be viewed as an important and rewarding activity, despite the apparently increasing demands on everyone's time. Freshmen, for their part, reported a variety of feelings about their advisors, many of them reassuringly positive. During the coming year, the Council plans to look more systematically into both the benefits of the freshman advisory program and the demands on time for all concerned.

The Freshman Advisory Council has been fortunate to have the continued strong and effective support of students -- a few on the payroll, but the vast majority volunteers. Steven Wallman, Class of 1975, organized very effectively the large number of volunteers who ran Residence/Orientation Week. Students contributed extensively to many parts of the Freshman Handbook, contributed time to the Advisory Group to the Chairman of F. A. C., and, of course, served as associate advisors.

Academically, the year 1973-74 was somewhat different from the previous one. The new credit limit took effect, and was enforced rigorously by the Committee on Academic Performance (C. A. P.). Some freshmen petitioned the C. A. P. unsuccessfully for a waiver of the limit, a few advisors and freshmen voiced objections to the limit, but the most obvious

result was the truncation of the credit distributions at the end of each term. The principal change in teaching style occurred in 8.01 Physics, where the staff returned to a more traditional recitation and testing pattern after several years of experimentation with a limited form of self-pacing. There were no major changes in curriculum content during the year, but considerable faculty effort (culminating in a vote of the faculty) resulted in major changes in the Institute Requirement in the Humanities, Arts, and Social Sciences, to become effective for the class entering in September, 1974. Throughout the year, faculty members teaching major freshman subjects reported higher class attendance and generally greater interest than they recalled in any recent year.

The number of students in academic difficulty at the end of each term was similar to previous years: three percent received letters from the C.A.P. at the end of the fall term, and four percent at the end of the spring. Eight students -- one percent of those entering in September -- were asked in June to withdraw for at least a term.

During the past academic year, F.A.C. staff activities included: more individual counseling than in previous years; more work on the Freshman Handbook, to improve its effectiveness as both an orientation and a recruitment document; support of the housing program, through the design, distribution, and evaluation of a questionnaire survey; a modest effort at understanding better the experience of minority freshmen and at addressing issues raised by them; and a brief look ahead at the possible impact of the larger number of women arriving in the fall. The last two areas mentioned certainly deserve more effort in the coming year, as does the perennial enigma of how best to help freshmen make reasoned course and career decisions.

Professor Thomas B. Sheridan completed his first year as Chairman of the F.A.C., providing encouragement and support at many points along the way. Nancy Wheatley, with the assistance of Marie-France Pierre, continued to administer the Undergraduate Seminar Program and to support the F.A.C., although a portion of Ms. Wheatley's F.A.C. time was transferred formally to the housing program at midyear. Linda Rosness, who has served most effectively as F.A.C. secretary since 1972, will move with her husband to Norway in July; replacing her will be Susan Baram and Naomi Landau, who were hired as a team on a job-sharing basis. Ms. Pierre continues to provide secretarial support to the F.A.C., and Janis Bestul, Class of 1976, and Clifford Wald, Class of 1975, joined the office on a part-time basis in May.

PETER BÜTTNER

Undergraduate Seminar Program

The academic year 1973-74 was an excellent one for the Undergraduate Seminar Program. Participation on the part of both faculty and students remained high, and those who participated generally were enthusiastic about their experiences. During the fall term, 61 seminars were offered. Sixty-eight faculty members and 625 students (533 freshmen and 92 upperclassmen) were involved. During the spring term, 65 seminars were offered, with 78 faculty members and 526 students (362 freshmen and 174 upperclassmen) involved. The participation of upperclass students has been encouraged, and their numbers have begun to increase.

Professor Ernest Cravalho joined the Program as faculty chairman on July 1, 1973. His enthusiasm, new ideas, and hard work have been assets to the Program.

In discussions with students during the fall, their interest in seminars of a "how-to-do-it" nature came to light. The Program, therefore, has been encouraging faculty members to

design seminars which will offer students an opportunity to tackle an academic problem while "getting their hands dirty" -- that is, using their hands in acquiring skills such as welding, woodworking, or making music. These seminars are not intended to be a usual classroom experience. The first group will be offered in the fall of 1974.

NANCY J. WHEATLEY

Undesignated Sophomore Program

The past academic year was fairly routine for this rather low-key Program, which continued at about the same level as in the past. There were 221 students involved at the beginning of the fall term, and 133 in the spring. It was necessary to recruit quite a few more advisors, however, since most continuing advisors preferred to have fewer advisees. The average was three students per advisor, compared to five the previous academic year. In the spring, Professors Leonard and Suzann Buckle of the Department of Urban Studies and Planning were asked to form an informal advisory group for the Program, and it is expected that this group will begin work in the fall.

ROBERT L. HALFMAN

Minority Students

There has been increased activity in counseling minority students. In the academic year 1973-74, 418 scheduled undergraduate appointments were completed, compared with 277 for the year 1972-73. This total does not reflect walk-in or emergency appointments, nor does it include appointments with resource persons at M. I. T., representatives of industry, or educational institutions and agencies.

Activities initiated during the academic year 1972-73 have been continued. Small group meetings, luncheons, and class dinners provide an opportunity for students to interact. Breakfast meetings on Wednesday and Friday mornings were another opportunity for students to get together. These were surprisingly well attended by undergraduate students, some graduate students, and exempt and biweekly staff members.

The departmental student committees continued to operate. Course II students who call their group "Black-me" (Black Student Mechanical Engineers) presented a complete set of notes to the Black Student Union (B. S. U.) tutorial library. The premedical students in Course VII have sponsored several informal meetings with excellent resource people such as Dr. Robert H. Ebert, Dean of the Harvard Medical School, and Dr. Frank Erby. At the suggestion of Professor Margaret MacVicar, Gregory Smith of the M. I. T. Corporation became the advisor to this group. Medical students from Harvard University, Tufts University, and Boston University groups also were presented. The Dean's Office continued support for outside student educational participation. Several students attended the Medical Students' Conference in Atlanta, Georgia.

Through the efforts of Professor Paul Penfield, the sum of \$200 was donated to the Dean's Office, to be used specifically for the student-faculty luncheons. The Dean's Office hopes to improve communications between minority students and the departments.

Under the leadership of Robert Pickney and Ernest Cohen, a minority committee of the Alumni Association has begun to promote greater involvement of black alumni and students.

The Black Student Conference on Science and Technology was held again. It featured six workshops, some more popular than others, and student participation was adequate. The continued effort to help minority students secure information about career possibilities was strengthened by the cooperation of industrial and professional persons.

The previously held career days were not planned this year. Students were encouraged to use the resources of the Career Planning and Placement Office. Director of Placement Robert Weatherall planned several meetings with students and company representatives.

Summer jobs sought directly by the Dean's Office resulted in 25 students being hired by the following companies: General Electric Company, 12; Procter & Gamble, 8; Western Electric, 2; Bell Laboratories, 2; and International Business Machines, 1.

The Black Christian Fellowship Group presented many inspiring programs, open to the M.I.T. community. Several coffee houses, retreats, bible studies, potluck dinners, worship services, and receptions were very well attended. The Gospel Concert held in Kresge Auditorium for the benefit of the Day Care Center of New Temple Baptist Church of Roxbury was a resounding success, attracting people from as far away as Baltimore, Maryland.

The academic progress of minority students continued to be monitored. Again this year, letters were sent to congratulate those whose averages were 4.0 and above. Letters of encouragement and offers of assistance were sent to those students whose grades indicated that help was needed.

Students continued to become involved in house government. Women students organized a cheerleading squad to support the efforts of student athletes.

The numbers of minority undergraduates receiving degrees in June, 1974, were: black, 26; Puerto Rican, 3; and Mexican-American, 1.

MARY O. HOPE

Project Interphase

For the fifth straight year, M.I.T. has conducted at its expense a summer academic program, Project Interphase. As in earlier years, the 1973 summer program aimed at strengthening the backgrounds and easing the adjustments of a group of entering M.I.T. freshmen who had been judged intellectually and personally capable of succeeding at M.I.T., but who also were considered to have somewhat weak high-school backgrounds.

In 1973, the format of Project Interphase was essentially the same as it had been in 1970 and 1971. The required calculus and physics components, the optional chemistry classes, and the athletic-recreational activities of Interphase incorporated the minor suggestions that had resulted from earlier programs. The humanities component retained the basic creative photography option, but, in response to a poll of the incoming students, replaced 1972's music option with a set of art classes. The art classes covered sculpturing, charcoal drawing, and painting. The art component introduced students to the basic techniques of these art forms, gave them some appreciation of the finer techniques of each, and allowed students to begin to find ways of expressing their own creative ideas and perceptions. As first became clear in 1972, the use of creative and practical subjects in the humanities component of Project Interphase proves far more satisfactory to students and their instructors than did the literature classes conducted in the summers of 1970 and 1971.

The 27 participants in the 1973 program included five black females, one oriental female, 13 black males, three Mexican-American males, and five other males. All of these students completed Project Interphase and both the fall and spring terms. The group's academic record during the year 1973-74 was an improvement over previous years. Only three of the 1973 Project Interphase participants ended the academic year with very serious records. Of these, one has been asked to withdraw on academic grounds. Two, if they choose, will be allowed to continue.

It is sad to report that the record of graduation of the 1969 and 1970 Project Interphase participants has been substantially less than was expected. Of the 44 students who attended the 1969 summer program, only 24 have received M. I. T. degrees. Five still are pursuing degrees at M. I. T. Two are enrolled as part-time special students. The remaining 13 have left M. I. T., following marginal or failing terms. Of the 39 students who participated in 1970, one completed the degree requirements in three years, and 14 others in four years. Thirteen continue to pursue their undergraduate degrees at M. I. T., but 11 no longer are enrolled as M. I. T. students.

JAMES J. BISHOP

Counseling

To attempt to say something new each year about student counseling is to invite factitiousness. Each member of the counseling staff changes a bit each year, for better or for worse. Students change; they grow and mature and graduate, making room for a new group. The Institute moves, not quite as slowly as a glacier; the world changes. Yet the ills to which the human spirit is heir remain pretty much the same.

Cain and Abel might have profited from some counseling. However, there was no one around except their parents, and any counselor knows he cannot counsel his own offspring. At any rate, Adam and Eve had never experienced the pangs of late adolescence. Siblings might have taught Cain how to curb his aggression, but Genesis makes it clear that the other siblings arrived much too late to be of any help.

Today, parents forget their own adolescence, or tend to look back on it with rose-colored glasses that screen out the fears, pains, and uncertainties. If parents managed to come through that period without stress, they have difficulty understanding that their sons and daughters find life different. The author who described his years at an Ivy League college about half a century ago, when there was no competition for admission, thought he would dedicate his book to his alma mater as the place where he spent the happiest years of his life -- until his wife saw the dedication.

Listing all the "ills" faced by contemporary students would be tedious. A few examples will suffice. To their surprise, young men and women find themselves confronted with the task of learning the care, nurture, and upbringing of parents. They must learn that time, which in high school was like an ample bank balance, at M. I. T. suddenly has become an overdraft. Priorities must be clarified, though there is yet little experience on which to draw for guidance. Procrastination, which in high school seldom had disastrous consequences, now causes nightmares when a term paper is due. The wish to be first (even if the student must settle for primus inter pares) brings to mind Job's feelings when the Lord thundered, "Where were you when I laid the earth's foundations? Tell me, if you know and understand. Who settled its dimensions? Surely you should know." (The quotation is not borrowed from a freshman physics exam.) Humility, sturdy self-reliant humility, comes hard. Fortunately, however, students discover in themselves untapped springs of endurance and courage.

As usual, finances are a source of worry for a large number of students. The job market, especially for an underclassman, is an unpredictable element. Yet both finances and the job market may influence a student's choice of major field, either consciously or unconsciously. Trouble may follow if a student chooses for economic reasons a field in which his or her true interests do not lie, or a field requiring a mode of thought which is not the mode in which that student's mind works most effectively. Grades, for those aiming at graduate work, especially in law and medicine, can become an obsession which increases the already heavy weight of competition.

Fortunately, the draft no longer has the effect of forcing a student to choose to continue at M. I. T. when he feels a desperate need to break the lockstep of education and to withdraw temporarily. Without relying on statistics, the counseling staff generally believes that almost all the students who drop into (not "drop out of") the everyday world benefit from their experience, whether it is a job, travel, or a chance for reflection in a cabin in the Sierra Nevada. Students who make this decision, often the first really independent decision in their lives, might approve of this observation: "The time for the digestion and assimilation of what is presented to them and for clear and careful thinking must be very considerably increased." (-- Professor Clifford, in a report on the Department of Electrical Engineering, 1906)

The perception of "counseling deans" as people who see only those students in academic trouble is a false one. Even a student who received all A's may find that the taste of them is as dust and ashes in the mouth. It is true that most students who come to see the counseling staff begin by saying they want to discuss an academic question. This gives them a chance to size up the counselor, and to decide whether he or she can be trusted to be told what is really in the student's mind and heart.

Among those students who do not withdraw temporarily in order to "clear their heads," many derive the same benefits by taking advantage of the Undergraduate Research Opportunities Program (U. R. O. P.), or of departmental offerings known in general as "special topics."

It may not be that all students would assent to the proposition that M. I. T. is becoming more humane, but a significant sign of such progress is furnished by the Committee on Academic Performance (C. A. P.). Under the direction of Professor Arthur C. Smith, the retiring chairman, the C. A. P. has continued to be guided by the premises that very few students are incapable of earning their degrees, and that those who are in temporary academic difficulty should be persuaded to withdraw for a while (rather than having the Committee resort to "disqualification"). That dread word, when entered on a student's official transcript, has been considered by other colleges as the academic equivalent of a felony conviction.

Time away from M. I. T. is no magic panacea for a student. Some students welcome the opportunity, whether they grasp it voluntarily or because of a gentle prod from the C. A. P., and have the inner resources to profit from it. Others, however, need more help than M. I. T. currently provides in planning and in finding fruitful occupations. The intangible element that some students need is evidence that M. I. T. believes in them and trusts them to come successfully through this "dark night of the soul." Since the parents of a few students angrily regard withdrawal as copping out, M. I. T. occasionally can revert (without excuse) to in loco parentis.

Lest this report appear to emphasize "ills," attention should be drawn to several facts. A large portion of the student body sails through M. I. T. with zest and success (though accompanied by legitimate griping), without any need for the counseling service of the Office of the Dean for Student Affairs. The counseling staff enjoys and profits from friendships with such students, when they come to know them through common interests such as extracurricular

activities, social events, and athletics. Superb singing in a musical production, a record-breaking pole vault, and countless other student accomplishments give life at M. I. T. a measure of the classical Greek belief in excellence in fields other than the purely cognitive.

Toward the end of the academic year, Associate Dean William Speer moved from student counseling to work that will lead to a sketch of the history and development of the Dean's Office, and to an "oral history" of Mrs. Karl T. Compton's rich and vivid reminiscences of her late husband and of M. I. T. Dean Eisenberg expects to complement the counseling staff by adding another part-time faculty member.

JAMES J. BISHOP
ANNE ELLISON
ROBERT L. HALFMAN
MARY O. HOPE
WILLIAM SPEER

Women's Program

This year, the Assistant Dean for Student Affairs with primary responsibility for the Women's Program continued to divide her time among counseling, other Dean's Office activities, and activities which were related more directly to women students. Ms. Ellison estimates that the total number of students (both men and women) she saw in formal counseling contacts rose this past year, and that 40-50 percent of these were women (compared to approximately 33 percent in the previous year). Among students whom she sees informally (who drop by the office and stay to talk), considerably more were women students.

The Dean's Office was pleased with the number of women applicants this year. The women who applied seemed highly qualified, with an intelligence and vitality which came through in the applications. Happily, the new class reflects the success of Institute efforts to recruit women, and the largest number of first-year women students (210) in the history of the Institute is anticipated. The women students who worked with the Assistant Dean to produce the booklet "M. I. T. : A Place for Women," which was mailed to approximately 10,500 prospective applicants last fall, were gratified also by the favorable and surprisingly extensive press response it generated.

The Association for Women Students continued to meet this year, and again provided support and a focus for a number of interested women students -- and men students as well, as several asked to be added to the A.W.S. mailing list and began to attend meetings. Activities in the 1973-74 academic year included a continuation of last year's meetings with members of the faculty and administration, who talked informally about their careers and lifestyles, and programs with a broader focus: Dr. Mary Rowe on androgyny; Eunice West, producer of a feminist television program; and a speaker on sexism in children's literature. Filmmaker Joyce Chopra was generous enough to show her film, Joyce at 34, and after the showing stayed for discussion with her husband and young daughter. At another meeting, Dr. Paul Rosenkrantz, a clinical psychologist, gave a lively talk about the strengths and difficulties of dual-career marriages. It is interesting that approximately one-third of those attending this discussion were men. Other activities were primarily social in aim -- open houses, a Christmas party, and a highly successful Sunday brunch for women faculty and students, their spouses, and children.

During the Independent Activities Period, a series of talks was presented which illustrated different lifestyles; the introductory talk and overview were given by Dr. Mary Howell, Associate Dean for Students at Harvard Medical School. Members of A.W.S. sent handwritten letters to all accepted women applicants to M. I. T., and a few continued to "sit in"

Women's Program

the Office of Admissions during the peak period of interviewing, in order to chat informally with all prospective applicants. Early in the admissions process, A.W.S. sent a letter to all women faculty members, encouraging them to become members of admissions teams, in the hope that each team would include at least one woman member. These activities were carried out in cooperation with the Office of Admissions.

A.W.S. members currently are planning activities for the summer and fall of 1974. They are working with the residence/orientation coordinator for women to plan orientation for new women students. They plan to send a letter to all incoming women students during the summer, welcoming them and inviting their questions. They will update and reproduce a booklet of information and resources for women students, which was prepared last fall in conjunction with the residence/orientation committee, and will distribute it to new students this fall, and later to all women students, faculty members, freshman advisors, and undesignated sophomore advisors. Along with a Women's Forum representative, Dorothy Bowe of the Office of Student Financial Aid, and the Assistant Dean, a number of A.W.S. students are planning a booklet along the lines of the M. I. T. Observer, which would contain news clippings about the M. I. T. women's community during the past year.

The Assistant Dean's role in these activities has been to provide support and encouragement. The organization suffers from lack of funds, and although this was less acute than in the previous year, some financial support was provided by the Assistant Dean. Times have changed at M. I. T.; there is a big difference between a diverse 800-woman student body, and the era when there were 50 women students closely united by adversity. The women in A.W.S. have spent some time struggling with the question of where they can best direct their energies, and how they can provide diverse programs that will attract and serve different interest groups among the women attending the Institute.

Assistant Dean Ellison was appointed to the Joint Committee of the Wellesley-M. I. T. Exchange Program late in 1973-74. She also participated in a series of meetings (along with Jane Sauer, Administrative Assistant to the Committee at M. I. T., a number of Wellesley College administrators concerned with the Exchange, and a group of M. I. T. and Wellesley women students) intended to explore common areas of interest. These meetings were lively, and several controversial subjects were aired; some friendships were formed. There was an awareness of and concern for the needs of M. I. T. women students on the part of the Wellesley group and others on the Committee. The M. I. T. women students contributed to this by their frank and open discussion. Jane Sauer has been pursuing the idea of a joint women's studies program with M. I. T. and Wellesley faculty and students. At the meeting of the Joint Committee in the spring, the Wellesley members introduced the idea of a Wellesley women's studies subject, to be held in the coming year on the M. I. T. campus. Several M. I. T. women students met the idea with enthusiasm; the suggestion is responsive to their criticism that women students at M. I. T. are less likely than men to overcome the "bus barrier" and travel to Wellesley for a subject.

The Cheney Room, the women students' common room, has undergone extensive cleaning, repair, and minor renovations this past year. After discussions with the Safety Office, the Cheney Room Committee, and Campus Patrol, a questionnaire concerning the use and security of the room was composed and sent to all women students. Hopefully, the information obtained will allow some decisions about the room to be made during the coming year.

During the past academic year, the Assistant Dean participated in discussions with current and prospective residents of coeducational housing, and in the decisions that had to be made about new coeducational housing. She also kept in contact, as far as time allowed, with the Women's Forum, the new women administrators' group, and with the women faculty group. In the first term, two students assisted her in rounding out some of the research on literature they had carried out on factors related to the education and careers of women in science

and technology. This had been begun for the Workshop on Women in Science and Technology, held in May, 1973. In the second term, with Deans Peter Büttner and Kenneth Browning, the Assistant Dean worked with a group of exceptionally able students in conducting a fairly extensive study of the off-campus and on-campus living situations of students. This study will continue over the summer of 1974 and possibly into the fall. Ms. Ellison also served as a member of the Committee on Student Environment.

ANNE E. ELLISON

Student Activities and Governance

Approximately 175 organizations and 600 student leaders are subsumed under this title; they affect all students in some regard, but most directly the 2,700 students involved in the programs associated with these units.

All of these student community activities engage in programming with varying frequency and objectives -- social, service, cultural, special interest, and hobby. They are increasing the use of Institute space and facilities. In response to the escalating difficulties of scheduling space, a series of six formal meetings was held in midwinter to compare the inventory of present space with program demand, in order to determine in a preliminary way where the crunch occurs and how it might be resolved. This study, which began early in the fall of 1973 with the Executive Committee of the Association of Student Activities, was extended to include representatives from special activities, the Student Center Committee, Dormitory Council, Undergraduate Association, Graduate Student Council, Committee on Student Environment, Activities Development Board, Athletic Association, and the Planning Office. This initial survey pointed to a shortage of certain types of special-purpose space. The study is continuing with the formal assistance of the Planning Office. Also under investigation, by a committee chaired by Dean Jon E. Hartshorne, is the possibility of a centralized method of scheduling student program space, as a means of maximizing the correlation of desirability and function.

The several Undergraduate Association governance structures increased their effectiveness during the past year, especially the Finance Board, Association of Student Activities, Student Center Committee, Student Information Processing Board, and Nominations Committee, while the Secretariat became more visible. Derrick Vlad, Class of 1974, Co-President of the Undergraduate Association, gave valued leadership and time to the investigation of a council that would function as a means of formal communication linking student leaders. It is anticipated that some kind of mechanism will evolve from his and others' efforts. The Nominations Committee has continued to play an effective role in governance by channeling students to the several committees, boards, and task forces. Faculty, staff, and administration serving on these committees have been impressed by the quality of these students' efforts and the genuine substance of their contributions.

The Graduate Student Council, while experiencing a rapid turnover of officers, continued its basic programs and appears to be well prepared with new programs of orientation for graduate students in the fall. The projected plans reflect a desire to work more closely with the graduate academic departments, as a means of assisting new graduate students. Johnny S. Lim, a graduate student in Course XV, treasurer and acting president of the Council, was a corecipient of the first Chalmers International Students Award, presented in recognition of outstanding contributions to extracurricular affairs. The management of the Muddy Charles Pub has regularized its operation, and no subsidy from the Council budget was required this year.

The Association of Student Activities Executive Committee, the reference point for some 120 undergraduate activities, has extended its planning into several new areas under the leadership of Fred Duncanson, Class of 1974, and Michael Kozinetz II, Class of 1975. Workshops, general meetings, criteria for the holding and use of space, community programming, financing, scheduling of space, and "how-to-do activities," are a few of the topics presently being considered by the Committee.

The Activities Development Board, reorganized four years ago by its chairman, Professor Charles E. Holt III, as a body which would distribute capital equipment and minor space change funds to community activities, has had an extremely busy year. More requests have been considered this year than in any previous year. Over the past four years, approximately \$36,000 has been distributed in 55 grants to activities for such items as: English-language tapes for the Technology Matrons English classes for foreign student wives; the construction of the Outing Club cabin; and the installation of an audio system for the Little Theatre. This has been an important and beneficial resource for community life; the Institute is grateful to Professor Holt, who is concluding his term on the Board.

Student activities themselves seemed to have enjoyed a good year. Arvind Khilnani, Class of 1974, also a corecipient of the first Chalmers International Students Award, was cited for his contributions to a seminar program for national vocational reorientation of students returning to their home countries. MITV (M. I. T. Television) began its series of biweekly programs in March, 1974; it looks forward to better coverage of on-campus events, issues, and personalities in the fall. Robert McCadden, supervisor of the Hobby Shop, retired after 32 years of association with students. A certificate of appreciation presented to him at the Awards Convocation in May, 1974, read in part:

We honor thus your affection for craftsmanship, your dedication to the disciplines of a "safe and put-away-shop"; and while sorrowed that you now leave us, we are grateful for your enduring thesis: that hands, and machines, and materials can combine together skillfully to create objects of beauty and utility.

A highlight of the Awards Convocation this year was the surprise presentation to Mrs. Karl Taylor Compton of the silver tea set symbolizing the Compton Prize. Noting her bright speaking presence at these occasions for over 20 years and her articulation of the meaning of the Prizes, her citation read: "Trusted Interpreter of Citizenship and Community."

The M. I. T. Chapel was the setting during the year for five christenings, 95 weddings, seven memorial services, and 27 music programs, including the very popular Thursday noon-hour concerts. In addition, there were 450 scheduled religious services, and the Chapel organ was used for practice by students on 228 occasions.

It is clearly evident that these organizations and groups, and student participation in them, are a part of the vitality of the M. I. T. community and equally a part of its hope and its memory.

ROBERT J. HOLDEN

Student Center, Kresge Auditorium, and Talbot House

In the spring of 1974, a small group of students of varied backgrounds, with experience in a number of different extracurricular activities and projects, met to discuss extracurricular activities with a view toward understanding in what ways they have or have not been growth-promoting. It was hoped that these discussions might reveal certain basic factors and

variables influencing a student's experience outside of the classroom, and indicate what kinds of educational values are represented in student community activities. This discussion group also was intended to be preparation for the Visiting Committee session on September 27-28, 1974, which will deal with the Office of the Dean for Student Affairs program in the area of student community activities. The discussion group probably will be continued in the fall.

Dennis Catanzano, a former M. I. T. undergraduate and currently a graduate student in the Sloan School of Management, was the first Program Development Intern in the Office of the Dean for Student Affairs. Operating within the general area of student activities and government, his first task was to become familiar with the wide range of extracurricular offerings at M. I. T. The next step was to select several organizations, and to assist them in the development of their programs and in their general efforts. This year Mr. Catanzano focused primarily on the Undergraduate Association and Talbot House, and was quite successful in establishing supportive relationships with the people and programs in these areas. This first year was experimental, and in the coming year it is hoped that the role of the intern will be sharpened further, in order to increase the effectiveness of the Dean for Student Affairs Office's support of student community activities.

During the Independent Activities Period (I. A. P.), a group of students under the leadership of Professor William Lambe, a member of the Talbot House Committee, visited Talbot House and presented several reports suggesting ways in which its program could be improved. The enthusiasm of the students for the Talbot House program was inspiring. In addition to offering a number of valuable ideas for future development, the group prepared a loose-leaf notebook containing much information on recreational and cultural opportunities available in the Woodstock, Vermont area.

Scheduling for Talbot House always has been a delicate operation, since during most of the year demand exceeds capacity. The Talbot House Committee has been in existence for two years, grappling with the volatile issues involved in scheduling. At this point, a series of guidelines and procedures have been drawn up, which hopefully will make possible greater fairness in assigning this very attractive space to M. I. T. student and community groups. Mr. Catanzano also designed and helped to implement a record-keeping system for the management of Talbot House, which will make possible more efficient fiscal management in the future.

M. I. T. 's biannual Open House, held in the spring of 1974, was by all accounts a very successful program. It was produced by an ad hoc Undergraduate Association committee, chaired by Robert Kenley, Class of 1975, who won a Stewart Award for his efforts. It is no small task to coordinate various departments, organizations, and individuals of a large educational institution and to focus their energies on the creation of an Institute-wide program. However, this was accomplished in such a way as to bring the M. I. T. community closer together in the effort; at the same time, it provided an exciting day on campus for members of the wider Cambridge-Boston community.

The Student Center continues to be a heavily used facility, with an average of two million visitors per year. This year saw the Student Center Committee and the administration focus their attention on several areas of program management. A computer program was designed which will provide information on usage of the Student Center (as well as Kresge Auditorium and the Chapel), which will be more complete, accurate, and informative than that gathered less systematically in the past. In addition, time was spent in developing a policy for the consumption of alcohol in the building. Conversations with Campus Patrol continued on the subject of security in this public building (open 24 hours each day). The wise and thoughtful counsel of students and administrators has helped to make these very

difficult issues manageable, if not ultimately solvable.

Kresge Auditorium continues to be the center for an expanding music and drama program at M. I. T., as well as one of the major facilities for a wide range of academic and nonacademic productions. Sadly, increase in the number of programs inevitably means increased competition for space. However, the necessity of dealing with these pressures and learning to live together in a situation which is far from ideal has been a growth experience for many of those involved. In the future, the Dean for Student Affairs Office will initiate long-range planning for facilities to support an expanding program in the area of student community activities.

JON E. HARTSHORNE

The Living Environment

Fraternities

The fraternity system remains a strong part of the residence program, and in fact is showing a reawakening of spirit, organization, social life, and concern for the future. The opening in January, 1974, of the Fraternities Collaborative, housing Alpha Tau Omega and Kappa Sigma, has helped to focus the interest of most fraternity members and many alumni on the future of their own physical plants. One house is in the advanced stages of planning for a major renovation (hopefully to begin in the fall of 1974), and at least two more have indicated strong, serious interest in pursuing building programs.

To assist houses considering major renovations or who just want an evaluation of their physical plants, the Dean for Student Affairs Office has reinstated a thorough physical plant and safety inspection for those who request it. This inspection is coordinated very ably by Howard F. Miller, Assistant to the Director of Physical Plant, and is participated in by a number of Department of Physical Plant and Safety Office personnel. There is a great interest in this program, and there is currently a backlog of houses wishing to be inspected.

The Alumni Interfraternity Conference (A. I. F. C.) has been revitalized, and through this medium the Dean's Office is working to provide program, management, and planning support to fraternities and their house corporations, and to stimulate renovation and building efforts. Glenn P. Strehle, Class of 1958, has succeeded D. Reid Weedon, Jr., Class of 1942, who served ably as chairman of the A. I. F. C. for several years.

Central to the physical improvement program in the fraternity system is the replenishment and expansion of the Independent Residence Development Fund (I. R. D. F.). Without the low-interest, long-term capital provided by the I. R. D. F., such projects cannot be made financially feasible. It currently is estimated that \$12 million (in 1974 dollars) will be required over the next several years to meet the renovation and new construction needs of the fraternities. The A. I. F. C. and the Alumni Fund are working to increase the flow of gifts through the annual giving program, but development support clearly is necessary to meet the capital requirements of this program.

Three new members have been appointed to the three-member I. R. D. F. Allocation Board, effective July 1, 1974. (All three positions had become vacant due to expiration of terms, and no new appointments had been made in the past three years.) They are Lindsay Russell, Class of 1950 (formerly a member), Chairman, for one year; Earl H. Eacker, Class of 1922,

for two years; and James Champy, Class of 1963, for three years. The efforts of the three most recent members, whose terms have expired -- Marshall Dalton, Class of 1915; Daniel Holland, Class of 1958; and Edmund Swanberg, Class of 1943 -- are recognized and appreciated greatly.

The Interfraternity Conference (I. F. C.) has shown new signs of life, as members of fraternities have come to realize again that there is value in communication and interaction with other houses, and that the system collectively can do things which the separate houses cannot do alone. This atmosphere has been helped along -- and in part recreated by -- the continued growth in interest and enthusiasm shown by I. F. C. officers over the past two and one-half years (particularly during the most recent term). Concern has been evident in areas of social activity, collective buying, the physical condition of the houses, pledge orientation, alumni relations, and in house government and management.

Particularly noteworthy is the rebirth of interest in the Fraternity Tutor Program, which had atrophied and finally was cancelled for fiscal year 1974. The program has been reinstated (at the request of the students) for the coming year, and it is expected that at least six houses will have graduate residents.

Fraternity rushing and pledging in September, 1973, again was quite successful, with most houses attaining their desired number of pledges, and a system total of 381. Particularly satisfying was the fact that the three or four houses which had not had good rushes for several years were successful in 1973.

There continues to be some interest in coeducational living in fraternities, but the Dean's Office is proceeding cautiously in this area. Three independent living groups currently are coed, and it is felt that their problems and progress should be observed for a longer period of time before extending coed living to other fraternities.

To carry out the various physical and social programs and projects, Assistant Dean Kenneth C. Browning has been designated informally as advisor to fraternities and coordinator of fraternity affairs. He expects to spend approximately one-half of his time in this role. To generate this time, Nancy J. Wheatley, Class of 1972, Assistant to the Dean for Student Affairs, has begun to share Institute House affairs, particularly room assignments, orientation, and special problems, with Dean Browning.

At the annual Awards Convocation in May, 1974, Andre R. Jaglom, Class of 1973, was presented the Frederick Gardiner Fassett, Jr. Award, in recognition of his service and dedication within the I. F. C. and his broad range of interests in the M. I. T. community.

Institute Houses

Continuing students again returned to their spaces in the Institute Houses at record-breaking rates -- with return rates for sophomores, juniors, and seniors of 95, 89, and 85 percent respectively (compared with 97, 88, and 82 percent a year ago). Thus, the Institute experienced overcrowding of 30 students, although the entering class's targeted size had been reduced to 900 (893 registered). However, successful student-run orientation programs in the Houses led to a situation which made this overcrowding a much more acceptable experience than in past years. The housing satisfaction of the freshman class was enhanced further by the success in assigning 82 percent to their first-choice houses, and another 10 percent to their second choices.

The success of Residence/Orientation Week was an indication of an increase in the concern, dedication, and spirit of house residents. Social activities increased in frequency and quality; house governments were strengthened; wide support and enthusiasm for the Faculty and

Graduate Residents Program was evidenced; and several complicated issues were addressed substantively.

House judicial systems have been scrutinized by a group of students, faculty, and Dean's Office staff, as part of an overall review of the Institute's judicial and disciplinary processes. It is anticipated that this fruitful series of discussions will continue into the coming academic year. An improvement in attitude and process in house judicial matters already has been noted.

In May, 1974, final approval was given for the construction of a new house for 300 single undergraduates, on the site immediately west of MacGregor House. Targeted for occupancy in the fall of 1975, this house should eliminate the overcrowding which has existed for many years, and also offer a place to certain college transfer and readmitted students who currently must be turned away from on-campus housing because of lack of space. Pressures for increased undergraduate enrollment, coupled with continued high return rates on a sizable housing demand, make it clear that some additional housing for undergraduates will be necessary.

The target for the freshman class size in 1974 was raised to 1,000, mostly because of economic pressures and the capacity of academic facilities and personnel to accommodate a slightly increased enrollment at a small cost. This will necessitate the overcrowding of 40 to 60 rooms (affecting 120 to 180 students directly), and the reluctant use of 60 spaces in Ashdown House for undergraduates. This latter action is possible for the coming year only because the reopening of the remainder of Ashdown House will allow a significant increase in single graduate housing (even with these 60 spaces set aside for undergraduates). The undergraduates who reside in Ashdown will be provided with graduate residents, as in other houses. They will form a nucleus of residents for the new house, when it opens. On the positive side, this new space in the undergraduate system will provide the opportunity to begin a French and German House for students who wish to study these languages and cultures.

Coeducational living continues to be a generally successful program and a valuable experience for those students who are able to participate. Interest in expanding coed living -- both within existing coed groups and to other living groups -- was high, as it became apparent that the increase in the number of women students in the entering class for 1974 would necessitate an increase in women's housing.

In an effort to solve some of the problems existing in coed living groups -- which usually stem from an insufficient number and proportion of women students -- it has been resolved first to expand coed living in those living groups already established, to whatever extent seems desirable and possible. In general, coeducational areas are expected to have female-male ratios of 1:3 or better this fall. To accommodate the remainder of the increase in women students and to extend further the living style options available to women, two floors in Baker House will become coed in the fall.

The energy crisis and the resultant skyrocketing increases in the cost of utilities prompted a record 15 percent increase in Institute House rents for 1974-75. A similarly large increase in commons costs was necessitated by large increases in the cost of food. The need for these increases and the method of structuring rents throughout the undergraduate houses were studied in detail by a committee of students (representing all of the houses), who worked with representatives of the Dean's Office and the Housing and Food Services office.

Although these increases came at a time when students are quite concerned about the costs of attending M. I. T., a significant increase in students' moving to apartments is not expected. Comparable facilities at lower costs are not generally available, and utility cost increases

are having their effects off campus as well. Fraternity house bills have not yet increased as much as Institute House costs. While they are expected to increase, it appears that living in fraternities still will cost less, on the average, than living in the Institute Houses.

In October, 1973, Molly McBride, Administrative Assistant to Dean Browning, left to return to her home in Ohio. She was instrumental in setting up the on-campus room assignment and charging systems, and was completely unflappable in difficult situations. She is missed as much by students as by the staff.

Faculty/Graduate Residents Program

The Faculty/Graduate Residents Program has continued to be an important part of the on-campus living experience of M. I. T. students. The faculty families and graduate students are regarded by the residents in the Houses as supportive and interested friends, not only in times of personal or academic crisis, but also in times of joy and good fortune.

Members of this Program and the Dean's Office staff have met regularly throughout the year to discuss various issues and problems, and will continue to meet next year. Each house has its own style, and thus its own areas of concern. All have learned from each other, and are striving to understand better that unique individual -- the M. I. T. student.

Professor and Mrs. Jerome Y. Lettvin accepted appointment as faculty residents in Bexley Hall, effective February 1, 1974. They bring a wide range of interests and ideas to the Program. Professor Lettvin is affiliated with the Departments of Biology and Electrical Engineering. Maggie Lettvin, the creator of Channel 2's "Maggie and the Beautiful Machine," is already known to the M. I. T. community through her very popular exercise classes held under the auspices of the Department of Athletics.

The Program lost five of its "family" at the end of the academic year, with the resignations of Professor Ernest and Elizabeth Cravalho, junior faculty residents in MacGregor House; Elaine and Mark Price, junior faculty residents in Baker House; and Professor Jeffrey Steinfeld, junior faculty resident in Senior House. Their advice and counsel have been invaluable, and they will be missed by all.

Ronald and Jane Prinn will be moving into Baker House in August, 1974, as junior faculty residents; Professor Prinn is in the Department of Meteorology. The Dean's Office and the residents of the house are pleased that they have chosen to join this exciting Program, and look forward to working with them.

Graduate and Married Student Housing

In the fall of 1973, the first restored section of Ashdown House was opened for occupancy, and work was begun on the remaining half of the building. This project is proceeding well and will be completed prior to the fall term of 1974. With Tang Residence Hall, this brings the number of good-quality spaces for single graduate students to 790 (although 60 of the spaces in Ashdown House will be used for undergraduates in 1974-75). This addition of space will bring the Institute closer to meeting the total on-campus housing demand for single graduate students, but there is still not enough housing space for every unmarried graduate student who desires to live on campus.

As Ashdown House has taken on a new appearance, the concern of its residents has increased. A more positive feeling exists within the house, and student representatives are engaged in a range of constructive issues, including concern for the orientation and interaction of residents, and the selection of a senior faculty resident to fill that currently vacant post.

As Tang Residence Hall approaches a steady-state operation (after its start-up pains), its governmental structure appears to be approaching a working equilibrium. Due to its apartment design, interactions among its residents have been few, and a sense of community has not developed yet.

Married student housing continues to be in extremely short supply, relative to the demand. The waiting list remains at approximately 300, with average waits of more than a year. Concern has been expressed that this waiting list is artificially long due to inactive applications. This simply is not true, when the entire calendar year is viewed. Almost all applications are fully active for August and September vacancies, but many applicants are unable to take apartments at other times of the year due to lease commitments off campus. Married students are at a particular disadvantage in the off-campus market (compared to single students), because of their inability to band together and thus to afford better the higher rents of good-quality housing.

As with undergraduate housing, rents in graduate and married student housing have experienced unprecedented increases, ranging from 7 to 17 percent, for 1974-75, due to increased utility costs. The need for these increases, and the overall financial picture of house operations, were reviewed by committees of residents from each of the houses, working with the Housing and Food Services staff.

KENNETH C. BROWNING

Foreign Study Office

The Foreign Study Office has experienced a most successful year. A total of 531 persons came into the Office during 1973-74 seeking information and counseling. Primarily, they were undergraduates interested in the Junior Year Abroad, the Domestic Year Away, and the January Independent Activities Period (I. A. P.) Exchange programs. Others were graduate students, postdoctoral fellows, faculty members, and employees looking for financial assistance (in the form of scholarships and grants) in order to study, do research, or teach abroad.

The increased number of people visiting the Office was due to the publicity campaign undertaken during the past two years by the Foreign Study Advisor to inform the M. I. T. Community, and particularly the student body, of the resources available at the Foreign Study Office. Announcements and advertisements were placed in Tech Talk, The Tech, and Thursday. Also, posters were designed and printed up for distribution to departments and living groups.

A new service, provided for the first time this year, was the issuance of the International Student Identity Card. The Office has issued 56 cards to date. The card offers students numerous discounts at theatres, museums, and restaurants. In addition, it provides reduced rates on air travel within Europe. The sale of the cards was begun as a means to introduce students to the Foreign Study Office, and also as a convenience for students embarking on the Junior Year Abroad.

Junior Year Abroad

This year, nine students participated in the Junior Year Abroad (J. Y. A.) program, studying in Australia, Austria, France, Germany, Israel, and Wales. Eight students plan to participate next year. Israel and the United Kingdom are the most popular countries for M. I. T. students studying abroad.

Although the number of students on the J. Y. A. program has remained small, those students who have participated in the program have been very enthusiastic about their year away. One student wrote: "If I may be candid, I do not miss the tense environment of M. I. T. very much at all. I am looking forward to returning as a senior, for academic and other reasons, but for now I am experiencing things that Boston just doesn't offer, things that I think are very important to my college experience."

Domestic Year Away

Six students participated in the Domestic Year Away (D. Y. A.) program during the past year. They attended the University of Illinois, University of Washington, and Vassar College. There are four students planning to be away during the coming year.

The D. Y. A. program is still an experimental program of the Committee on Educational Policy. In May, 1973, the C. E. P. decided to continue the program as an experiment, "...pending conclusion of a more general examination of credit, residence, and exchange issues."

Independent Activities Period Exchange Program

This was the second year in which exchanges between M. I. T. students and students from other colleges and universities took place under the I. A. P. Exchange Program. The students participating in the exchange were from Denison University, Middlebury College, and the University of Redlands. The Foreign Study Office received letters from five schools expressing an interest in setting up an exchange program with M. I. T. during January, and 39 students from other schools wrote inquiring about the possibility of exchanging places with an M. I. T. student for I. A. P.

The prospect of spending the January term abroad is becoming increasingly appealing to students at M. I. T. Three students went abroad during this January's I. A. P. Two travelled independently, and one student joined the Bucknell University Study Tour of Russia.

The Foreign Study Office again held seminars on England, France, Germany, and Israel as an I. A. P. project. The seminar leaders were members of the student body and faculty who had studied and taught abroad. Each discussed his or her experiences and answered questions. The talks were well attended, with an average of 30 persons at each lecture.

Graduate Study Abroad

Fourteen M. I. T. students applied for the Churchill, German Academic Exchange Service (DAAD), Fulbright, and Marshall scholarships. Two students were offered Churchill Scholarships; both turned down the awards, in order to accept funds for graduate study in the United States.

The DAAD awarded two M. I. T. students direct scholarships for study in Germany. One student, Lily Gardner, accepted the grant. The second awardee turned down the scholarship in favor of accepting funds for graduate study in the United States.

There were only five candidates for the Fulbright-Hays Scholarships. This was due in part to an effort by the Foreign Study Office to attract only those academically qualified applicants who had some graduate school training. Graduating seniors have been at a disadvantage in the competition in recent years, and several colleges and universities are permitting only graduate students to apply. Two of the Fulbright candidates passed the preliminary screening on the national level. One student withdrew his application, and one student still is awaiting a decision from the binational commission.

In May, 1974, the Foreign Study Office held a workshop on graduate grants for study abroad. Speakers at the workshop were members of the faculty who had been former Churchill, Marshall, or Rhodes scholars. Approximately 20 persons attended.

WILLIAM N. LOCKE

Department of Athletics

In his remarks at the dedication of the David Flett du Pont Athletic Center in October, 1959, President Julius Stratton commented: "Society asks more of most men than sheer intellectual ability -- it demands also moral hardiness, self-discipline, a competitive spirit, and other qualities that in more old-fashioned terms we might simply call character."

Fifteen years later, this quote provides an appropriate statement of continuing challenge, as the events of the past year are reviewed, and future goals for the M.I.T. athletic program are projected in light of the Department's foremost objective -- to develop in the young men and women of M.I.T. those personal qualities which Dr. Stratton emphasized.

In order to meet this objective, special emphasis continues to be placed on a broadly based program of instruction in a wide variety of sports and recreational activities which encompasses all levels of student interest. While intramural sports and casual recreation regularly attract the greatest number of students, the Department recognizes the value of and supports those disciplines which develop only through maximum commitment in the more highly organized and more keenly competitive intercollegiate sports. These latter sports continue to attract a large segment of M.I.T. students -- both men and women.

The ability to team with, as well as to exert leadership among, one's associates is among the more desirable experiences which a sound athletic program provides in an educational environment. These are qualities for which there is no formal training in the classroom -- qualities which clearly define a major function of athletics at M.I.T.

The highlight of the past year is the implementation of funding strategies for two projects intended to provide new and expanded athletic facilities for the M.I.T. community -- a new ice rink-field house-events center, and an expansion and renovation of the sailing pavilion. The concept of an athletic program emphasizing participation interests among all students has compounded the need to expand and to upgrade these facilities. This need has been compounded further by the development of the on-campus residence system.

Students, the staff of the Department of Athletics, and the entire M.I.T. community are indebted to the Institute administration and to the national sponsoring committees of both projects for their commitment to enrich these physical resources.

Indeed, President Stratton's quote of 15 years ago will be a source of inspiration and strength to all involved in the task of securing private funding in excess of \$5 million for ultimate completion of both projects -- no small challenge, particularly at this time.

Women's Athletics

Another major highlight of this past year is the further solidification of commitment from M.I.T. women to physical fitness, recreational interests, and competitive sports, and an expansion in the range of interests and the numbers of women active in all phases of recreation and athletics.

This trend will continue as increasing numbers of women are admitted with the entering classes. Indeed, the expectation of a community of approximately 1,000 undergraduate women will enable the Department to extend athletic opportunities for women in certain sports where there are presently insufficient numbers for team organization. During the interim, a few sufficiently skilled women are competing on the M. I. T. varsity teams in pistol, riflery, and skiing. The implications of continued increases in the enrollment of women and a continued expansion of programming requirements obviously have direct impact on the Department's operating budget (coaching, equipment, scheduling, services, and so forth), and on the need for additional funds for capital improvements and support services specifically related to the needs of women.

Funds have been provided in support of the new programming of competitive athletics described in this report, and the Department has been able to accommodate the growth in its instructional and noncompetitive programs. Similarly, there has been much understanding and cooperative effort in adjusting to relatively minor inconveniences while available funds are allocated to the basic needs of program growth, during this period of fiscal discipline at all levels at the Institute. For example, members of the women's crew have been dressing and showering in the du Pont Athletic Center, following discussions which led to the consensus that available money should be spent on rowing equipment and operating expenses until a plan could be devised to locate and construct a women's locker room in the Pierce Boathouse.

It should be noted that the following projects within existing facilities have been completed this past year to provide comparable facilities for women in athletics at M. I. T.

1. Briggs Field House Visiting Team Room A was renovated completely to provide a quality dressing and shower facility for women, with a locker and basket system to accommodate 198 women.
2. The women's locker room at the swimming pool was renovated and expanded to meet a capacity of 112 women at any given period.
3. A sauna was installed in the women's locker room at the du Pont Athletic Center.
4. A temporary training room for the treatment of injuries was established at the du Pont Center.

It should be noted further that projects under way this summer include:

1. Purchase of 68 additional lockers, to be installed in an expansion area provided in the new women's locker room at the Briggs Field House.
2. Relocation of 39 of the existing full-length lockers in the women's dressing room at the du Pont Center to a new facility for women's rowing; they will be replaced by 78 double-tier lockers.
3. Renovation of an unused portion of the indoor rowing tank room at Pierce Boathouse, to provide an adequate dressing and shower facility for women.
4. Completion (in the fall) of a new women's training room in the du Pont Athletic Center for the treatment of athletic injuries, which will serve as a very acceptable facility until an expanded training room is made available.

Professor Mary-Lou Sayles accepted an invitation to join the staff this past year, thereby becoming the first woman appointed to faculty rank in the Department. She replaced Christine

Randall, who had served as coach of several women's sports and as M. I. T. 's first Director of Women's Athletics. Mrs. Randall had resigned to accompany her husband in a change of employment.

Maggie Lettvin has been appointed to a full-time staff position as lecturer in charge of the Self-designed Fitness Program. This appointment gives recognition to the unusual contribution which Mrs. Lettvin makes to the M. I. T. community, including an opportunity for undergraduates (who may enroll in her program for credit) to meet the physical education requirement.

Betsy Mayers, a practicing physiotherapist, has accepted a part-time appointment as trainer for women's sports. She will operate in the new women's training room being constructed in the du Pont Center this summer.

Program Highlights for 1973-74

Physical Education

The opportunities for professional instruction in a wide variety of sports and recreational interests through M. I. T. 's physical education program account for much of the growth in the Institute's athletic program over the past decade. This observation is particularly applicable to the broad base of informal recreational and physical fitness activities, among staff as well as students. It is interesting to note that while there has been a 57 percent increase in total registrations with the Department over the past five years, there has been a 199 percent increase in noncredit registrations during the same period.

This past year, 2,067 of the total of 6,036 registrations made by students and staff with the Department were not related to the physical education requirement for undergraduates. Further analysis of the noncredit registrations for 1973-74 reveals that 713 subject registrations were from graduate students, and 389 from staff. It is reasonable to assume that many of the graduate student and staff registrations will lead to the development of lasting recreational interests. Many of these individuals will remain as part of the M. I. T. community for varying periods of time, and will look to the Institute's athletic plant for facilities for regular use. This reinforces the need for continued implementation of the plans for long-range improvement and expansion of the Institute's athletic facilities.

The following table portrays registration statistics in 42 subjects offered during the regular academic year, plus 5 different subjects given during the Independent Activities Period in January. Subjects in dance, self-designed fitness, yoga, rock climbing, scuba diving, and bicycling led the increases in registration, while instruction in swimming, tennis, physical development, sailing, ice-skating, volleyball, and fencing continue to attract large numbers. An Advanced Diving Program in Scuba, generally recognized by the National Association of Underwater Instructors as one of the finest scuba diving programs in the country, is experiencing a growth pattern which closely parallels the interest in oceanography.

In other interesting sidelights, 31 Wellesley College students registered for credit during the past year; 40 students sought and obtained advanced credit through proficiency tests in sports skills.

Registration Statistics for 1973-74				
Swimming	582		Judo	165
Beginning		285		
Intermediate		62	Karate	164
Synchronized		7		
ARC Water Safety		92	Squash	162
ARC Lifesaving		68		
Scuba Diving		68	Golf	155
Tennis	552		Beginning	119
Beginning		370	Intermediate	36
Intermediate		182	Rifle	150
Self-designed Fitness	489		Pistol	145
Dance	468		Gymnastics	124
Folk		134	Beginning	46
Modern		148	Women	15
Couples		131	Trampoline	63
Ballet		46		
Square		9	Touch Football	113
Development	465		Yoga	106
Sailing	356		Badminton	105
Ice-skating	265		Sculling	96
Beginning		242	Softball	68
Figure		23		
Volleyball	220		Rock Climbing	63
Fencing	203		Lacrosse	39
Beginning		183	Skiing	38
Advanced		20		
Archery	174		Bicycling	24
			Independent Activities	
			Period	545
				6,036

Intercollegiate Athletics

In most respects, this has been quite a characteristic year for intercollegiate athletics at M. I. T. There have been large numbers of undergraduates deeply committed to their respective sports at the more disciplined level of varsity or subvarsity competitions, practicing and competing regularly in efforts to achieve excellence. They have been largely self-motivated, and have generated self-respect, pride, cohesiveness, and identity, usually in the absence of any major spectator interest. This is amateur athletics at its best.

In several respects, however, the academic year 1973-74 will be remembered as outstanding. The heavyweight crew concluded a great season, finishing second to the University of Wisconsin in the Intercollegiate Rowing Association Championships. The baseball team was selected to represent New England in the National Collegiate Athletic Association (NCAA) Division III Championships. Hammer thrower John Pearson, Class of 1974, won the NCAA Division III National Championship. Foilman Johan Akerman, Class of 1977, led the foil team to the Intercollegiate Fencing Association Championship. The pistol team, led by All-Americans Karl Seeler, Class of 1975, and Stephan Goldstein, Class of 1976, won the National Rifle Association's Collegiate Championship.

William Young, Class of 1974, the #1 singles seed in New England College Division tennis, teamed with Lee Simpson, Class of 1974, also top seeded in doubles, in the NCAA College Division Championships at the University of California at Irvine. They competed successfully in doubles among some 200 entries before being eliminated in the round of the final 16 entries. The wrestling squad, led by New England champion Ed Hanley, Class of 1974, and the lightweight crew also finished among the top teams in their respective fields of competition.

Approximately 781 undergraduate men competed in 510 contests at the varsity, junior varsity, or freshman levels in 22 intercollegiate sports. In addition, three undergraduate women filled managerial roles in gymnastics, lacrosse, swimming, and water polo. A tally of awards, in accordance with established minimum requirements in each sport, reveals that there were 287 varsity letters awarded, 132 junior varsity letters, and 150 freshmen numerals, totaling 569 (which includes women's sailing and crew).

Competitive Athletics for Women

Following discussions among the staff of the Department, the student Council on Women's Athletics, and the Athletics Board, the Institute filed application for membership in the Association for Intercollegiate Athletics for Women, and was accepted. Thus, M.I.T. subscribes to the principles and policies being developed by professional leadership within the AIAW to guide the growth of, and determine the rules for, governing intercollegiate athletics for women. One of AIAW's intents is to avoid the problems which have accompanied excessive commercialization of men's intercollegiate athletics at some institutions.

The Department currently sponsors separate women's teams in 10 sports. Four of these (sailing, rowing, basketball, and fencing) have been accorded intercollegiate status, following an apprenticeship of several years of club status. Continuity in interest, the numbers of undergraduate students involved, and the feasibility of scheduling with other New England colleges are among the criteria considered in the conferring of advanced status.

Intercollegiate status requires that each individual competing on a team adhere to all eligibility rules of the conferences or sports associations with which M.I.T. is affiliated. Intercollegiate status for women's teams also necessitates eligibility for all intercollegiate awards, comparable facilities, coaching, equipment, scheduling, and services traditionally associated with men's intercollegiate teams.

The remaining six women's teams (field hockey, tennis, swimming, gymnastics, volleyball, softball) are classified as clubs; all of them may be en route to intercollegiate status. However, some of the teams may prefer to remain club sports, in order to retain graduate students or otherwise to avoid compliance with eligibility rules governing intercollegiate sports. For all practical purposes, the Department does not differentiate between women's intercollegiate and club teams in extending its resources to their programs, particularly during this period of assisting the growth of competitive sports among M.I.T. women.

A review of the 1973-74 academic year reveals that approximately 118 women were active in nine competitive sports. Field hockey attracted insufficient numbers of participants after two years of marginal interest.

At the conclusion of the spring, 1973 term, the sailing team won the Women's National Championship, having qualified through the New England eliminations. Shelley Bernstein, Class of 1974, was high point skipper in the Nationals. In the spring of 1974 at the New England Championships, the M. I. T. women again qualified for the Nationals in San Diego, and placed a respectable fourth in that competition, as Princeton University took top honors.

Crew, in its first year as a varsity sport, established a reputation with early-season victories over Williams College, Worcester Polytechnic Institute, and Boston University, before losing the Charles River title to Radcliffe College. This was followed by a respectable fifth-place finish in the Women's Eastern Sprint Championship, where the eight-oared shells of 16 institutions competed.

After several years of successful competition among regional colleges, the women's basketball and fencing teams were elevated to intercollegiate status. M. I. T. hosted the New England Women's Fencing Championships in the du Pont Center on February 24, 1974. The basketball team hosted a four-team elimination tournament on January 31 and February 1, 1974; the University of Chicago, Brown University, and Radcliffe College joined M. I. T. in this tournament. Plans are under way for a basketball doubleheader with women's and men's varsities; dates and opponents are still to be determined.

In the women's club area, the tennis team competed successfully in fall and spring matches and appears to be headed for intercollegiate status in the near future. The gymnastics team schedule included doubleheaders with the women's and men's teams from Dartmouth College and Yale University. The doubleheader concept is attracting spectator interest, as well as reducing travel and meet expenses.

The swimming team, with daily formal practices beginning in December, and weekly competitions with regional colleges through March, has attracted increasing numbers of women interested in perfecting swim stroke techniques and in building endurance. Similarly, teams are being developed in volleyball and softball; these give promise of further growth as the enrollment of women increases.

Intramural Athletics

Intramural athletics continue to attract the largest participation within the scope of the M. I. T. athletic program. A total of 6,949 students participated on 800 teams in 19 sports, which represents an increase of 11 percent over the previous year. Most of the increase is reflected in the growth of interest in the popular team sports. Sixty-two new teams were organized among living groups and campus oriented independents, in basketball, ice hockey, touch football, soccer, and volleyball.

The planning and implementation of this vast program are accomplished by the Intramural Council, which consists of undergraduates who manage each of the 19 sports plus representatives of the dormitory system and the Interfraternity Conference. Staff support is given by Professor David Michael, Supervisor of Intramurals, and Rosemary Viano, Intramural Secretary.

The teams in each of the major sports are classified into one of three levels of competition, based on an effective procedure developed within the Council over the years to promote competition at all levels of skill. In basketball this past year, the 115 teams were classified for round-robin weekly competition as follows: 16 teams in four "A" leagues; 36 teams in four "B" leagues; and 63 in seven "C" leagues.

Student leadership in solving the problems of scheduling, officiating, protests, eligibility, and so forth, is the major factor in the success of the intramural program. Increasing numbers of women are participating in most of the sports; the Intramural Council is attempting to attract women and graduate students to administrative positions within the system.

One of the innovations being planned for the coming academic year is a program of training student referees and officials, through subjects offered in physical education which will carry credit toward the requirement. Compensation for intramural referees will be up-graded in a manner consistent with "efficiency ratings" obtainable through the instruction, and with a performance evaluation being developed by the Council. The new program should provide an incentive for students who use intramural officiating to supplement their income, and should improve the quality of service rendered, particularly in the keenly contested team sports at the "A" league level.

Intramural Participation Statistics for 1973-74

<u>Sport</u>	<u>Number of Teams</u>	<u>Total Participants</u>
Badminton	32	160
Basketball	115	920
Bowling	76	380
Cross-country	--	69
Cycling	5	20
Football	65	975
Hockey	63	630
Rifle	30	145
Sailing	10	40
Soccer	47	705
Softball	84	1,092
Squash	38	152
Swimming	12	108
Table Tennis	38	190
Tennis	49	196
Track	20	175
Volleyball	82	656
Water Polo	24	288
Wrestling	<u>10</u>	<u>48</u>
Totals	800	6,949

Club Athletics

A club, as distinguished from a university sponsored intercollegiate squad, generally is a self-motivated team drawn from a special interest group which participates in one of the sports less popularly supported among the colleges of this country. Often, club status is a desirable base for sports competition among college communities. There are no eligibility rules, nor any of the traditional college awards. Club athletics are particularly attractive to graduate students and members of the faculty who are unable to make regular commitments to highly organized sports programs.

This is not to infer that all clubs are entirely "low-gear." The rugby club competes regularly in the "A" and "B" league schedules, and this past spring won the Championship Tournament of the New England Rugby Union. A volleyball club has been active in New England tournaments this past year, and soon may be petitioning for intercollegiate status.

Graduate clubs in soccer, ice hockey, and crew enable many students to continue their interests after their undergraduate years.

Although club status connotes self-support, the Department of Athletics encourages and supports club athletics within the practical limits of the available budget. This backing is based on the belief that clubs bring together undergraduates, graduates, and faculty in informal athletics which foster desirable relationships outside the classroom.

Clubs Active in 1973-74

<u>Club</u>	<u>Roster</u>	<u>Club</u>	<u>Roster</u>
Badminton	14	Karate -- three clubs	60
Bicycling	6	Rugby -- two clubs	40
Cricket	15	Scuba	30
Graduate Crew	12	Table Tennis	10
Graduate Soccer	20	Volleyball	15
Ice Hockey -- two clubs	30	Water Polo (spring)	12
Judo	45	White Water	<u>22</u>
			331

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

As emphasized in the introductory section of this report, a major objective of the M. I. T. athletic program is to introduce all students to lifelong sports interests in which they may develop participation habits in the years following graduation. The Department extends this objective to members of the faculty and staff, and, wherever possible, to their families.

The completion of the new ice rink-field house and the continued use of Rockwell Cage will enable the Department to meet more equitably the needs of the "casual" participant, particularly during the popular hours in the late afternoon, when most of the athletic facilities are committed to the formal aspects of the intercollegiate and intramural programs.

The continued development of decentralized facilities readily accessible to the units within the expanding residence system is equally important. The construction this past spring of two new tennis courts adjacent to Tang Hall is typical of the type of recreation facility which should be incorporated with the development of the West Campus.

The best single index of M. I. T. community participation in athletics is the annual sale of athletic cards. Again this past year, approximately 70 percent of all registered students were active in some phase of the athletic program, as were a sizable number of faculty, staff, alumni, and employees.

Athletic Card Sale for 1973-74

Students	5,577
Faculty	369
Academic Staff	597
Exempt Employees	101
Biweekly Employees	465

Athletic Card Sale continued

Hourly Employees	<u>115</u>
Total	7,224
Alumni	282
Summer Specials	<u>127</u>
Grand Total	7,633

Sailing Card Sale for 1973-74

Students	658
Faculty/Staff	207
Alumni	69
Specials	179
Physical Education	<u>354</u>
Total	1,467

Cambridge and Boston Community Relations

The Department regularly extends the use of its facilities to community interests at times when there is no conflict with its primary commitment to M. I. T. students. The Department particularly hopes to sponsor programs which involve interaction between M. I. T. students and young people from the surrounding communities.

In general, these accommodations can be divided into two categories: continuing programs during periods of off-peak use by M. I. T. students, and short-term commitments, usually a single date. Examples of the continuing commitment are: weekday use of the du Pont gymnasium during the indoor season by small supervised groups from the Kingsley School for Girls, between the hours of 9:00 and 10:00 A. M. ; and use of the outdoor running track by the teams of Cambridge High and Latin and Rindge Technical Schools, in consultation with the M. I. T. track coach.

The single-event commitments include a wide range of activities which take place mainly during recess periods, or during the late spring, summer, and early fall season, when the Institute's indoor facilities are more readily available. These include major community-wide events, such as the St. Patrick's Day party for Cambridge, the Massachusetts State Science Fair, the National Tennis Championships of the American Tennis Association, and the National Paraplegic Olympics. Commitments to smaller groups from the Cambridge Sports Union and the Cambridge Recreation Department are too numerous to mention.

Major Athletic Awards for the Year

The Class of 1948 Award to the Senior Athlete of the Year

William D. Young '74

The Admiral Edward L. Cochrane Award to the senior who has combined best the qualities of leadership, humility, and scholarship in intercollegiate athletics

Edward J. Hanley, Jr. '74

The Eastern College Athletic Conference Merit Medal to the Scholar-Athlete of the Year

Lawrence D. Bell '74

The M. I. T. A. A. Pewter Bowl for outstanding contributions to women's athletics by a woman student

Shelley F. Bernstein '74

The Straight T Award for national or regional recognition in intercollegiate athletics at M. I. T.

Johan G. Akerman '77
Philip J. Brucat '77
Shelley F. Bernstein '74
Stephan C. Goldstein '76
Edward J. Hanley, Jr. '74
Brian W. Moore '73
John F. Pearson '74
Richard W. Reimer '77
Gilbert W. Sanchez '76
LeRoy E. Simpson, Jr. '75
Arlie G. Sterling '77
William D. Young '74

The Burton R. Anderson, Jr., Award to the Manager of the Year

Lawrence D. David '75
Michael Sarfatti '75

The Varsity Club Award to the Freshman Athlete of the Year

Johan G. Akerman '77

The Harold J. Pettegrove Award for outstanding contributions to intramural athletics

Michael S. Cucchissi '75

Personnel

Professor Benjamin R. Martin, Jr., professor of physical education and head coach of hockey and lacrosse, resigned effective June 30, 1974. The following appointments were made: Professor Mary-Lou Sayles, to serve as director of women's athletics, effective July 1, 1973; Lecturer Maggie Lettvin, who will be in charge of the Self-designed Fitness Program, effective July 1, 1974; and Assistant Trainer Robert G. McQuaid, effective July 1, 1974. The following promotions were made: Professor Gordon V. Kelly to the rank of associate professor with tenure, effective July 1, 1974; Professor David Michael to the rank of associate professor, effective July 1, 1974; and Professor Francis C. O'Brien, Jr., who was approved for tenure, effective July 1, 1974.

ROSS H. SMITH

Provost

Elsewhere, the Provost has had an opportunity to comment at some length on M. I. T.'s patterns of growth and change during the last thirty-odd years. Hence this is hardly the place or the year to discuss in detail how the collection of Institute units -- laboratories, centers, and committees -- and programs whose reports follow have a special relation to the Provost's office. This list does not only grow by accretion; every once in a while, a project terminates or transfers to one of the Institute's five Schools.

This year the Cambridge Project, whose beginnings may be remembered as somewhat controversial, terminates. A report on the project that succeeds it (Project Overlap) will be found next year within the report of the Dean of the School of Architecture and Planning.

During the past year, Joel Orlen has served as chairman for a task force concerned with long-range planning for the M. I. T. Libraries. In addition to his customary dedication and seriousness, Mr. Orlen has brought a quality of leadership to this task which it is a pleasure to acknowledge.

In midsummer, Professor Edward Fredkin found that he was anxious to accept the offer of a visiting professorship at the California Institute of Technology for the academic year 1974-75. He also took this opportunity to resign as Director of Project MAC, a post he had held since 1971. The Institute was extraordinarily fortunate to be able to persuade Professor Michael L. Dertouzos to accept the directorship on very short notice.

At midyear, Professor Hartley Rogers, Jr., joined the office of the Provost as Associate Provost. The presence of this valued faculty colleague, whose leadership and service to the Institute have been outstanding, should enable the Provost's office to provide more continuing and deeper consideration of the Institute's academic programs. The Provost is personally gratified to have Professor Rogers join him.

WALTER A. ROSENBLITH

American Journal of Physics

In 1973, the Institute became the home, probably for a six-year period, 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.

The editorial office of the journal moved to M. I. T. as a result of the appointment of Dr. Edwin F. Taylor, Senior Research Scientist in the Department of Physics, as editor. He is assisted by Professor Anthony P. French, Consulting Editor, Constance Carpentiere, Administrative Editor, and Mona Nagai, Editorial Assistant. In addition, Charles P. Friedman served as assistant editor during 1973-74.

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 subjects in physics; innovative 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

Artificial Intelligence Laboratory

The Artificial Intelligence Laboratory is concerned with understanding the principles and details underlying the acquisition and exhibition of intelligence. Its research includes work on machine vision, understanding English text, learning, expert problem solving, human development and education, and productivity technology.

During the past academic year, Professors Marvin Minsky and Seymour Papert led the general studies in artificial intelligence and cognitive theory. Professor Berthold K. P. Horn directed the work in machine vision and in productivity technology. Professors Ira Goldstein and Gerald Sussman worked in the area of learning theory and expert problem-solving systems. Professor Carl Hewitt supervised work on programming semantics and theory of computation. Professor Vaughan Pratt continued in the area of natural language studies. Professors Hal Abelson, Jeanne Bamberger, and Ira Goldstein assisted Professor Papert in his educational experiments. Professor Patrick H. Winston served as acting director of the Laboratory.

Substantial progress was made particularly in the area of knowledge representation, in self-debugging systems, and in productivity technology. The goal of the knowledge representation work is to devise structures suitable for accepting and facilitating the use of information bundles such as might be associated with the visual appearance of an office or the activities ordinarily involved in something like a child's birthday party. Since a need for good, purposeful description seems generally important to the creation of intelligent programs, this fundamental work on knowledge representation has wide applicability. In self-debugging systems, for example, progress resulted largely from advances in the understanding of how programming knowledge can be represented and factored into various categories.

Work in the area of human development and education again yielded striking insights. The Laboratory is enlarging its education experiments in cooperation with the Division for Study and Research in Education (D. S. R. E.), with a view toward providing learning environments in which students can formulate and "debug" ideas about their own problem-solving procedures.

Finally, in the productivity technology area, the development of an inexpensive laboratory for visual inspection and for manipulation studies is essentially complete. The equipment already has been used to detect faults in printed circuit conductors and to assemble radial-bearing assemblies using force feedback to cope with tight tolerances.

Nine faculty members, one research associate, 28 research staff, 14 support staff, 18 research assistants, and 25 M. I. T. students were employed in research activities. These activities were supported by funding from the Advanced Research Projects Agency/Office of Naval Research, the National Science Foundation, and International Business Machines, Incorporated.

PATRICK H. WINSTON

Cambridge Project

The Cambridge Project comes to the end of its five years this summer. About 60 members

of the faculties of M. I. T. and Harvard University have participated. Nearly 200 students and other employees participated at one time or another, some working with faculty members and some serving on the Project staff.

The purpose of the Project was to make the digital computer -- and especially the time-shared computer -- more useful in the behavioral and social sciences, both in pure research and in practical applications. This broad territory led the Project to engage in an almost bewildering range of activities, a sampling of which will be listed below. During the first year, the participants in the Project decided to assemble a collection of computer programs which could be used in combination by a scientist who was not a programmer. The chief obstacle to on-line use of computers in the behavioral sciences, and in their practical applications, was the effort required to transform data so that the results of one program could be used as inputs for another. The labor needed to make the transformations -- whether by hand or by writing special ad hoc programs -- was so large that work which in principle could be done in an afternoon's use of a time shared machine routinely took days or weeks. The Project therefore set as one of its main goals the construction of a Consistent System of programs for handling data, for data analysis, and for modeling. Programs for controlling laboratory experiments were omitted, as they did not seem appropriate to a machine of the size that some of the others would require.

Detailed planning was begun in the summer of 1970, at the end of the Project's first year. An attempt was made to picture what the collection of programs should be like, and it was concluded it should be based on the MULTICS system. MULTICS is a very advanced time-sharing system -- now the most advanced in the world -- which then was being developed by Project MAC and the computer manufacturer (General Electric at first, then Honeywell). In the following year, a small collection of programs called TOSS was constructed on MULTICS as an experiment, and it was brought to the point where it actually could be used. It had a profound effect on the plans for the organization of the Consistent System, and for its relation to MULTICS. New plans were settled in the summer of 1971, and the first version of the SUBSTRATE, a group of routines that mediate between MULTICS and the programs in the System, was ready in the fall. At that point the collection of programs could begin to grow. It has been growing ever since, and currently amounts to over one million words of object code. When the Cambridge Project ends, the responsibility for maintenance and continued growth will be assumed by Project Overlap, which is being organized in the Laboratory of Architecture and Planning by a committee chaired by Dean William Porter of the School of Architecture and Planning.

The System is available to any user of the MULTICS machine at M. I. T. and now has been installed on two other MULTICS machines elsewhere. Because the M. I. T. MULTICS is on the ARPANET, an experimental computer network sponsored by the Advanced Research Projects Agency of the Department of Defense, use of the System on the M. I. T. machine is not confined to M. I. T. and Harvard University. The users are spread across the continent -- notably at Stanford Research Institute and the University of Illinois -- and there has been some tentative use as far away as England and Hawaii. The interests of the users have not been confined to what is ordinarily called behavioral science; they have ranged from dentistry to keeping track of fuel stocks during the shortage that began in the past year.

The System currently includes almost 200 programs, some quite small, and others that are systems in themselves, containing on the order of 100,000 words of object code apiece. The collection can be divided into six parts.

1. Janus This is a system for handling what is probably the most common kind of data in the behavioral sciences -- i. e., data on a number of "entities" (e. g., people), all of which are treated as having the same attributes (e. g., age, sex,

number of children, etc.). Janus is unusual in that it handles relations between such sets of data. It was developed by Jeffrey Stamen and Robert M. Wallace with the assistance of Pamela Hill and other members of the Project staff. The present version is a prototype and is to be replaced by an improved one.

2. Discourse This system also deals with entities and attributes; however, it can locate the entities on a two-dimensional grid and can deal with spatial properties like the center of gravity. It was developed by Lecturer Wren M. McMains of the Department of Urban Studies and Planning, Dean William Porter of the School of Architecture and Planning, and their associates.
3. Time Series Processor/Cross Section Processor John Brode, with the help of other members of the Project staff, adapted this system from an earlier version that was designed for batch processing. It is intended mainly for econometrics, but includes statistical routines which are useful in many other fields.
4. Diana and other programs for handling text Diana is a group of programs for scanning large bodies of natural English text to find documents that appear relevant to a given subject. It was developed by Research Associate Rosemarie Rogers and her colleagues at the Center for International Studies, with the assistance of E. Ricardo Quiñones, Elaine C. Franklin, and others on the Project staff. Other programs for handling text are the work of various members of the staff.
5. The Reckoner This is a loose group of about 90 programs. Their design was influenced strongly by the Reckoner systems at the Lincoln Laboratory. They work on numerical arrays, in some cases accepting arrays with labels on the rows, columns, planes, etcetera; they include routines for extracting subarrays, joining arrays together, matrix arithmetic, statistics, plots of data, and so on. These programs provide users with a way of doing computations for which more convenient provisions cannot be found elsewhere in the System. Most of the work on the statistical programs was done at Harvard University, under the supervision of Dr. Donald Rubin of the Department of Statistics and Richard D. Ferguson of the Department of Psychology. The rest of the programs were written by Marcia Siegel, Dr. Charlotte R. Gilson, and other members of the staff.
6. Miscellaneous and service programs These programs, which are vital but often tedious to write, were produced entirely by the staff. They perform such services as listing all the files named in the user's directory and transforming data from one format to another. They also include macro-builders, which permit the user who is not a programmer to combine a number of programs into a macro-program of his own.

Perhaps just as important as the contents of the present System are the measures that were devised for controlling and documenting a collection of this size, for keeping it consistent, for keeping it working in the future with a minimum of "maintenance," and for encouraging users who were also programmers to add to it. These measures were the work of John C. Klensin, Dr. Raymond A. Wiesen, Caroline S. Lange, Susan W. Godsell, Robert K. Sorrentino, John M. Strayhorn, Dr. Joseph Markowitz, Dr. Douwe B. Yntema, and other members of the staff. The conventions that define consistency are especially important. Some are conventions about data. A program must be able to determine whether a file of data is of a type on which it can operate, and it must refuse in an orderly manner if it cannot. The others are conventions about the way programs must behave so that a nonprogrammer can combine them into macro-programs.

The Consistent System, with its present programs, represents perhaps two-thirds of the Project's effort. The rest of the work also was aimed at making computers more useful in the behavioral and social sciences, but the projects undertaken in the course of the past five years were so varied that any attempt to describe them properly would consume a disproportionate amount of space. It may be better to list a few examples, both large and small, that illustrate the range of accomplishments. This list omits some projects that were at least as fruitful as any of those which are included.

1. Professor Ithiel de Sola Pool of the Department of Political Science has been directing the construction of an interactive system that will help its users to translate social theories from verbal statements, such as those usually found in textbooks, into logical propositions whose implications can be deduced by the computer. The system is called Implicat, and it is designed to become part of the Consistent System.
2. Professor Craig Fields of the Department of Psychology at Harvard University set up a computerized laboratory for experiments on the conditioning of the autonomic nervous system in humans, which included, for example, experiments on the voluntary control of the heart rate.
3. Professor Daniel Roos and others in the Department of Civil Engineering made a theoretical study of data management from the point of view of the user. The study described the trade-offs among several methods as a mathematical optimization problem and suggested an approximate solution. To explore these results and to test some new algorithms that promised great increases in efficiency, an experimental data management system, DAMAS, was constructed on MULTICS.
4. Dr. Richard W. Chadwick, working with Professor Karl W. Deutsch in the Department of Government at Harvard University, developed FORTRAN routines that detect and analyse patterns in a transaction matrix -- a matrix showing the flow of trade between different parts of the world, for example.
5. Professor Robert F. Engle of the Department of Economics wrote subroutines that embodied new methods for the spectral analysis of a time series. Their utility was verified by Monte Carlo tests as well as in practical applications.
6. At the Sloan School of Management, Professor Gordon M. Kaufman and Abba Krieger developed a program for computing Bayesian estimates when both cross-section and time series data are available.
7. Professor James L. McKenney and others at the Harvard Business School devised methods and prepared programs for collecting and analysing data on the cognitive strategies that players of the Business School Game follow when they use an on-line information system in making their decisions.
8. Professor Philip J. Stone and his associates in the Department of Social Relations at Harvard University revised their General Inquirer, which is a batch-processing system for content analysis of passages of natural language. The new version, which is called Inquirer II, is written in PL/I and contains fundamental improvements; in particular, it has procedures for discriminating between different words of the same spelling.

The Cambridge Project has had more than its share of troubles, and this report would be incomplete if it did not mention them. Those at the beginning were by far the most serious. The Project originally had been conceived by members of the faculties of both M. I. T. and

Harvard University -- principally Professor Joseph C. R. Licklider of the Department of Electrical Engineering and Professor Pool at M. I. T. and Professors Fredrick Mosteller and Karl W. Deutsch at Harvard University -- who envisioned it as a joint undertaking. Since the primary sponsor was to be the Advanced Research Projects Agency of the Department of Defense, and since much of the academic world then disapproved of research supported by the Department of Defense, the Project encountered opposition on both campuses. It was attacked in handbills and posters, and provoked much discussion about the use of computers in behavioral science, the threat computers could pose to privacy, the relation between universities and the government, the value of the behavioral sciences, and the limits of academic freedom. Some of this opposition was thoughtful, and some seemed to be based on astonishingly inaccurate reports about what the Project planned to do. Their inaccuracy became more evident as time went by; in fact several people who had been opposed to the Project, or at best very dubious about it, joined the staff and made significant contributions, especially to the Consistent System.

In the meantime, the controversy at Harvard University continued for months. After two committees had studied the question at length, and had recommended that the university participate, a motion was put on the agenda of the Faculty of Arts and Sciences condemning the Project and declaring that the university should have no part in it. Finally an agreement was reached. The supporters of the motion withdrew it before a vote was taken, and the supporters of the Project agreed not to ask that it be given any formal recognition by the university. Work at Harvard therefore proceeded under subcontracts, for which individual members of the faculty applied to M. I. T.

This arrangement was quite difficult to administer. The controversy had lasted almost a year, during which it was impractical to choose a director for the Project or to begin recruiting a staff. That any progress was made at all was due to the persistence of an interim committee with members from both M. I. T. and Harvard University. Professor Mosteller was chairman, and Professor Aaron Fleisher of the Department of Urban Studies and Planning was vice-chairman of this committee. Although continually uneasy about its status, and continually hoping that it could be discharged soon, the committee persevered, month after month, in making plans and attempting to initiate useful work.

The problems that arose later seemed minor by comparison. MULTICS still was having growing pains when work on the Consistent System began, and these were more protracted than anyone had expected. Trying to build a complex collection of programs when the underlying system and the compilers were full of "bugs" and continually changing was extraordinarily difficult. Although the developers of MULTICS did what they could to be helpful, the loss in time and energy was serious. Another problem was the inevitable conflict between the goal of consistency and the goals of programmers who wanted to go in their own directions (in particular, those who were more interested in seeing their programs used outside the Consistent System than inside it). In spite of endless discussion and some admirable compromises, this problem never was solved completely.

The director of the Cambridge Project has been Douwe B. Yntema, Senior Research Associate in Psychology at Harvard and Senior Lecturer in the Sloan School of Management. Joseph Markowitz and Norman Magnussen were appointed assistant directors in 1972, and Oliver G. Selfridge, Research Associate in the Department of Electrical Engineering, was appointed associate director in 1973.

The Project was fortunate in the constitution of its Advisory Committee on Operation: Professors Arthur P. Dempster of the Department of Mathematical Statistics (who served after the summer of 1971), McKenney, Edwin B. Newman of the Department of Psychology, and Stone (who served until the summer of 1971), all of Harvard University; and Professors Fleisher, Licklider, Pool, and Robert H. Scott, Director of Information Processing Services, all from

M. I. T. Dr. Yntema acted as chairman. Besides meeting an average of two or three times a month for almost four years, the members of this Committee often served in planning groups and took on special assignments as trouble-shooters. They were very generous in the time they gave to the Project, and without them it would not have accomplished as much as it did. For two years there was also an Advisory Committee on Policy, chaired by Dean William F. Pounds of the Sloan School of Management, which was larger and met less often. The Project is grateful to the members of this Committee as well.

The funds for the Project came almost entirely from the Advanced Research Projects Agency of the Department of Defense, under contracts that included both the Cambridge Project and the work on dynamic modeling in Project MAC. Although his own interests were more in dynamic modeling, Professor Licklider acted as principal investigator for both. This was a very generous service; perhaps only those who have handled large contracts really can understand how generous it was. The other participants owe him a special debt of gratitude.

DOUWE B. YNTEMA

Center for Advanced Visual Studies

Since its inception, the primary aim of the Center for Advanced Visual Studies has been to explore creative ideas in art for the environment. Considering the large-scale, public nature of their work in the environment, which involves complex interactive systems, the Center's artists have had an exceptional opportunity for dialogue with M. I. T.'s scientists, engineers, architects, and planners. During academic year 1973-74, educational efforts were emphasized by means of teaching, as well as by the increased activities of the fellows of the Center. Besides seeking to fulfill its educational and research responsibilities within the Institute, the Center also seeks to appeal to a larger community, by spreading ideas through exhibitions, publications, and forums. These efforts have received a strong response from many individuals and communities in this and other countries, and have been complemented by another aspect of the Center's genuine interests -- individual research in the development of art forms that integrate media, design, kinetics, and conceptual approaches to contemporary life-styles.

During the past academic year, generous support for the Center's activities was given by the National Endowment for the Arts and the Kress Foundation, through the extension of a \$100,000 grant. Other support came from two sources at the Institute: the office of President Jerome B. Wiesner, and the office of the Dean of Architecture and Planning, Professor William Porter. Outside funds to individuals at the Center were made available from the Fulbright and Guggenheim Foundations. During the year, the Center had 15 research fellows, one visiting fellow, and 11 students.

In the fall term of 1973, nine students worked at the Center and participated in the development of ideas, proposals, and models for two ongoing projects, each aimed at finding artistic solutions for urban environments -- Times Square (New York City) and Boston Harbor. These civic-scale environmental design projects provided students with an opportunity to work directly with the artist-fellows at the Center. During the spring term, the students worked on "A New Spring Festival" for M. I. T., using new materials and technology such as polyethylene/helium structures and holography. Throughout the year, weekly seminars and attendance at fellows' presentations of their own work allowed students to collaborate in, and learn from, the activities and interests of the Center. Research Fellows Paul Earls and Friedrich St. Florian offered an Independent Activities Period (I. A. P.) subject, Artistic Synesthesia: Environmental Applications, in which approximately 40 students participated. This short-term series of seminars, lectures, and presentations dealt with the potentials for inter-sensory expression (particularly as applied to urban-scale environmental projects) through the use of new transducer technology.

Collaborative work on the Charles River Project, which was started in 1971-72, continued. This year's participants were Research Fellows Lowry Burgess, Athena Tacha, Michio Ihara, Luis Frangella, Paul Earls, Joe Moss, Maryanne Amacher, Stanley Resnicoff, Keiko Prince, and William Parker.

Mr. Burgess completed his master plan for a new Charles River park system, and worked on the adoption and implementation of various parts of the report with the Metropolitan District Commission Planners. Ms. Tacha designed and executed a 17-foot-long model of a large environmental step sculpture for the banks of the Charles River, along Memorial Drive. Mr. Ihara, in collaboration with Mr. Earls and Mr. Frangella, completed the designs for a "Floating Walkway System" for the Science Museum Basin. This system incorporates floating barges and offers the possibilities of programming light, sound, and water displays. Mr. Moss applied his work with auditory environments to the problem of high noise levels along the banks of the Charles River. Large reflective shapes would be used to enhance the natural sounds of the river and to block the disquieting noises of traffic on Storrow Drive. Ms. Amacher proposed gardens of sound and stillness for the banks of the river. Her plan called for natural structures (bamboo and wind) and environmental recordings that evoke a sense of place. Two other projects involved the use of light and natural rhythms. Mr. Prince designed a "Sun-Water Dial" for Magazine Beach, which combined the effects of prisms, reflection of water and light, and the changing movements of the sun and seasons. Mr. Parker, choosing to focus on the river at night, created designs and models for mobile, illuminated, floating fountains which employed buoy construction and radio control of the fountains' movements over the river by on-shore computers.

The year's second major collaborative project was the revitalization of Boston Harbor. Messrs. Burgess, St. Florian, Earls, and Professor Otto Piene collaborated on an extensive artistic proposal entitled "Four Boston Harbor Islands: The Shaping of an Environment as Art." Its aim was to use environmental art as a means of initiating the reintegration of Georges, Gallop, Lovell, and Rainsford islands with the city. Work on these proposals will continue in Mr. St. Florian's Architectural Design studio at M. I. T., and it is hoped that students will become involved in the possible transformation of Boston Harbor into a contemporary, celebratory, recreational environment. In an independent contribution to the Harbor project, Juan Navarro-Baldeweg developed a design that would channel sunbeams through fiber-optic carriers to create a "solar light" configuration of flashes over the Harbor, in correspondence with the kinetics of the sun-Earth system. Mr. Frangella contributed drawings and plans for several smaller-scale designs that would represent the movement between interior and exterior space and would expand the meaning of architectural elements in the urban environment.

A third major collaborative project of the Center during academic year 1973-74 was the continuation of the Multiple Interaction Team -- a traveling exhibition/event of work by fellows of the Center, under the direction of Coordinating Artist St. Florian. This exhibit, supported by a grant from the National Endowment for the Arts, went to art and science museums all over the country: the New Orleans Museum of Art; the Science Museum of the Franklin Institute, Philadelphia; the Museum of Fine Arts, St. Petersburg, Florida; the Hall of Science, New York City; and the California Museum of Science and Industry, in Los Angeles. Created in the spirit of the interaction of art and science, this collaborative exhibition won considerable acclaim for the Center in 1973-74.

In addition to these ongoing collaborative projects, Center fellows have worked individually on various other environmental projects. Douglas Davis, Art Editor of *Newsweek* and author of an important new book on modern art, technology, and science, has been engaged in three related projects during his residence as a fellow at the Center. One was the collection and viewing of images and sounds recently detected in the solar system by the National Aeronautics and Space Administration. This material will be used for a video work using the facilities of the

Center for Advanced Engineering Study and in collaboration with WCVB-TV, where the tape ultimately will be broadcast. Mr. Davis also has worked with computer programming and dialogue in collaboration with the Architecture Machine Group of the School of Architecture and Planning. Many students have been and will be involved in a third project, using a large-screen multi-image closed circuit piece which ultimately will be presented at M. I. T. and Harvard University's Carpenter Center for the Visual Arts.

Rockne Krebs, an artist from Washington, D. C. , who has been working with laser light, generated two bold proposals for the Boston area. One, submitted initially to NASA, was a city-scale laser piece celebrating the coming of the comet Kohoutek; the other, submitted to the Boston Museum of Science, concerned the permanent installation of a laser light structure at the Charles River Basin. In addition, Mr. Krebs realized an acclaimed laser work for the Kennedy Center show, "Art Now '74," in Washington, D. C. , using two-mile-long argon-ion laser beams. He also has initiated research at the Center with continuous laser-line drawing and stereo vision that will culminate in an exhibition at the Walker Art Center museum in Minneapolis, Minnesota. Carl Nesjar continued his work with "all-year" fountains which are designed to become ice sculptures in the cold seasons. Sculptural designs, models, and studies of freezing patterns for the fountains were done at M. I. T. in collaboration with the Fluid Mechanics Laboratory and the Departments of Metallurgy and Materials Science and Electrical Engineering.

Mr. Parker developed a proposal for "Energy Indicators" in response to the energy crisis, which would demonstrate to the public the use of energy in time by means of a plasma gas sculptural display. Alejandro Sina worked with electrical energy in several projects that applied the natural variations of light and color to participatory public sculptures. Messrs. Earls and Sina and Ms. Amacher participated in Visiting Professor Piene's exhibit "Weather," staged in Lobby 7, which used experimentation with environmental "process" art and involved the collaboration of M. I. T. students and faculty. In another Lobby 7 piece, "Music in Public Spaces," Mr. Earls created a performance using ceremonial music and laser light.

In February, 1974, the Center, in collaboration with the School of Architecture and Planning and the Council for the Arts, sponsored a symposium entitled Arts and the University: The Visual Arts at M. I. T. , which dealt with the clarification of the role of the arts within the university. Among the participants were: Provost Walter Rosenblith; Professor Robert Gardner, Director of Harvard's Carpenter Center for the Visual Arts; Jonathan Benthall, English art historian; Professor Emeritus Roy Lamson, Special Assistant to the President on the Arts; Professors Richard Leacock, Robert Preusser, and Judith Wechsler of the Department of Architecture; artists Harold Cohen, Mr. Davis, Mr. Krebs, Visiting Professor Piene, and Mr. St. Florian; and (in a final dialogue in Kresge Auditorium) Institute Professor Emeritus Gyorgy Kepes, Director of the Center, R. Buckminster Fuller, philosopher and designer, and Robert Motherwell, painter. The symposium was an experimental forum for ideas on the role of artistic values and creative processes in the university, and on the significance of pioneering research in the visual arts.

Several of the fellows at the Center received public recognition for their work during the past year. Mr. Earls was awarded a fellowship by the National Endowment for the Arts to complete his work on a chamber opera, scheduled for the year of the bicentennial. Mr. Ihara won the Massachusetts Arts and Humanities Foundation's open competition for a work of art for the Fitchburg, Massachusetts Public Library. Messrs. Earls and Burgess were appointed consultants to Boston 200 on planning collaborative sound and visual events featuring all the bells and bands of Boston, in a celebration for the Boston bicentennial to be held in April, 1975.

Professor Kepes, founder and director of the Center for Advanced Visual Studies since 1967, has been appointed artist-in-residence at the American Academy in Rome for 1974-75, and

will be leaving the Center for one year. The newly appointed director is the German artist Otto Piene, Professor of Visual Design in the Department of Architecture. Professor Piene has made several recommendations for the future of the Center. These include more extensive contact with the various M. I. T. departments; intensified educational programs; art and building commissions; information research; art curricula development; and closer collaboration with local and foreign television. The Center is in a very delicately balanced financial situation at this time, and therefore, plans for future activities depend heavily upon successful fund raising.

GYORGY KEPES

Center for Cancer Research

The Center for Cancer Research came into operational existence in the academic year 1973-74. During the year, the group of cancer research scientists already on the faculty of the Department of Biology was joined by four additional faculty members. By June, 1974, six persons of professional rank and their associates had occupied laboratories in the Seeley G. Mudd Building or were preparing to do so. Four additional laboratories are expected to be occupied in the next academic year by new faculty members. The completion of the Seeley G. Mudd Building in near record time (with some laboratories functioning by January, 1974, less than 14 months after the official approval of construction plans) was made possible by the untiring efforts of the M. I. T. personnel involved in this project.

The scientific program of the Center, supported primarily by a grant from the National Cancer Institute, generous gifts from the James and Lynell Holden Foundation and from other sources, and research grants and contracts to individual faculty members, has developed along the lines outlined in the proposal to the M. I. T. Corporation in 1972. The work of the Center is directed strictly toward fundamental studies of cancer biology, with a concentration on specific cancer problems rather than on background research that may relate indirectly to cancer. Thus the virology group, including Professors David Baltimore, Nancy Hopkins, and Robert Weinberg (soon to be joined by Professor Phillip Sharp), is studying the mechanisms by which cancer viruses multiply, how they become incorporated in the genetic material of animal cells, and how they cause these cells to act as cancer cells. This work ties in directly with the work of Professor Phillips W. Robbins and his colleagues in the cell biology group, who are studying the specific chemical components that distinguish normal from cancer cell surfaces. This latter work will be expanded next year with the arrival of Professor Richard B. Hynes from the Imperial Cancer Research Laboratory. The research of the immunology group of Professors Herman Eisen and Paul Gottlieb also relates to that of other groups in the Center, in the study of specific immunoglobulins present on the surface of cells of cancer of the bone marrow and on the structure of these proteins. It is hoped that close collaboration among the various groups will be maintained, as well as between research groups in the Center and those in various departments of the Institute, despite the physical separation by floors and by building.

Although at present the Center has no facilities for clinical research work, it was able to develop close research cooperation with the leukemia research group of Professor David Nathan of Harvard Medical School and the Children's Hospital Medical Center. This collaboration has involved an exchange of research personnel between Professor Nathan's laboratory and that of Professor Baltimore. Several joint publications on leukemia have resulted.

A gratifying indication of the recognition gained by the faculty and staff of the Center is that all research grant proposals submitted have been approved and funded, and many fellowships have been awarded.

It is a special pleasure to report that Professor David Baltimore was elected a member of the National Academy of Sciences, and also received the Academy's highly prized U. S. Steel Award in Molecular Biology.

Professor Robert Weinberg was the first recipient of the newly established Faculty Research Award from the American Cancer Society, Massachusetts Division.

SALVADOR E. LURIA

Center for International Studies

During the past academic year, the Center for International Studies (C. I. S.), under the direction of Professor Eugene B. Skolnikoff, continued to develop research programs on problems involving the impact of scientific and technological change on the international system.

The joint M. I. T. -Harvard seminar on international technology, which in 1972-73 had explored various aspects of the energy problem, turned its attention this year to questions related to the oceans -- food and mineral resources, exploration and research, and related problems of international regulatory institutions. The two major objectives of the seminars are to inform the natural and social scientists who comprise it, and hopefully to stimulate further research. The previous year's concentration on energy did play a part in the development of a research project on the future nuclear energy industry, which will commence during the coming year. This research will be undertaken by Professors Henry Jacoby of the Sloan School of Management, Paul Joskow of the Department of Economics, and Joel Yellin of the Department of Political Science.

The more general question of the utilization of technological information in the policymaking process is being studied by Research Associates Howard Margolis and Anne Cahn. Dr. Cahn is examining several questions related to making technical advice available to the United States Congress. Mr. Margolis is exploring the development of a decision-making model that would incorporate technical advice along with other considerations. He hopes to develop this model further and to apply portions of it to an analysis of the United States and European responses to the 1973 energy crisis.

Several Center studies have examined problems common to advanced industrial societies. Professors Suzanne Berger of the Department of Political Science, Lisa Peattie and Martin Rein of the Department of Urban Studies and Planning, and Michael Piore of the Department of Economics have completed the first year of a three-year study of "economic dualism." Their concern is to explain the economic and social significance of the persistence of traditional sectors in advanced industrial economies. Professor Skolnikoff, in collaboration with scholars at other American universities and European institutions, has been developing a series of comparative studies of environmental policy decisions. Professors Berger, Piore, and Rein, along with Lecturer John Zysman and Professor Marc Roberts of Harvard University, have been working on a European based study of the application of social science research to such policy problems as poverty, income distribution, and the environment.

The project on international nutrition planning, sponsored jointly by the Center and the Department of Nutrition and Food Science, has made significant progress during the year. Under the direction of Professor F. James Levinson, it has attracted major financial support and has initiated an active program of advice, research, and education that will strengthen the Institute's long-run capabilities in this field and will produce shorter-term results. During the past academic year, training workshops were held for Agency for International Development (AID) personnel, representatives of voluntary agencies, and nutrition planners from a number of developing countries. Plans are well advanced for a yearlong training course which will be

conducted in conjunction with the Center for Advanced Engineering Study. Several research projects were begun, including a study of United States food policy from a nutrition perspective. The program also offered advisory services on nutrition planning in Pakistan, Indonesia, Brazil, Jamaica, Chile, Thailand, and El Salvador.

Problems of arms control are the focus of another Center research program. During the past academic year, Professors Jack Ruina of the Department of Electrical Engineering and George Rathjens of the Department of Political Science worked with the Aspen Institute of Humanistic Studies and the Harvard Program for Science and International Affairs on a study, to be held in the summer of 1974, for academic, business, and government participants. This study will focus on current and future arms control issues facing the United States. Professors Ruina and Rathjens also have been developing, with Harvard University, a new undergraduate subject for the 1974-75 academic year. The M. I. T. and Harvard arms control programs also jointly sponsored a series of seminars on arms control issues that were open to the Cambridge community. In addition, research is under way in several areas: on the lessons of SALT I by Research Associate Margolis; on conventional arms trade by Amelia Leiss, Assistant Director of the Center; and on the attitude of the middle powers on arms control by Research Associate Enid Schoettle.

Research on communications policy is being carried out in collaboration with the Center for Policy Alternatives. At the Center for International Studies, Professor Ithiel Pool has directed most of the work in this field. Among the topics under study are: international controversy over direct satellite broadcasting; spectrum allocation for land-mobile communication; and data communications systems for developing countries.

Professors Everett Hagen, former director of the Center, and Richard Robinson of the Sloan School of Management are directing a series of research projects on international business. They are concerned with problems raised for the international system by the operation of international business as well as problems encountered by international business. Among the subjects being studied are: monetary system reform; trade adjustment provisions; direct foreign investment; "reverse investment"; exchange rates; workers' participation in management; and licensed production of high-technology weapons. In addition to the research being directed by Professors Hagen and Robinson, Professor Willard Johnson of the Department of Political Science is studying the role of business leadership in the economic development of Africa, and Dr. Aron Basak, visitor in the Sloan School of Management, has been developing a research program on the role of public sector enterprises in economic development.

For a number of years, individual research projects in the Center have dealt with the political effects of the movement of people within and among states. During the past year, Professors Myron Weiner of the Department of Political Science and John Harris of the Departments of Economics and Urban Studies and Planning have organized a student-faculty Migration and Development Study Group, to design further research on: the place of origin of migrants, factors influencing out-migration, and the impact of out-migration and return migration; migration of skilled populations; and the relationship among employment, wages, migration, and distribution of income. In addition to Professors Weiner and Harris, the following individuals expect to participate in research in this field: Professors Jagdish Bhagwati and Piore of the Department of Economics; Professors Nazli Choucri and Wayne Cornelius of the Department of Political Science; and Research Associates John Field and Robin Remington of the Center.

A number of Center studies can be grouped under the heading, political problems and conflict. Professors Hayward Alker, Jr., Lincoln Bloomfield, and Choucri, all of the Department of Political Science, are nearing completion of a study of "interdependence." They have examined the varied meanings given this term, the relevance to policy of scholarly studies of various forms of interdependence, and a case study of energy resources illustrating how various

interdependencies might be analyzed.

Under Professor William Griffith of the Department of Political Science, work continued during the past year on the study of communist, revisionist, and revolutionary movements. Professor Douglas Hibbs of the Department of Political Science completed his analysis of membership in radical left mass political movements and its relationship to underlying political, economic, and social factors. Professor Pool and Research Associate Zev Katz concluded work on two major studies of Soviet society, which drew both on recent work by Soviet sociologists and the recently published 1970 census; the first dealt with the structure of Soviet society, the second with major Soviet nationalities. Professor Donald Blackmer of the Department of Political Science has continued work on left-wing politics in Europe, with particular focus on Italy. African liberation movements are the subject of continued study by Professor Robert Rotberg of the Department of Political Science; Professor Bloomfield has continued to develop his experimental computer system, designed to store and analyze data on local conflicts.

Political and economic development remain a major part of the Center's research program. During the past year, the following projects have been in progress: Professor Weiner's study of Indian elections; Dr. Remington's work on the Yugoslav constitution; Professor Harold Isaacs's (Department of Political Science) studies on ethnicity and on group identity; Professor Lucian Pye's (Department of Political Science) work on elite communication in Indonesia, Asian political cultures, and modernization in Asia; and Professor Michael Mitchell's (Department of Political Science) work on black political participation in Brazil. Professor Pye also completed a report on personnel practices and policies in developing countries.

As in the past, work on improving social science methodology has been an important part of the Center's program. Research Associates Stuart McIntosh and David Griffel continued development and testing of the ADMINS Marc V system. Professor Alker has continued his research on cybernetic models of political systems. Forecasting methodology has been a major focus of Professor Choucrist's work; in conjunction with the Institute of World Order, Professor Choucrist organized a major conference on forecasting in the fall of 1973. Research Associate Rosemarie S. Rogers completed the development of computer-implementable rules for identifying themes in political documents.

During the past year, in addition to the research projects outlined above which are supported by funds administered by the Center, other scholars have visited the Center for stays of varying lengths, to engage in their own research and to interact with C. I. S. members. A complete list would be too lengthy to include here; the following were in residence for the full academic year: Col. Emmett DeAvies, Betsy Gidwitz, Professor Marion Just, Professor George Kistiakowsky, Peter Prifti, Dr. Enid Schoettle, and Dr. Kosta Tsipis. Their research interests included Soviet commercial aviation, arms control, Albanian politics, and political alienation. In addition, the Center continued its practice of organizing seminars on a variety of international topics which are open to the entire M. I. T. community.

EUGENE B. SKOLNIKOFF

Committee on the Visual Arts

The Committee on the Visual Arts (C. V. A.) is a faculty committee established in 1966 to act as a coordinating body for the varied and growing nonacademic interests 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 program of the Committee on the Visual Arts is guided by the following responsibilities:

1. To initiate extracurricular activities in the visual arts -- lectures, colloquia, exhibitions, etcetera -- ranging from small student discussions to major events open to the M.I.T. community and the general public.
2. To initiate exhibitions in Hayden Gallery, Hayden Corridor Galleries, the adjoining outdoor court, and other designated areas to complement the educational programs, in an effort to bring the entire M.I.T. community into close touch with the artistic events of its time.
3. To oversee the Institute art collection and promote its use to enhance the visual environment of the Institute.
4. To oversee the Catherine N. Stratton Collection of Original Graphics and promote its use by students to enhance their living environments.
5. To cooperate with the Planning Office in its effort to improve the visual environment of the Institute.
6. In general, to act as a coordinator for interest in the visual arts at M.I.T. for their full realization and greatest benefit to the M.I.T. community.

The faculty membership of the C.V.A. includes: Professor Wayne V. Andersen, Chairman, of the Department of Architecture; Professor John Buttrick, of the Department of Humanities; Robert J. Holden, Associate Dean for Student Affairs; Professors Donlyn Lyndon, Head of the Department of Architecture, Boris Magasanik, Head of the Department of Biology, and Bruce Mazlish of the Department of Humanities; Institute Professor Philip Morrison; and Professor Judith Wechsler, of the Department of Architecture. Ex officio members are: Walter A. Rosenblith, Provost; Bruce K. MacDonald, Assistant Director of Exhibitions; and Peter M. Spackman, Director of the Council for the Arts at M.I.T. Jawaid Ismail serves as student representative.

Committee Activities

During the past year, the Committee on the Visual Arts has continued to carry out the various duties stated in its guidelines. Special emphasis is being placed now on the development of a long-range program that will make outdoor art visibly accessible not only to the M.I.T. community but to the general public as well. A precedent was established with Alexander Calder's La Grande Voile in McDermott Court, and plans are under way to place monumental pieces by Picasso and Henry Moore on the Memorial Drive axis.

The one-percent-for-art-for-new-buildings program is progressing, with many acquisitions for the Sherman Fairchild Electrical Engineering building installed, and a proposal is now under study for a sculpture by Chryssa. Preliminary plans are under way for the use of the one-percent funds for the new Chemical Engineering Building and for the Center for Cancer Research. M.I.T.'s support of contemporary art in public spaces is providing a model for Boston and other cities interested in revitalizing the outdoor environment.

A Henry Moore for the Killian Court In the fall of 1971, the chairman of the Committee on the Visual Arts proposed a sculpture by Henry Moore for M.I.T.'s Killian Court, one of the large marble pieces he had seen earlier in an exhibition in Florence. Mr. Moore was very receptive to the notion of having one of his monumental sculptures in an impressive location at M.I.T. A detailed album entitled "This is M.I.T." was produced for the artist by the Committee on the Visual Arts.

The artist was very much impressed with the presentation, and a subcommittee was formed to consider the final selection and installation. Further study by the Committee revealed that long-term exposure of Carrara marble to the New England climate was inadvisable, and Moore suggested a bronze as being more practical and impermeable to weather changes. He dispatched photographs of three large sculptures for the consideration of the Committee, and recommended especially Double Oval (1966). The Committee agreed that this was the most

fitting piece for the grand scale and landscaping of the Killian Court. Scale renderings in Moore's own watercolor technique indicating the relationship of Double Oval to the other environmental elements of the Killian Court were forwarded to Moore. In a personal visit to M. I. T., Moore enthusiastically approved the site. Feasibility and cost considerations now are being studied.

A Picasso for the Courtyard between Buildings 2 and 14 It is planned that in late summer, Figure découpée, a concrete sculpture approximately 14 feet high designed by Pablo Picasso and executed by Carl Nesjar, will be placed in the courtyard between Buildings 2 and 14. Nesjar, who is currently a research fellow at the Center for Advanced Visual Studies, has executed a number of Picasso's designs. Using a "betogrove" technique perfected in Oslo, Nesjar reproduces Picasso's brushstrokes on a cast concrete skin by means of high-power jets of sand. A revitalization of the entire courtyard was designed by Dean Emeritus Lawrence Anderson of the School of Architecture and Planning and studied by the Committee. The model calls for the siting of the Picasso in a prominent location to the left of the stairs leading to Hayden Gallery and Library from Memorial Drive, and includes landscaping and seating to provide an inviting area for visitors to the scene. The project and supporting documentation have been forwarded to the appropriate departments within the Institute. It is hoped that this project will "reclaim" an area which has been a problem for many years.

One Percent for Art Program on construction costs of new campus buildings The "one percent for art program" for the new Electrical Engineering facility was completed in the winter of 1973-74. The final phases of the program included the selection of public and private spaces in Buildings 36 and 38, and the installation of the art objects acquired for the building. Twenty-two paintings and lithographs, including works by Andy Warhol, Ellsworth Kelly, Adolph Gottlieb, Jim Dine, Louise Nevelson, Alexander Calder, Richard Serra, Robert Motherwell, and Roy Lichtenstein, were placed in offices of the buildings, with efforts made to insure the security of the works and to allow the greatest visibility to students, faculty, and staff. Important works were placed in the lobbies of Building 36, which was judged to have the greatest traffic flow. Among them were: a portrait bust by Ros Newman of Sherman Fairchild, commissioned by President Jerome Wiesner; an Edison Generator, dated 1880, donated by the Boston Edison Company and restored and repainted by the C. V. A.; paintings by Jack Bush and Jacqueth Hutchinson; and a tapestry by Fernand Leger. A sculpture by Chryssa, who works in neon, is under strong consideration for the glassed-in lobby area of Building 36. In addition to its aesthetic appeal, the electrical associations of her work are thought to make the piece most appropriate for the buildings. Its feasibility will be explored further.

A C. V. A. group met with I. M. Pei Associates, the architects of the Chemical Engineering Building, to discuss the disbursement of art funds. A tentative proposal was suggested to use approximately one-half of the funds for small portable objects to be placed in offices and public spaces, and the other half for a single monumental work to be sited either inside or outside the Building. Some of the artists mentioned were Louise Nevelson, Jean Dubuffet, Isamu Noguchi, and Carl Nesjar. A mural, light sculpture, or a work created by an artist working with chemical engineering technology also will be considered, and new possibilities are being explored. Another meeting was held with the head of the Department of Chemical Engineering to determine the views of those who will occupy the building. It was decided that a committee representing the interests of the Department of Chemical Engineering will be formed as the client committee.

Proposals to the Committee on the Visual Arts Among the various proposals brought before the C. V. A. during the past year were a fountain by Carl Nesjar, a research fellow at the Center for Advanced Visual Studies; the acquisition of a 400-pound bell dated 1864, an artifact of nautical history; a steel piece by Friedrich St. Florian, also a research fellow at the C. A. V. S.; the future enlargement of Hayden Gallery; a benefit exhibition of works in the

collections of M. I. T. alumni; the permanent siting of a Beverly Pepper sculpture donated by Roger Sonnabend, which currently is located in the courtyard near the Alumni Pool; and the possibility of Committee support for an effort to beautify Kendall Square.

Office of Exhibitions Activities

The 1973-74 Exhibitions Program continued the standard of excellence it has maintained over the years. Administered by a professional staff of five, the schedule included five exhibitions organized at M. I. T. and three originated at other institutions. The complementary roles of art and technology were the focus of "Lightworks" and the paintings of Donald Robertson. "Celebrations" was a tribute to Minor White, Professor of Photography at M. I. T., who is retiring this year. A critical examination of a recent avant-garde art movement was offered in "Interventions in Landscape." The show also provided a new and creative means of utilizing the exhibition as an integral part of the formal learning experience. The concept, developed by Professor Andersen, will be explored further in the coming year. The Exhibition Program's continuing commitment to Boston artists was reflected in this year's staging of the Boston Visual Artists Union show. The work of Henry Moore and Kurt Schwitters, both internationally recognized modern artists, was shown; an outstanding and unusual collection of nineteenth century paintings from the Museo de Arte de Ponce, Puerto Rico, founded by M. I. T. alumnus Luis A. Ferré, closed the season.

The Hayden Gallery Corridor exhibitions included many excellent showings of works on paper, from Professor Jan Wampler's photo-documentation of self-motivated, nonprofessional architecture to a sensitive display of photographs of women of the theater from 1875 to 1925, borrowed from the Harvard Theater Collection in Houghton Library, Harvard University.

Publications

The M. I. T. Art News first was published by the Committee on the Visual Arts in the fall of 1972, as part of its effort to bring M. I. T. students into close contact with all areas of the visual arts.

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 that provide the M. I. T. community with a broad range of opportunities for experience and participation in the visual arts. It also is intended as a vehicle for informing the M. I. T. community on the history and development of the Institute as a visual environment.

Acquisitions

Highlights of the new acquisitions to the permanent collection were six photographs by Harold Edgerton and Kim Vandiver, placed in the new Sherman Fairchild building and in the Faculty Club, and ten graphics by M. C. Escher, which were donated by Charles E. Reed. A photograph by Minor White, entitled Boarded Bay Window, San Francisco, California, also was hung in the Faculty Club. Other major additions to the collection included: a portrait of Raymond Beach Price (M. I. T. Class of 1894), a gift of Odette S. Price; Fifteen Shoeing Smith, a piece by Carl Andre commissioned for the Hayden Gallery exhibition, "Interventions in Landscape"; And Again, by Howard Mehring, donated by the Boston Foundation; and Bayan by Jim Huntington. New loans included Red Vault by Paul Reed, loaned by Roger Sonnabend, and eight oil paintings by Elbon (Dan Noble, M. I. T. alumnus).

The Catherine N. Stratton Collection, a collection of prints by prominent artists available free to students on a yearly loan basis, was increased by eight color serigraphs of Carl Gerstner, donated by Max Wasserman; three silkscreens, by Richard Anuszkiewicz, Robert Motherwell, and R. B. Kitaj; nine lithographs, by Lowell Nesbit, Al Held, Richard Serra,

Ed Moses, Alex Katz, Claes Oldenburg, Sam Francis, Ron Davis, and Frank Stella; and two screenprints, by Jack Bush and John Hoyland.

Other Activities

As the M. I. T. art collection expands, more adequate curatorial space and record-keeping equipment are required by the Exhibitions Office. In addition, exhibitions planned for next year include three presentations that call for budget augmentation: the Otto Piene profile, the Tibetan art show, and "Environmental Symbolism." The staff is aware of an increasing need to obtain outside funding in the future, and presently is involved in the formulation of a procedure to gain expertise in foundations research and proposal writing.

This year the Committee on the Visual Arts was awarded a \$2,000 grant by the National Endowment for the Arts for C.V.A. Chairman Wayne Andersen's Artists-in-Residence Program, part of his Environmental Symbolism seminar/"Interventions in Landscape" exhibition project. Also, a matching grant of \$2,500 was made by the Council for the Arts to the Committee on the Visual Arts toward the publication of the catalogue for the exhibition of nineteenth century paintings from the Museo de Arte de Ponce. Financial assistance proposals for storage space renovation and curatorial equipment, the Otto Piene exhibition, and the Tibetan art show are under way.

The M. I. T. Faculty Club was renovated by the Boston architectural firm of Goody, Clancy, and Associates, and the Exhibitions Office assisted by lending works from the M. I. T. permanent collection on a long-term basis. Suitable spaces were chosen both for aesthetic workability and security. In addition to a painting by Thomas Doughty, Romantic Landscape, two photographs (by Minor White and by Harold Edgerton and Kim Vandiver) were lent to the Faculty Club. Lithographs, aquatints, and photographs on loan from the Francis Russel Hart Nautical Museum also were installed. Posters designed for past Hayden Gallery exhibitions by Jacqueline Casey of M. I. T. 's Office of Design Services were framed and mounted in the corridors.

Staff

The staff of the Committee on the Visual Arts consists of: Professor Wayne V. Andersen, Chairman, Director of Exhibitions; Bruce K. MacDonald, Assistant Director of Exhibitions; Stephen Ringle, Gallery Manager; Susan C. Hayes, Administrative Assistant; Robyn Wessner, Exhibitions Assistant; Meg Shore, Editorial Assistant; and Joanne Sliker, Secretary. As of July 1, 1974, Mr. MacDonald will serve as Director of Exhibitions; Marjory Supovitz became editorial assistant on May 1, 1974.

WAYNE V. ANDERSEN

Division for Study and Research in Education

The academic year 1973-74, as the initial year of the Division for Study and Research in Education (D.S.R.E.), has been one of development and growth. The main accomplishment of the year has been a coming together of faculty from widely different disciplines, with the goal of defining common intellectual areas; sharing assumptions, knowledge, and background; and working on common problems. As the year progressed, the Division moved toward a multi-focal structure, which allows it to express an overall research strategy in its choice of foci without attempting to impose a uniform policy on all its members. The foci are intended to represent subcommunities or subcultures within the Division. They are chosen by criteria which include their potential for fertile interaction, but once chosen they are to be allowed enough autonomy to lead independent, internal intellectual lives. This structure

is intended to be a guiding principle for the Division, but not a rigid formula. Clearly there must be room in the Division for individual faculty members who are not associated with any focus or who are associated with more than one.

The current growth plan includes establishing two major foci now and setting up a process which will select two or three more within two years. The initial foci are: 1) a style of education research with an emphasis on knowledge structures and individual learning of the kind called information processing theories of cognition (as articulated at M. I. T. by Professor Seymour A. Papert and associates); and 2) a style of research with an emphasis on institutional processes and the concept of public learning (articulated by Professors Donald A. Schon, Benson R. Snyder, and associates).

Professor Papert was given an appointment as the Cecil and Ida Green Professor of Education for a term of three years. This chair, the first in the Division, was made possible through an earlier generous gift to the Institute from Cecil H. and Ida M. Green. The appointment recognizes not only Professor Papert's outstanding contributions in research and teaching, but also his fine work in the development of the Division. During the year the Division also received the good news of a further gift of \$1 million to the Institute by Cecil H. and Ida M. Green, to be used to help support the new Division. These gifts are indications of the deep and abiding interest in higher education of Mr. and Mrs. Green, and they assure the Division of a basis on which to move forward. The entire Division and the Institute are deeply appreciative of these generous gifts.

Personnel

In addition to the initial appointments of the Division, Judah L. Schwartz, Professor of Engineering Science and Education in the School of Engineering, was given a joint appointment with the School of Engineering and the Division at the beginning of 1974.

Professor Jerome S. Bruner, Watts Professor of Psychology at the University of Oxford, spent part of the spring term as visiting professor in the Division. Professor Malcolm R. Parlett, formerly of the University of Edinburgh, also spent the past year with the Division as visiting professor. Robert Karplus, Professor of Physics, University of California at Berkeley, was visiting professor in the Division during the fall term, and Dr. George Hein, of the Education Development Center, Newton, Massachusetts, was a guest of the Division for the year as a visiting scholar.

Among the short-term visitors during the year were Professor Hans Freudenthal of the Mathematical Institute, Utrecht; Professor Dietrich Goldschmidt of the Max Planck Institute of Educational Research in Berlin, and Yale University; Professor Joseph Katz of the Wright Institute of the State University of New York at Stony Brook; Professor Hermina Sinclair-Zwart of the Institut des Sciences de l'Education in Switzerland; Professor Martin Trow of the University of California at Berkeley; and Sir Geoffrey Vickers of Goring-on-Thames, England. Students and faculty in the Division gained a great deal from the presence of these visitors.

Jeanne S. Bamberger was promoted to associate professor jointly in the Division and in the Department of Humanities (Music Section) effective July 1, 1974. Other appointments for 1974-75 include Dr. Thomas F. Jones, former president of the University of South Carolina, who will spend the year at M. I. T. as a visiting professor jointly in the School of Engineering and in the Division. Dr. K. Nagaraja Rao, Senior Research Associate in M. I. T. 's Center for Policy Alternatives, also will hold a part-time appointment during 1974-75 as senior lecturer in the Division, while continuing his appointment in the Center. Sir Geoffrey Vickers has accepted an appointment as senior lecturer in the Division from September through November, 1974. As the first year of what is expected to be a continuing and

important program, three special lecturers were appointed: Steven T. Rosenberg, of the Department of Psychology, Carnegie-Mellon University, and Ben-Zion Shanon, of the Department of Psychology, Stanford University, both for the academic year 1974-75; and James L. Stansfield, of the Bionics Research Laboratory, University of Edinburgh, for the spring term of 1975.

Richard M. Guttmacher, Executive Officer of the Division, resigned effective July 24, 1974, to accept a position at Medical Care Development, Inc. in Augusta, Maine. Special thanks from the Division as a whole are given to Mr. Guttmacher. His skill, excellent judgment, and deep understanding of the goals of the Division were of inestimable value during its initial year. The Division was very fortunate in the appointment of Elaine Medverd as administrative officer, as a replacement for Mr. Guttmacher. Ms. Medverd, who had held the position of special assistant to the dean of the College of Liberal Arts at Boston University, will join the Division July 16, 1974.

Doctoral Program

Students interested in new kinds of careers in education research may work in an interdisciplinary Doctor of Philosophy program administered by the Division in collaboration with various M. I. T. departments. Three students were enrolled in this program during the academic year 1973-74. The number will increase to approximately eight during 1974-75. This program, which has attracted strong candidates, enables a student to pursue his or her course of study and supervised research along the lines of a program worked out individually by a committee from the concerned department and the Division.

Academic Program

In addition to the regular subjects given by the staff of the Division during the fall and spring terms, one key activity in the academic program was a seminar in education conducted by Professors Papert, Schon, and Snyder during the fall term. The purpose of this seminar was to elicit, and to pursue in depth, confrontation between different intellectual approaches to education represented in the Division's faculty. The seminar considered the ways in which learners construct models of the subject they are learning, of the process of learning, and of the importance of the context in which learning occurs. The seminar, which was attended by students and by several senior staff members of the Division, served as a central focus of the Division's academic and research activities. An activity which grew directly out of this seminar was a program conducted by Professors Papert, Schon, and Snyder with selected undergraduate students, which reviewed with them individually and in depth their style of learning and in particular the way they looked at their science and mathematics subjects in the freshman and sophomore years. A second outcome was a study led by Professor Schon and other members of the Division on the use of metaphor in the learning and teaching process.

During the spring term Professor Schon, under the sponsorship of the Division, led four sessions on professional education with leaders in the field of professional education from within M. I. T. and from other institutions in the greater Boston area. These four sessions, which proved to be very stimulating and enlightening, will serve as the basis for a further study and a formal subject offering on the topic by Professor Schon.

Lilly Postdoctoral Teaching Awards

Near the end of the academic year, the Division received the good news of a \$50,000 grant from the Lilly Endowment, Incorporated, to be used for Lilly Postdoctoral Teaching Awards for the academic year 1974-75. Under this program, ways of enhancing teaching effectiveness will be explored by 13 recipients of these awards, who will hold part-time fellowships

in the Division. The fellows -- assistant professors and postdoctoral instructors from 11 of M.I.T.'s 24 academic departments, each of whom was nominated by the head of his or her department -- will aim to improve their level of functioning as teachers by investigating various aspects of the teacher-learning interaction. Professor Roy Kaplow of the Department of Metallurgy and Materials Science will serve as coordinator of the program. Discussion seminars, guest speakers, class visitations, and audio-video tapings of teaching presentations will be some of the methods used to examine pedagogic techniques. This program affords a unique opportunity for a collaborative effort between Institute departments and the Division on the important task of the improvement of teaching.

In Recognition

Special thanks are given to Dr. Barbara Scott Nelson, Assistant to the President and Chancellor. Her wise counsel and her active participation with the faculty and Policy Committee of the Division are valued by all. This special mention of Dr. Nelson is given because of the many contributions she generously has made without a formal appointment in the Division. Special thanks are also due the members of the Policy Committee, who have given so freely of their time and have helped to guide the Division wisely during this formative period.

WILLIAM T. MARTIN

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

Educational Programs

Curriculum in Biomedical Sciences

The past academic year has seen further evolution of this curriculum. The Curriculum Committee, under the chairmanship of Dr. David W. Hamilton, has begun the implementation of new elements of the curricular plan. Students in the Program are encouraged to pursue advanced study in areas of their interest that may complement the subjects in the biomedical sciences. This study may be undertaken as part of the curriculum leading to the Doctor of Medicine (M.D.), or may be pursued in a combined M.D.-master's degree or M.D.-Doctor of Philosophy program. Students also are expected to choose a field of concentration in which they will spend approximately one-half of their elective time; these fields are: 1) neural sciences; 2) musculoskeletal system; 3) cardiovascular, renal, and respiratory systems; 4) endocrinology and metabolism; or 5) reproductive and developmental biology. Faculty tutors will provide guidance in the choice of subjects and in the pursuit of independent study. Prior to graduation, Program students will be expected to present evidence of scholarly work in the form of a thesis based on laboratory research, clinical investigation, critical analysis of a significant medical problem, or other activities approved by the faculty tutors. These new provisions will be required of students admitted into the Program after September, 1974.

In accordance with the objective of promoting the integration of the quantitative physical sciences into the biomedical sciences, a series of lectures and conferences entitled "Quantitative Topics in Physiology" was presented by Professor George Benedek of the Department of Physics. These lectures are part of a continuing effort to develop the interface of human physiology and the physical sciences. Related elements in this development are three subjects in quantitative physiology offered in the School of Engineering: 2.791J

Cells and Tissues, 2.792J Organ Transport Systems, and 2.793J Sensory and Motor Systems. These subjects are taught by Professors Robert W. Mann of the School of Engineering, Ascher H. Shapiro of the Department of Mechanical Engineering, William M. Siebert of the Department of Electrical Engineering, and Lawrence R. Young of the Department of Aeronautics and Astronautics, and their associates. At Harvard University, in the Division of Engineering and Applied Physics, two subjects, Introduction to Systems Analysis with Physiological Applications, and Fluid Flow in the Human Body, are taught by Professor Thomas McMahon of that Division. Bioelectrical Signals and Their Processing in Neural Networks is offered by Lecturer Yehoshua Zeevi of the Department of Biophysics at Harvard College. The Curriculum Committee recognizes, however, that for further successful development of quantitative human physiology, the appointment of one or more new faculty members highly qualified in physically oriented physiology is essential.

There are important elements of the curriculum yet to be developed. The economics and politics of health care, the social determinants of health, the social consequences of illness, the sociology of the health professions, and the legal and ethical problems that accompany the advances in the science and technology of medicine are not adequately presented yet. More attention and resources also should be directed to the study and teaching of the biological determinants of human behavior.

The admission of students into the Program is determined by a faculty committee that operates as a subcommittee of the Admissions Committee of Harvard Medical School. This year, Professor Walter H. Abelmann of the Department of Medicine at Harvard Medical School served as chairman, and Professor Herman H. Eisen of the Department of Biology served as cochairman of the Program's committee. Nine faculty members from M. I. T., Harvard Medical School, and Harvard College comprised the membership of this committee. There were 750 applicants for the 25 places available for the class entering in September, 1974. The quality of the applicants, especially those selected for admission, was outstanding.

With the entry of the first students into the clinical clerkships at the Harvard teaching hospitals, it has been possible to begin to evaluate the preparation for clinical medicine which the Program provides. Initial reports have indicated a high level of performance by the great majority of these students.

Medical Engineering

An important element of this Program is the development of programs in medical engineering and medical physics which can bring together effectively personnel and facilities of both universities and of the teaching hospitals. The development of departments or units of medical engineering and medical physics in the teaching hospitals would provide a setting for educational, research, and service programs with strong clinical interest and orientation. During the past academic year, a task force of faculty members of Harvard Medical School and M. I. T. has been studying the issues and problems associated with the development of medical engineering and medical physics in the Harvard-M. I. T. teaching hospitals setting. The task force, chaired by Professor Young, will report its deliberations in the near future.

The Harvard-M. I. T. Rehabilitation Engineering Center at the Children's Hospital Medical Center has been reconstituted, and the scope of its program has been expanded. Professor William Berenberg of the Department of Pediatrics at Harvard Medical School is the director, and Professor John Hall of the Department of Orthopedic Surgery at Harvard Medical School and Professor Mann serve as co-directors. Other principal participants are: Professors Melvin J. Glimcher, Harriet M. Peabody Professor of Orthopaedic Surgery, Israel F. Abrams of the Department of Neurology, and W. Keesley Welch of the Department of Neurosurgery, all at Harvard Medical School; Dr. Martin Schultz, Director of the Hearing and Speech Division of the Children's Hospital Medical Center; George F. Dalrymple, Acting Director of the

Sensory Aids Evaluation and Development Center; Lecturer Nathaniel P. Durlach of the Research Laboratory of Electronics and Department of Electrical Engineering; Lecturer Derek Rowell of the Department of Mechanical Engineering, and Professor Young.

A medical engineering program at the West Roxbury Veterans Administration Hospital is still in the planning stage. This program, which will place special emphasis on the study and treatment of spinal cord injury, should afford excellent educational and research opportunities.

An educational program on ultrasound in medicine is being developed at the request of the Veterans Administration and with the support of the National Science Foundation. This program in ultrasonics is being designed for graduate physicians who wish to become knowledgeable in the physics of engineering of ultrasound and expert in its clinical applications. This program is being developed initially by a committee consisting of Professor S. James Adelstein of the Department of Radiology at Harvard Medical School; Dr. Irving A. Berstein, Program Officer for Research and Development; Professor Gordon Brownell of the Department of Nuclear Engineering; Professor Karl Ingard of the Departments of Physics and of Aeronautics and Astronautics; Professor Padmaker Lele of the Department of Mechanical Engineering; Edward Smith of the Department of Radiology at the Peter Bent Brigham Hospital; and Professor Young.

New subjects introduced during the past academic year included: HST-520 Artificial Internal Organs, taught by Professors Clark Colton of the Department of Chemical Engineering and Warren Zapol of the Department of Anesthesia at Harvard Medical School, and Instructor Edmund Lowrie of the Department of Medicine at Harvard Medical School; 2.76 Biologic Effects and Medical Applications of Ultrasound and Other Non-ionizing Radiations, taught by Professor Lele; HMS 754.70 Topics in Biomathematics, offered by Professors Thomas Weiss of the Department of Electrical Engineering and Young; and, at Harvard College, Engineering Science 148, Bioelectric Signals and Their Processing in Neural Networks, taught by Lecturer Zeevi.

The interdepartmental program in biomedical engineering, which is supported by the Program, has five students enrolled as candidates for a doctoral degree.

Research and Development

Interdisciplinary Program in Biomaterials Science

This program is now in its third year of operation, with the support of a five-year Program Project Grant of the National Heart and Lung Institute. This research consists of 19 projects and involves 35 faculty members; it is supervised by Professor Mann and a steering committee of 12 faculty members. The progress of the research has been evaluated annually by an advisory board, whose chairman this year was Dean Robert Alberty of the School of Science. The vigorous development of this program has prompted the submission of a supplementary proposal to permit continuation and expansion of the current research effort.

Research Program in Nuclear Medicine

This interdisciplinary program involves six collaborative research projects with 20 investigators from the Divisions of Nuclear Medicine of the Peter Bent Brigham Hospital and the Children's Hospital Medical Center, the New England Regional Primate Center, the Department of Orthopedic Surgery of the Robert Breck Brigham Hospital, the Physics Research Laboratory and Endocrinology Department of the Massachusetts General Hospital, and the Department of Nuclear Engineering at M. I. T. The major part of this research is supported by a three-year grant from the National Institute of Arthritis, Metabolism, and Digestive

Diseases. The subjects under study include neutron activation analysis for the study of osteoporosis, clinical research with activation analysis on disorders of calcium metabolism, and radiation synovectomy for the treatment of arthritis. A related study of a radionuclide generator for angiocardiology is being supported by a grant of the National Heart and Lung Institute for three years.

A fifth project in this program, A Proportional Counter for Imaging in Nuclear Medicine, has been approved, and a sixth, Semiconductor Detectors for Gamma Camera Applications, has been funded.

Energy and Health

The National Science Foundation has provided support for an initial study entitled Priorities for Health Research Relating to Energy System Development, carried out under the auspices of the Program and the Harvard School of Public Health (HSPH). The collaborating groups involved in the initial study include investigators from the School of Public Health, the Departments of Aeronautics and Astronautics, Chemical Engineering, and Nuclear Engineering, and the M.I.T. Energy Laboratory. Professor David Rose of the Department of Nuclear Engineering and Associate Dean James Whittenberger of the HSPH are the principal investigators on this study. It is hoped that the work accomplished in this study will lead to a significantly greater research program in this important area.

Rehabilitation Engineering Center

This Center, described in the section above on medical engineering, is supported by a grant of the Social and Rehabilitation Services of the Social Security Administration.

Research Programs in Preparation

A major collaborative program is being developed on the optimization of dose distribution in cancer radiation therapy, involving the Harvard Joint Center for Radiation Therapy, M.I.T.'s High Voltage Research Laboratory, Department of Mechanical Engineering, Artificial Intelligence Laboratory, and the Charles Stark Draper Laboratory. The proposal consists of nine projects and involves 13 investigators. The principal investigators are Professors Martin B. Levene of the Joint Center for Radiation Therapy and Henry M. Paynter of the Department of Mechanical Engineering.

A proposal is being developed for submission to the National Institute of General Medical Sciences for the establishment of a Biomedical Engineering Center.

Collaborative research on the diagnosis and treatment of muscular disorders resulting from upper extremity stroke involves Professor Thomas Sheridan of the Department of Mechanical Engineering and Drs. Robert Leffert of the Department of Orthopedics and Robert Young of the Department of Neurology, both of the Massachusetts General Hospital. An initial research program has been developed, and a symposium and research planning meeting to engage additional collaborators in a number of fields are planned.

Dr. Irving A. Bernstein, Program Officer for Research and Development, has been a prime mover in the organization and initiation of many of these collaborative research efforts.

Administrative Structure

During the past academic year, the first steps were taken to implement the recommendations of the Planning Committee, chaired by Dean Robert H. Ebert and Provost Walter A. Rosenblith, which were accepted by the Executive Committee in the spring of 1973. As a step toward the institutionalization of the Program, the Planning Committee recommended the recognition and identification of the participants in the Program as the "Faculty and Staff of the Harvard-

M. I. T. Program in Health Sciences and Technology." It also recommended the formation of a Joint Faculty Committee, to function as a Standing Committee of the Program within the Faculty of Medicine of Harvard University and M. I. T.

The functions of the Joint Faculty Committee are: 1) to determine the criteria for membership in the faculty of the Program in Health Sciences and Technology; 2) to review periodically appointments to the faculty of the Program; 3) to oversee the Curriculum Committee, the Admissions Committee, and the research and development activities of the Program; and 4) to serve as a liaison body to other faculties and to the Curriculum Committee of Harvard Medical School and the Committee on Educational Policy of M. I. T.

The Joint Faculty Committee met monthly during the past academic year, and reviewed the educational and research activities of the Program. It decided that the guiding principle for membership in the faculty of the Program should be significant participation in the teaching activities of the Program. Research alone would not be sufficient qualification for faculty status, but it could be recognized by designation as Research Member of the Program. The Committee has reviewed the qualifications of the participants in the Program, and will present its recommendations to the Executive Committee in the fall of 1974.

The procedures for appointments, promotions, and decisions on tenure at M. I. T. and in the various faculties at Harvard were reviewed by Associate Dean Robert Blacklow of Harvard Medical School; Dr. Eleanor Shore, Assistant to President Derek C. Bok of Harvard; and John Wynne, Vice President, Administration and Personnel of M. I. T. Fortunately, the procedures do not differ greatly, so that appointments and promotions in a faculty that is part of both universities appear feasible.

Professor Robert W. Mann has been named the first Uncas A. Whitaker Professor of Biomedical Engineering.

With endowment funds provided by the Becton Dickinson Company, four nontenure faculty awards have been established: two Hermann von Helmholtz associate professorships at M. I. T. and two Lawrence J. Henderson associate professorships at Harvard. Professors Roger G. Mark of the Department of Electrical Engineering and H. Eugene Stanley of the Department of Physics have been appointed Hermann von Helmholtz Associate Professors of Health Sciences and Technology. Professors David W. Hamilton, of the Department of Anatomy, and Harvey Goldman, of the Department of Pathology, both of Harvard Medical School, have been appointed Lawrence J. Henderson Associate Professors of Health Sciences and Technology.

IRVING M. LONDON

Independent Activities Period

The 1974 Independent Activities Period (I. A. P.) was the fourth such January session, and the first since it became a permanent feature of the M. I. T. calendar. The list of offerings was lively and active, and I. A. P. appears to continue to meet its objective of providing a needed break and change of pace in the academic year. Over 80 percent of students were on campus and in attendance at approximately 450 different activities. The number of I. A. P. activities which were identical with regular academic subjects dropped markedly from the previous year, from 17 to three percent, and the proportion of semi-academic activity rose from 57 to 77 percent. Semi-academic activities included hands-on shop and studio work and aspects of academic topics presented in innovative formats, such as design and construction of the "world's largest yo-yo," and investigation of the question "Why do mirrors reverse left/right but not up/down?" The remaining 17 percent of nonacademic activities included

Independent Activities Period

such offerings as auto repair (the most popular), yoga, wine making, movies, ragtime, old-time jazz, and jam sessions.

Several special studies of I. A. P. were carried out under the auspices of its Policy Committee. This is the faculty-student group charged with making and overseeing policy and compiling material for the next I. A. P. evaluation, to be presented to the faculty no later than 1977. The results of these special studies provide data relevant to several controversial questions which have been raised repeatedly since I. A. P. began in January, 1971.

I. A. P. is popular with students (94 percent approve) and with faculty (87 percent approve), but there has been concern that only a small proportion of its activities are led by faculty, and that these tend to be junior faculty members. In fact, 23 percent of the 450 offerings this year were led by full professors, 13 percent by associate professors, and 16 percent by assistant professors; the remaining 48 percent, however, were led by instructors, staff, graduate and undergraduate students, or consultants from outside M. I. T.

The count of 450 activities gives an incomplete picture of I. A. P. since it includes activities that meet only once -- to see a film or hear a lecture -- as well as those that meet three times or more each week. Of the 450 activities this year, 8 percent met once only; 17 percent met more than once in a given week; 24 percent met frequently each week; 47 percent held four or more meetings per week; and 4 percent met more or less daily for three weeks.

I. A. P. is not intended to be a mini-term for credit, though activities for up to six units of credit are allowed. Approximately 225 roll cards were submitted for credit by undergraduates during I. A. P. '74. This compares with an average figure of 36,000 undergraduate roll cards in a regular term. Of the 225 I. A. P. undergraduate roll cards this year, only 32 were for letter grades for regular subjects in intensive form. This data may be of special interest, since I. A. P. '74 was the first time that letter grades were permitted.

There was an initial surge of incomplete grades for the fall term when I. A. P. started, from just over 2 percent of total roll cards to a high of approximately 8 percent, presumably because of the difficulty in adjusting subject material to the shortened term. With successive I. A. P. 's, this adjustment was made, and the level of incompletes dropped back to a more acceptable figure of just over 5 percent. This is higher than before I. A. P., and suggests that a few students use the time to make up incompletes. However, as the incompletes appear to be highest in departments where term papers are of great importance, this increase may reflect an accommodation to the new calendar that accords well with the intent and spirit of I. A. P.

A sampling of student and faculty attitudes, obtained through replies to questionnaires, indicates that I. A. P. has sustained its place in the Institute calendar as an opportunity for experiences and activities that do not take place during the regular term. Scattered criticisms do appear, however. These concern the length of I. A. P., its placement between terms (rather than at some other time in the academic year), the profile of activities offered, and the I. A. P. atmosphere and publicity; they tend, however, to cancel each other out instead of pointing to a significant trend that would prompt major changes. These criticisms and others made during interviews with members of the staff also may be read as a positive sign that I. A. P., though a permanent part of the academic calendar, is not being taken for granted by students, faculty, or staff.

JOEL ORLEN

Joint Center for Urban Studies

The year 1973-74 has been an extremely successful and productive one for the Joint Center. The program of research on housing policy has continued to expand considerably, and much progress has been made in developing an agenda of research in a second area of concern, the delivery of public services. Projects tentatively scheduled in the previous year now are firmly in process, and further proposals are being formulated. The major successes of the Joint Center during the year relate particularly, however, to the work that has been done on varying aspects of housing policy. The report published in December, 1973, entitled America's Housing Needs, 1970 to 1980, drew considerable attention in Washington and elsewhere, and appears to have been influential in helping to shape current thinking on the subject, as has the extensive work exploring the feasibility of housing allowances. Research on instability in the construction industry and the problems of financing home building also has been receiving wide and appreciative consideration. Unquestionably, the Joint Center has been making a mark for itself among policymakers and planners, and is drawing increasing attention to its work among both public officials and academics. Professor Bernard J. Frieden, Director of the Joint Center, Professor Arthur P. Solomon, Associate Director, and others on the staff have been receiving an increasing number of requests to testify at meetings in Washington or to speak to groups around the country.

Research on Housing Policy

National Housing Needs

This major project, initiated in 1972, completed the first stage of its work with a report to the U. S. Department of Housing and Urban Development (HUD) in August, 1973. A revised version of this report was published by the Center in December, 1973, under the title America's Housing Needs, 1970 to 1980. The study provided estimates of likely residential construction and the extent of inadequate housing for every section of the country during the current decade. It took issue with many of the concepts and methods of the 1968 Kaiser Committee report on housing needs for the country, which has formed the basis for recent Federal legislation and housing policy. The Joint Center's approach has been to accumulate statistics from all the individual metropolitan areas and the nonmetropolitan parts of states and then to aggregate the results, thus providing not only national totals but detailed information about local housing markets. Estimates of construction have been based on two main components: construction to meet the needs of additional households that will form during the period through population growth, migration, and changes in living patterns; and construction to meet other market requirements, such as the demand for second or vacation homes. The total construction need over this ten-year period was projected at 23 million new units. The extent of inadequate housing was measured in terms of the condition of the units, the ability of households to pay rent, and the existence of overcrowding. Using these criteria, it was determined that 13 million households were housed inadequately in 1970. Not taken into account, but recognized as an important additional factor determining housing inadequacy, was the condition of the neighborhood. This factor is expected to become the focus of future work at the Joint Center.

Supplementing the raw statistics was data gathered on consumer preferences in housing through the analysis of interviews conducted in Boston and Kansas City. These disclosed considerable present dissatisfaction with older neighborhoods and to some extent with the home itself, which suggests that the potential demand for housing may be greater (if resources allow) than the construction estimates projected in the study. This study of housing needs has been undertaken by a team of researchers at the Joint Center, under the principal direction of Professor

David Birch of the Harvard Business School. Proposals have been submitted to HUD for related work over the next three years. This research will take two directions: first, an analysis of neighborhood evolution and decay, which should help to clarify the factors surrounding housing deprivation that results from neighborhood problems; and second, the development of a simulation model of inter-area migration -- again refining another aspect of the earlier work. This continuing research also will be under the direction of Professor Birch.

Low-Income Housing Subsidies

A second major study forming a central part of the Joint Center's work during the year, also initiated in 1972, was close to completion by the end of the year, with a report to HUD to be submitted in August, 1974. This project has consisted of an interrelated series of 14 separate studies designed to test some of the major propositions and policy issues involved in the concept of a housing allowance program, and to develop policy recommendations for the design of such a program. The primary objectives of the study have been: 1) to identify the various factors that affect the housing of low-income households; 2) to evaluate the relative importance of each; and 3) to suggest conditions under which direct cash assistance may need to be augmented by other supportive programs and strategies. Research so far has determined that inadequate income alone does not account wholly for the poor quality of housing of most low-income households, nor does it explain the wide divergence in the quality of housing occupied by families of equally low income. Various aspects of the overall project also have been weighing the relative importance of other factors, such as the characteristics of the local housing market and of the families themselves, landlord attitudes, and racial discrimination. The source of income and the way in which it is provided also have been a subject of inquiry; researchers are investigating whether this is a factor that may handicap welfare families, in particular, in the private housing market. Individual parts of the research have included simulation models of market effects that might result from different formulations of a housing allowance, and probability models to test the effect of increased income on housing outcomes. A working paper on one aspect of the study, an analysis of an experimental housing allowance program in Kansas City, was issued in October, 1973. Further papers are due to follow. This project has been under the overall direction of Professor Solomon.

Housing Policy in the States

Individual states have a major role to play in the formulation and execution of housing programs, and during the last several years they have become involved increasingly in fulfilling this responsibility. During the past year, at the request of the Council of State Governments, a team of researchers at the Joint Center undertook a review of the roles, current responsibilities, and opportunities for state governments across the country to increase their involvement in formulating and implementing community development policy. A report on this study was submitted to the Council of State Governments in the spring of 1974, and is due to be published by the Council later in the summer. The principal investigator on this project was Professor Robert Schafer of the Department of City Planning at Harvard University, with the collaboration of Nathan S. Betnun, a graduate student in the Department of Urban Studies and Planning, and Professor Solomon.

Instability in the Housing Industry

Fluctuations in housing construction have been a continuing concern at the Joint Center, since the stability and level of construction are fundamental to the broader issue of housing policy. The Center has continued to support work in this area throughout the year. There have been two parts of this research, both undertaken by Kenneth Rosen, a research associate of the Joint Center who also completed the Ph. D. requirements for the Department of Economics in June, 1974. The first part of the research has been concerned with seasonality in construction; it formed the core of Mr. Rosen's doctoral dissertation. He analyzed the patterns,

causes, costs, and policy implications of fluctuations in construction, and determined that elements of demand, rather than bad weather, tend to explain the seasonal pattern. His study also has shown that high winter unemployment and summer accident rates in construction can be related directly to the seasonal fluctuations. Mr. Rosen documented programs in Canada and Norway which show that a small economic incentive can be very effective in shifting a large portion of single-family home building to the winter months. Mr. Rosen plans to refine his material and to publish several papers based on his research in the near future.

The second part of Mr. Rosen's research concentrated on cyclical behavior in housing construction. He has been developing a causal and predictive model of housing starts, with the ultimate aim of finding ways to modify the swings in construction activity. Cyclical fluctuations, conditioned by such factors as the economic climate, can be distinguished from seasonal fluctuations which occur within the year. An initial model has been developed and is being refined. Mr. Rosen already has used it rather successfully in forecasting levels of housing production during 1974. A working paper describing the structure of the model was issued in May, 1974. Further work on the model will include attempts to assess some of the derived costs of cyclical activity, such as unemployment, accidents, inventory accumulations, and shortages.

Environmental Controls and Subsidized Housing

A further study which was completed during early 1974 focused on the development of environmental controls and their confrontation with the expansion of housing construction in the suburbs. Professor Michael Baram of the Department of Civil Engineering at M. I. T. showed, in a working paper issued in February, 1974, how recent developments in pollution control and air quality standards, for example, have provided new opportunities for local governments to prevent new development within their boundaries, despite Federal and state policies that encourage the dispersal of low-income housing.

Ongoing Research

Work continued on the development of a computer based information system for the construction industry. This study, begun in 1972, has had the overall objective of improving the distribution of information on skill shortages and supplies, and aggregate information on wages, prices, and working conditions in the building trades. These trades have presented special problems for the gathering and distribution of information. Each local labor market is traditionally independent, and there is a large amount of short-term job turnover, leading to what is termed "frictional" unemployment. This particular study has focused on developing an experimental information system and field-testing it on one specific building trade. The trade chosen for this purpose has been the local bricklayers' union in the state of Vermont, which graciously granted access to its information resources. The field testing has been completed, and an interim report has been submitted to the Department of Labor. Further work is intended to develop a commercially feasible program which can have practical applicability for other regions of the country and for other trades. Research Associate Edward Markowitz has been the principal investigator on this project, which has been under the overall direction of Professor D. Quinn Mills of the Sloan School of Management.

Another project close to completion in June, 1974, has involved the study of problems, fiscal and otherwise, in the management of privately owned housing that receives government subsidies for its low-income tenants. This project, under the direction of Professor Langley Keyes of the Department of Urban Studies and Planning, has concentrated on certain specific housing projects in Boston. A working paper analyzing one aspect of the problem was issued in February, 1974. This paper discussed "hidden costs," the unrecognized costs of doing business with public agencies which impose regulations that are often time-consuming and expensive, to the managements of the buildings.

Several other projects are near completion. Professor Francine F. Rabinovitz of the Departments of Political Science and of Urban Studies and Planning has been studying the flow of minority populations into the Los Angeles suburbs, and the impact this has had on the politics and governments of those local communities. She currently is preparing a report on the subject. Professor John Zeisel of the Department of Architecture at Harvard University is writing a paper which completes his yearlong analysis of the ways in which housing design standards meet, or fail to meet, the preferences and needs of different types of families. Professor Daniel L. Schodek, also of the Department of Architecture at Harvard University, is reporting on his work during the past year on a related topic, the effect of building codes and standards on the costs of housing. He has illustrated, for example, the unspecified yet nonetheless very real relationship between building codes and zoning controls. Two other projects have examined environmental quality standards. The first of these, under the direction of Research Associate Alan B. Dolmatch, has involved the development and testing of new formulations of the components of residential environmental quality. A report on this project is due to be completed in the early fall. The second study, under the direction of Professor Kevin Lynch of the Department of Urban Studies and Planning, has concentrated on a specific problem, the need for improvements in the quality of the arterial streets, or "strips," radiating out from most American cities. A final report on this project, already prepared, is to be released in the early fall. It makes concrete suggestions on how the aesthetic and physical attributes of the "strip" could be altered or improved. A final project, which began in 1972 and will run through 1975, has involved the development and comparison of several versions of econometric models of metropolitan housing markets. This study is under the overall direction of Professor Jerome Rothenberg of the Department of Economics. An interim report on this project is due to be submitted to the National Science Foundation in the early fall.

Delivery of Public Services

Housing issues represent the greater part of the research being conducted by the Joint Center, but certainly not all of it. During the past year, in particular, advances have been made in expanding the range of work conducted in this second area of public service delivery.

Politics of Street-Level Bureaucracy

A first project, initiated during the spring of 1973, is concerned with the common features of public service bureaucracies, whose lack of time, information, and resources, and heavy work loads combine to make ideal treatment virtually impossible. During the year, work has been concentrated on delineating three dimensions of the problem: 1) the strategic interaction effects when clients seek out, or are subject to, street-level bureaucrats; 2) the "slotting" of citizens by bureaucracies which find that they have to routinize their activities if they are to respond at all efficiently; and 3) the dimensions of social control, particularly where social control does not fall within the mandate of the specific bureaucracy. Preliminary arrangements have been made to work with certain agencies in Boston. An interim report on this project is due to be submitted to the Russell Sage Foundation later in the summer. Professor Michael Lipsky of the Department of Political Science is the principal investigator on this project.

Revenue Sharing and City Budgeting

During the summer of 1973, a team from the Joint Center was invited to develop techniques that could be used by citizens' groups around the country to monitor the uses of revenue-sharing funds. The project, under the joint direction of Professors Lawrence Susskind of the Department of Urban Studies and Planning and Jeffrey Pressman of the Department of Political Science, was concerned primarily with monitoring the likely impact of general revenue sharing on the budgetary process in state and local governments. The instruments were given pilot tests in a city in Massachusetts, and interviews were held with local officials, community representatives, city department heads, and others. The results of this project

were submitted to the National Clearinghouse on Revenue Sharing in Washington, D. C., at the end of the summer, and have been incorporated into a national two-year project to monitor revenue sharing which has been initiated by a consortium of public interest groups.

Public Employee Unions and Urban Services

This study, which is under the joint direction of Professors Ralph Jones of the Department of City and Regional Planning at Harvard University and Robert Fogelson of the Department of Urban Studies and Planning, was launched formally on June 1, 1974, and is expected to run for three years. Preliminary work on formulating the project had been done earlier during the year. The overall objective of the study is to describe, analyze, and evaluate the impact of municipal employee unions on the delivery of municipal services. Attention will be given to exploring the emergence and rapid rise of these organizations in the recent past, their objectives, and the policy implications of their growth.

Social Structure and Living Standards

A third category of research which has been of continuing importance at the Joint Center throughout the year has been changing social structure and living standards. Under this umbrella, Professor Lee Rainwater of the Department of Sociology at Harvard University and Research Associate Richard Coleman have continued to explore people's conceptions of poverty and social standing, consumer patterns of behavior and demand, and people's views of their own housing situations and aspirations. This latter work was carried out in conjunction with the analysis of the nation's housing needs, described earlier in this report. Much of the data under analysis comes from interviews conducted in Kansas City and Boston. A working paper on one aspect of this study was issued in the spring. A book, tentatively titled Social Standing in America: Exploratory Studies, currently is in preparation and nearing completion. A further book, What Money Buys, is due to be released by its publishers in the fall. A proposal for further research over the next two years on the explorations of economic success and social consumption has been submitted to the Department of Health, Education, and Welfare with firm expectations of receiving funding. Professors Christopher Jencks of the School of Education at Harvard University and Martin Rein of the Department of Urban Studies and Planning are expected to collaborate on this new study.

Fellowship Program

The Joint Center maintained its fellowship program for graduate students at Harvard University and M. I. T. who are completing work on their dissertations. A slightly larger number received fellowships this year; 11 grants were made. Topics of research have ranged widely, some reflecting work already under way at the Joint Center and others embarking on totally independent subjects. Among these topics have been black suburban migration, Federal aid to mass transportation, women in the labor market, the politics of city redevelopment, and the capabilities of state housing agencies. Two fellows of previous years had their work published during the year: The Micro-Society School: A Real World in Miniature, by George Richmond; and Bread or Justice: Grassroots Organizing in the Welfare Rights Movement, by Lawrence Ballis.

Seminars

During the past academic year, the Joint Center ran a luncheon seminar series on a biweekly basis. Speakers included faculty from Harvard University, M. I. T., and other universities, as well as people prominent in public affairs. The list of speakers included, among others, H. Ralph Taylor, a former Assistant Secretary at HUD in charge of the Model Cities Program; David Grossman, presently with the Chase Manhattan Bank and formerly Director of the Budget for the City of New York; Philip Rutledge, from the National League of Cities/ U. S. Conference of Mayors; and Lawrence Sager, Professor of Law at New York University,

who has pleaded a case against exclusionary zoning before the U.S. Supreme Court.

Meetings also were held three times during the year, on a regular basis, for representatives of the industrial firms which provide some of the financial support of the Joint Center. Research under way at the Joint Center formed the core of the agenda for these meetings, but guest speakers also were invited to give presentations. At the October, 1973, meeting, Floyd H. Hyde, then Under Secretary of Housing and Urban Development, delivered a talk entitled "New Directions for HUD and the Future Outlook for Housing Programs"; Professor Mills discussed the functions and workings of the construction industry's stabilization committee. At the February, 1974, meeting, the guest speaker was Michael H. Moskow, Assistant Secretary for Policy Development and Research at HUD, who outlined the research priorities of his department. In May, Oakley Hunter, President and Chairman of the Federal National Mortgage Association, and Garth Marston, a member of the Federal Home Loan Bank Board, together discussed the impact of financial institutions on housing production.

Survey Research Program

This Program, which is under the joint sponsorship of the University of Massachusetts and the Joint Center, has continued to conduct studies throughout the year, with Dr. Floyd J. Fowler as its director. In August, 1973, Dr. Thomas Mangione was appointed assistant director. Dr. Mangione comes to the Survey Research Program from the University of Michigan's Survey Research Center.

During the past academic year, a project with the Hartford Institute of Law Enforcement and Criminal Justice (HILECJ), funded by the Institute, has involved working with an urban design team to develop a crime control program for two target neighborhoods. The program will involve the utilization of environmental design, police, and community participation efforts. Under the direction of Dr. Fowler, the Survey Research Program is responsible for pre- and postimplementation surveys to assess the effect of the program on citizen fear and victimization experience. Analysis also will focus on the determinants and correlates of citizen fear. The preliminary measurements and planning were carried out during the past year, and the program is due to be implemented by January, 1975, with the evaluation to be completed in early 1976.

The Survey Research Program has been contracted by the Massachusetts Department of Public Health to carry out a statewide survey of the aged and chronically disabled. The purpose of the survey is to estimate the size of the population requiring various kinds of special medical and support services. The data on the noninstitutionalized population will be integrated with comparable data on the institutionalized population, to produce total estimates of need. A probability sample of 8,000-10,000 households will be screened to locate the over 2,000 aged and chronically ill to be interviewed. Fieldwork is due for completion in early 1975.

Research Associate Lawrence Branch continued his work with the Natick Laboratories, studying satisfaction with food services in the armed forces and designing ways to improve the situation.

Dr. Mangione continued his work with the University of Michigan's Survey Research Center, analyzing data on the relationship between job conditions and personally and socially destructive behavior. Dr. Fowler has been working with the Commission to Review National Policy toward Gambling to develop a research agenda to assess the consequences of current anti-gambling laws and recent and proposed changes in those laws.

Program staff are working with the Educational Planning Office of the University of Massachusetts at Boston to assess the needs, interests, and criteria of high-school students and

their parents in the Boston area with regard to higher education. Also included in the study are special samples of local college students and applicants to the University of Massachusetts at Boston.

Survey Research Program staff also are preparing a paper for the Comprehensive Health Planning Agency in Vermont, describing the main findings of a statewide health survey carried out by the Program in 1973.

Publications

During the past year, staff members of the Joint Center have published six books, one monograph, and six working papers. The Survey Research Program produced three publications. Throughout the year, the Joint Center continued to publish a newsletter. Two numbers were issued, in February and May of 1974, to a mailing list now numbering close to 1,000.

BERNARD J. FRIEDEN

Libraries

The chief characteristic of the M. I. T. Libraries' efforts this past academic year has been cooperation -- cooperation with libraries and with regional systems. Only by collaborative arrangements with others can libraries expect to continue a high level of service; without these kinds of cooperation, it would be impossible to apply new technologies to process the escalating amount and changing character of information.

Interlibrary cooperation in various forms has been practiced for years, but new formations -- regional systems, for example -- have developed recently that augur more effective results. The need for cooperation and the will to make it work were shown dramatically by the recent announcement of the formation of the Research Libraries Group, comprising Harvard, Yale, and Columbia University Libraries and the New York Public Library. The report of their proposals is prefaced by an explanation that long-range trends in education and dissemination of information make it necessary for research libraries to alter traditional self-sufficient policies of collection, organization, and services. It is noted that technological developments can bring more effective cooperation, and it is hoped that major improvements can be achieved with a reduction in the rate of increase in library costs.

Ohio College Library Center

The decision of the M. I. T. Libraries to join the Ohio College Library Center (OCLC) shared cataloging system through the New England Library Information Network probably will have far-reaching effects on M. I. T. library service and operations. The rationale for participation was the assured savings the system would provide in staff, plus greater efficiency and speed in operation.

Preparation for implementation was undertaken carefully and thoroughly. After several meetings of professional library staff members and a discussion by the Faculty Committee on the Library System, the decision was made to adopt, with a very few exceptions, the Library of Congress (LC) shelf-listing system in addition to the previously adopted LC classification scheme. It was recognized that some difficulties would arise in forcing an integration of materials shelf-listed under two systems; however, the overriding factor in the library administration's decision to accept the LC practice was the realization that if M. I. T. is to take full advantage of national systems now developing, its libraries must fall in line with nationally accepted library practice. The time for local systems or adaptation

has passed. Tailored systems are the products of a lavish library economy that no longer exists. Even locally, experience has shown that special arrangements usually must be undone at a later date. For example, a current study of the Music Library catalog reveals the necessity of extensive recataloging because LC standardization was not acceptable to members of the Music Section of the Department of Humanities in 1964 when steps first were taken in that direction. It is hoped that any dissatisfaction with subject entries and the need for providing additional points of access locally will not be critical once the full flexibility of the computer is applied to the bibliographical record. Libraries should direct their influence toward improvement of one national system, so that all will reap benefits.

Patricia M. Sheehan, Library Systems Designer, with the full cooperation of the Catalog Department, made a careful analysis of procedures and worked out new flow patterns to take maximum advantage of the complete data immediately available on the terminal without diminishing the Libraries' present cataloging standards.

In addition to cataloging current books with information available from LC, MARC tapes, and input from the approximately 200 libraries in the system, OCLC will provide an economical way to reduce backlogs and to reclassify. Although a decision was made in 1963 not to reclassify the entire collection, pressure continues for reclassification in some areas -- linguistics, American history, literature, and mathematics, for example. Other segments probably will have to be reclassified before the catalog can be put in machine-readable form. Perhaps these projects can be started as work on current operations is saved and backlogs are deleted.

A significant benefit of the system will be the elimination of the backlog of catalog cards to be typed. This is a serious situation at present; catalog access, except by main entry order slip, is lacking for much current material. There will be use and benefits of the system in areas other than cataloging. Already, quick location of an item requested in the interlibrary borrowing process is saving time. Searching on the terminal can aid also in book selection, possibly eliminating some duplication.

After a sufficient input of M. I. T. library acquisitions, it will be possible to generate useful lists, such as bibliographies on interdisciplinary subjects of documents throughout the system, lists of M. I. T. publications and theses, and consolidated monthly lists of all accessions by LC call number. All in all, the appearance of the OCLC computer terminals is generating much staff enthusiasm and expectation.

Northeast Academic Science Information Center (NASIC)

More visible to users is the Libraries' participation in the NASIC project. NASIC was planned as a regional agency which will provide effective access to machine-readable information by research institutions in New England, New York, New Jersey, Pennsylvania, and Delaware. The NASIC program was conceived by the New England Board of Higher Education and is funded by a grant from the National Science Foundation. Through promotion and marketing and through the training of information specialists at major academic institutions, NASIC aims to serve researchers in the Northeast who need comprehensive information.

In November, 1973, NASIC introduced experimental information services at M. I. T. They are being offered as part of a test to determine the best means of making computer processed information available on an academic campus. This pilot operation is discovering the receptivity of users to various specialized services and to the theory of fee-for-service in libraries. The analysis of use will indicate the demand for particular services and whether the prices necessary to assure continuance on a self-supporting basis are feasible.

M. I. T. 's Electronic Systems Laboratory, Information Processing Services, and Libraries work together under the Institute's subcontract to the New England Board of Higher Education. Professor J. Francis Reintjes, Project Director, heads a team from the Electronic Systems Laboratory. There is a coordinator for the Libraries, Mary E. Pensyl, and six information specialists, one from each divisional library plus another from the Science Library, where MEDLINE was installed concurrently with the first three NASIC data bases: CHEMCON, INFORM, and ERIC. Other bases added since are COMPENDEX, CAIN, and GEOREF.

The library coordinator and the senior information scientist from the Electronic Systems Laboratory team have undertaken the arduous task of intensively training the information specialists in the use of terminals, search strategy, and the characteristics of each data base. Information specialists are the interface between suppliers and users; they help to define the information requirements and select the most appropriate sources. This is a most important function, because the better the search strategy, the less time on-line, with a resultant lower cost.

The information specialists have had to devote more time to NASIC than was anticipated. Training is extremely time-consuming, but vital. Record keeping, policy decisions, publicity, demonstrations, information pamphlets, and meetings involve many hours of many staff members. The willingness of the information specialists to give the necessary "extra mile" has been a significant factor in the success of the project.

NASIC has brought the Libraries an invaluable opportunity, and the approximately 130 users to date have greeted these services with unanimous enthusiasm. Irma Y. Johnson, Science Librarian, who instigated the introduction of MEDLINE, has commented that the interactive interrogation of bibliographic data bases is a landmark addition to, and upgrading of, the Library's reference capabilities.

Other Cooperative Efforts

At the initiation of the Librarian of Washington University, St. Louis, librarians of the Ten University Consortium -- California Institute of Technology, Carnegie-Mellon University, Case Western Reserve University, Dartmouth College, Duke University, Johns Hopkins University, M. I. T., University of Rochester, Vanderbilt University, and Washington University -- have met several times during the year in exploratory meetings to exchange information and to discuss common problems. All are enthusiastic about continuing the meetings with somewhat more structured agenda; future meetings are planned to coincide with meetings of the Association of Research Libraries.

More tangible cooperation will be effected by the anticipated membership in the Greater Boston Consortium of Academic and Research Libraries, a group composed of the Boston Public Library and libraries of Boston University, Boston College, Brandeis University, Northeastern University, Tufts University, University of Massachusetts at Amherst, and Wellesley College. Although M. I. T. is not yet formally a member, the director of Libraries is participating in Board of Directors meetings, and members of the library staff are serving on several committees. It is expected that the usual benefits of consortia will accrue: certified users, faculty and graduate students, will have direct access to the collections of member libraries; a van will make daily deliveries of interlibrary loan materials; expensive items may be purchased cooperatively; and areas of subject specialties may be developed. Work has begun on a computerized union list of serials, which will indicate the holdings of each library.

As part of the Wellesley-M. I. T. Exchange Program, cooperative arrangements have operated for some time between the two schools' libraries. At present there is complete reciprocal use

of libraries -- borrowing and room use by students, faculty, and staff. Library handbooks and new book lists are exchanged. Interlibrary borrowing has been enhanced by arrangements for up to ten pages of free photocopying of articles; copies are sent immediately upon telephone request. Both institutions probably will become members of the Greater Boston Consortium, whose book delivery van will speed up loan requests. Efforts to buy expensive items jointly or to depend on each other's library for journals have not been very successful so far. Helen M. Brown, Librarian of the Wellesley College Library, distributed to Wellesley department chairmen a list of periodical titles to which that Library subscribes at their recommendation, asking which titles might be eliminated if available at M. I. T. with quick telephone connection and prompt photocopy service. Fewer than ten were so identified; the consensus was that journals immediately available on campus are essential to teaching and research. Members of the faculty stressed the importance of browsing through journals. Currently in the planning stage is a modest program of reciprocal staff visits to provide general information about the collections of both libraries and to enable staff members to meet one another.

In addition to the collaborations mentioned above, the Libraries continue special working arrangements with individual libraries, for example, between Dewey and Harvard University's Baker Library, between Rotch and Harvard's Loeb Library, and between the Industrial Relations Collections in the two institutions. Harvard has decided to disperse its industrial relations materials among several of its libraries. This seems an ideal area for the promotion of cooperation between Harvard and M. I. T. M. I. T. has a distinguished, specialized collection, superbly indexed, which this year has had increased use, probably as a result of society's current interest in such topics as discrimination in employment, women in the labor force, training, and education.

As part of the study of areas of cooperation between Harvard's Graduate School of Design and M. I. T.'s School of Architecture and Planning, a two-week census of library use was conducted in April, 1974, in the Loeb and Rotch Libraries. The study report has not been received yet, but as a by-product, an interesting pattern in the use of Rotch was revealed. About 30 percent of the users were members of the M. I. T. community but not of the School of Architecture and Planning; nearly eight percent were non-M. I. T. affiliated. A user study of all the M. I. T. libraries would be enormously helpful in planning for the next 10 or 15 years, and would be an appropriate activity for the Task Force on the Future of the M. I. T. Library System.

The Lincoln Laboratory Library and the main campus libraries have worked together for years. Lincoln maintains a full-time staff member, with an office in Hayden Library, who expedites the borrowing of books and purchase of photocopies for the Laboratory. Lincoln staff members have full library privileges at M. I. T. A program of mutual library staff visits is planned for next year.

An example of internal cooperation was the integration of the Barker Engineering Library into the official M. I. T. Library System after the termination of Project INTREX in the late spring of 1973. Efforts to insure a harmonious reunion have succeeded on the whole; however, in some areas greater understanding must be achieved.

As new technologies evolve and bibliographic access on computer terminals becomes available, different processes of the entire M. I. T. Library System must be studied to seek greater efficiency. Reorganization of staff, with less effort given to technical processing and more to user services, surely will occur. The M. I. T. library structure of divisional units and branches presents a unique opportunity to act as a model internal consortium, even as the Libraries join in cooperative efforts with other institutions and regional systems. Benefits may be gained as well from more cooperation with libraries on campus which are not part of the official system. For years the Libraries have consulted and cataloged for some of these

small units. This year one obtained its catalog data directly from the Libraries' Micrographic Catalog Retrieval System. A complete input of holdings from all library units will be a possibility as the OCLC machine-readable data base develops.

Current Concerns

Although collaborative activities were emphasized this year, much time also was taken with the continuing problems of space and financial resources. For many years, efforts to obtain more space have brought only stopgap measures. In 1966 the Rotch Library expanded onto the first floor; in 1973 the Dewey Library expanded onto the second floor of its building. In spite of those additions, both currently are operating under conditions far beyond shelf capacity. With remarkably good humor, the librarians continue to weed, squeeze, add higher shelves, and rearrange, while they hope for new space. During the past year all major segments of the Rotch collections have been shifted physically, and this coming summer every one of the 300,000 volumes in the Hayden basement stacks will be moved and arranged more efficiently to take advantage of recently added shelving. Such moves are costly, and working at full shelf capacity means inefficiency in operation, user frustration, and additions to book loss figures. Even Barker Library, where space seems adequate, may run into difficulty in a few years. In four of the past five years, it has been unable to follow the formula adopted five years ago under INTREX to withdraw as many volumes as were added. Its program of constant review of the collections in Epsco storage this past year sent 76 percent back to the shelf. Incidentally, requests for material there were 73 percent higher than in the previous year, with a total of 1,893 items recalled.

Fewer items were added to the Libraries this year, primarily because of inflation. In spite of the fact that actual dollars in the book, serial, and journal budgets have not decreased, inflation's toll showed up dramatically in 1972-73 when the number of journal subscriptions was cut, and in 1973-74 when the number of monographs acquired was substantially less than in the previous year.

Even with subscription cuts, it has been necessary to increase the proportion of the materials budget devoted to serials and journals. In 1972-73, the Libraries were spending roughly half the materials budget on books and half on serial and journal publication. In 1973-74, the proportion devoted to serials and journals was approximately two-thirds. The national average price increase of journals in 1973 over 1972 was 34.3 percent. However, in some of the areas in which M. I. T. must buy heavily, the increases were higher. Chemistry and physics journal prices, for example, rose by 45.8 percent, and engineering journal prices by 73 percent. Although the rate of increase lessened in 1974, the cost of some titles is staggering. Subscription rates for many government publications have risen an average of 75 percent.

The seriousness of the journal price situation is compounded by the enormous amount of photocopying in libraries. Publishers feel that the emergence of consortia will increase copying further, and are agitating to have the copyright law incorporate a charge mechanism. New ways of publication are being explored, such as publishing directly on microfiche or publishing abstracts only, with access to articles by request.

The results of the summer of 1973 sample inventory of missing books were discouraging: an average loss of seven percent of the monographs received in the previous ten years. The smaller M. I. T. libraries had smaller losses. Of the major libraries, Humanities and Science in Hayden, where there has been a bookchecker for many years, have a better record than Dewey and Barker, where the loss rates are very disturbing (10.8 and 11.1 percent, respectively).

Funds were found immediately to place a bookchecker in Dewey Library. Better security devices and bookcheckers now are being added to Barker, where the items actually noted

as missing in 1973-74 have increased threefold, from 350 in 1972-73 to 1,000. Of the 4,700 items requested from M. I. T. on interlibrary loan by other libraries, 40 percent could not be supplied -- 20 percent because the Libraries do not own them or do not permit their circulation, and 20 percent because they were missing. The entire book budget of the Chemistry Reading Room this year went for replacement of missing volumes.

Inventories of missing books at other institutions and estimates of librarians at institutions that have not conducted formal surveys report loss rates as great as M. I. T.'s. An analysis of reasons for this phenomenon would lead to speculation on many social factors.

It is a mark of M. I. T. that things get done by individual initiative. Often, however, there comes a time when the relationship of a project to the whole must be considered. It may be that the time has come for the Institute administration to clarify the roles of the Archives, Historical Collections, and proposed collections of the Technology Studies Group. Duplications of effort, complications for users, competition for space, and frustration for administrators are emerging. Professor E. Neal Hartley, Institute Archivist, notes that M. I. T. will be the better for these efforts, but it is important that lines of responsibilities be clarified promptly. The impact on the Libraries and on the Institute Archives is likely to be strong.

The Student Center Library has experienced a gradual decline in use over the past several years. The total number of persons using it now is approximately two-thirds of what it was five years ago. No one has been able to explain the decline, although it has been noted that it is greatest during the Independent Activities Period.

A look at statistics for a five-year period reveals other decreases: in the number of volumes being added, in circulation (weighted, however, by the fact that during the year some libraries changed from a two-week to a four-week loan period), and in interlibrary loan requests from other libraries. However, the M. I. T. Libraries had to borrow more volumes than ever before from other libraries, photocopying continued to increase, and the Engineering Libraries reported a high increase in requests for microfiche copies of technical reports, theses, and journal articles. The popularity of this service and the success of microfilm in the Chemistry Reading Room are important indicators for the future.

Personnel

No library can be better than its staff. The M. I. T. Libraries are fortunate to have staff members of high caliber. To continue and enhance this situation, the position of Personnel Librarian was created in September, 1973, and Suanne W. Muehlner was appointed to the post. Her success, and the need for the position, were immediately apparent. She has concentrated on affirmative action, orientation of new staff, recruitment and promotion of professional staff for vacancies, staff development, position classification, and compensation. In all of these activities, she works closely with pertinent offices in the Institute.

Mrs. Muehlner reports that a major personnel problem is the low salary levels of professional librarians. Considerable data on this matter has been submitted to the Institute administration. Improvement is anticipated as a result of the Libraries' participation in the Administrative Staff Classification and Compensation Study, being conducted for the Institute by Robert H. Hayes and Associates. A chief purpose of the Study is to provide a workable classification plan. Most academic libraries now use such schemes, which allow staff members to know their relative status and opportunities for progress. To ensure quality, the merit system will continue to operate.

The staff participated in many internal committees and engaged in many professional and educational activities. Under the Tuition Assistance Program, 27 persons worked toward library degrees at Simmons College, and 20 took courses related to career or subject

interests.

During the year, the following appointments were made: Ann M. DeVilliers, Assistant Science Librarian; Craig Harreld, Assistant Science Librarian; Hedy Mattson, Lindgren Librarian; Camille A. Motta, Cataloger; Patricia M. Sheehan, Systems Designer; and David C. Van Hoy, Cataloger. Promotions in the M. I. T. Libraries included: Sheelah Britt, Administrative Assistant; Lois M. Chalmers, Cataloger; Linda R. Cuccurullo, Cataloger; Margaret E. DePopolo, Rotch Librarian; David S. Ferriero, Assistant Humanities Librarian; Ann S. Longfellow, Assistant Rotch Librarian; Suanne W. Muehlner, Personnel Librarian; Susan K. Nutter, Associate Engineering Librarian; Jacqueline Stymfal, Assistant Dewey Librarian, and David C. Van Hoy, Head, Serials Cataloging Section. Resignations were accepted from: Mary Reay Freve, Rotch Librarian; Craig S. Harreld, Assistant Science Librarian; Deena Pers, Cataloger; Alicia M. Prata, Serials Cataloger; and Heddy A. Richter, Assistant Humanities Librarian.

Other Activities

The Rotch Slide Room, under the direction of Lenis H. Williams, conducted an experiment in and demonstration of access to visual collections. A variety of machine technologies was shown, and Peter R. Scott, Head of the Microreproduction Laboratory, contributed greatly to the display by producing color microfilms of 35-mm slides, 16-mm roll color microfilm, and replicas of slides in black and white on catalog cards.

The Barker Library held a successful film series, "The Edges of Engineering," attended by a total of 1,100 persons.

The Materials Center Reading Room was renamed the von Hippel Materials Center Reading Room, in honor of Institute Professor Emeritus Arthur R. von Hippel.

Independent Activities Period library activities, under the chairmanship of James M. Kyed, centered on film series, seminars, NASIC demonstrations, "browseries," and tours. Participation in library orientation presentations in the Lindgren Library included secretaries who often use the libraries on behalf of faculty members.

To aid in the energy crisis, the Libraries, except the Student Center Library, closed for four days during the Christmas holidays. Almost no complaints were voiced; a similar closing will take place during the July 4 weekend.

Through the offices of the Committee on the Visual Arts, two sculptures were placed in Hayden: Bourdelle's Tragic Mask of Beethoven in the Music Library, and Rodin's Large Head of Iris in the Humanities Library.

The Libraries are enriched each year by gifts from many organizations and individuals. Special mention should be made of: John J. Crnkovich's gift of the papers of John Ripley Freeman, Class of 1876, a distinguished engineer, insurance executive, and member of the M. I. T. Corporation from 1893 to 1932; volumes from the library of Dean John E. Burchard; and Degli Automati ovvero Macchini Semoventi, by Bernardino Baldi, a facsimile edition given by W. B. Hunter. Mrs. Hiram Beebe and the M. I. T. Club of Southern California established an endowed book fund in honor of Hiram Beebe, Class of 1910.

As always, the Libraries welcomed many visitors, both individuals and groups. This past year they included: students from the Dalhousie University School of Library Service, Nova Scotia; members of the Special Libraries Association of Japan; and a delegation from the People's Republic of China, headed by Liu Chi-Ping, Director of the National Library of Peking.

Future Prospects

This is an exciting time in the history of libraries. Bowed for years by shrinking funds and ever-increasing demands for materials and services, they now face the promise of technology. Computer costs are coming down; systems are operating which permit reduction in technical processing staff; and on-line data bases offer expanding networks of document and subject information access. Specialists in management, systems analysis, and computer and micrographic technology are being added to staffs to expedite the basic library functions of gathering and organizing information and delivering it to users. Librarians are learning new techniques to enhance their bibliographical expertise. These new approaches will allow university libraries to become dynamic agencies for communication. The challenge is in determining how to allocate limited resources among services, space, and technology.

The M. I. T. Libraries are planning for this stimulating future. In October, 1973, Provost Walter A. Rosenblith appointed a Task Force on the Future of the M. I. T. Library System, headed by Joel Orlen, Assistant to the Provost. Members of the Task Force have visited other libraries and have made studies of M. I. T.'s Library System. A working paper was written which currently is being discussed by concerned groups. With a program from the Task Force approved, a place for the Libraries in a major Institute fund drive, and the appointment of a new director of Libraries, the coming decade should be a good one.

The present director of the Libraries wishes to express thanks to members of the library staff. All have worked hard on plans and operations. Special thanks are due William J. Duggan and Margaret A. Otto, Assistant Directors. Miss Otto carried extraordinary responsibilities during the year, culminating with service on the Institute's Benchmark Committee of the Hayes Study. Members of the Libraries' staff enjoyed working with Professor J. Francis Reintjes and the members of the Electronic Systems Laboratory assigned to the NASIC project. The interest and advice of the Faculty Committee on the Library System, chaired by Professor Stanley Backer, and the Corporation Visiting Committee on the Libraries, chaired by Philip H. Peters, were greatly appreciated.

NATALIE N. NICHOLSON

Lowell Institute School

Beginning in the fall of 1973, the Lowell Institute School (L. I. S.) embarked on a new series of evening subjects designed to expand the vocational capabilities of industrial technicians. Replacing the two-year programs of previous years, these subjects exploit M. I. T.'s position in the forefront of technology to present instruction at the technician level which is unavailable elsewhere.

Subjects offered in 1973-74 included Television Systems Technology, Optical Systems Technology, Introduction to FORTRAN Programming, Digital Electronics, Principles of Metal Joining, High-speed Strobe Photography, Technical Typing, Machine Tool Fundamentals, and Dimensioning and Tolerancing for Engineering Drawings. Enrollment in these subjects totaled 199, with 77 percent of the students completing the certificate requirements. This is a sharp increase from the 1972-73 enrollment of 77, with only 47 percent receiving certificates. This increase in student interest in L. I. S. offerings is a direct result of the revised curriculum's heavy emphasis on practical applications and laboratory work.

Another innovation in L.I.S. programs is planned for the summer of 1974. A subject in Operation and Maintenance of Broadcast Video Tape Recorders will be offered in cooperation with the Center for Advanced Engineering Study. This subject will be a concentrated program, operated during the day for one week, directed at technicians employed by television broadcasters. While graduate engineers have come to M. I. T. for concentrated subjects for years, this is the first time such a program will be offered to technicians. If employers respond favorably, these summer subjects will be expanded in 1975.

BRUCE D. WEDLOCK

Northeast Radio Observatory Corporation (NEROC)

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. The primary current responsibility of NEROC is the operation of the Haystack Observatory, located at the Millstone Hill Field Station of M. I. T., Westford, Massachusetts. Through a NEROC-M. I. T. agreement, the administrative services of M. I. T. are used by NEROC in the conduct of its business.

The main instrument at Haystack is a 120-foot antenna, operable over a wavelength region from 21 to less than 0.8 cm, which is used (with National Science Foundation [NSF] support) for radio astronomy observations. Radar studies of the moon, Mars, Venus, and Mercury, using Haystack's high-power 3.8-cm radar, have been sponsored by the National Aeronautics and Space Administration (NASA), while observations of certain artificial satellites are funded by M. I. T.'s Lincoln Laboratory.

As of April, 1974, 45 radio observing projects and three radar projects were in progress, with 23 students and 73 scientists from 25 institutions involved in the work. During the preceding nine-month period, 53 radio observing projects and two short radar investigations (Saturn's rings and Comet Kohoutek) were concluded.

Of the 45 active radio observing projects, five were concerned with very long baseline interferometry (VLBI), a technique based upon precise frequency/time standards which, using the telescopes of two or more observatories, makes possible interferometer baselines of thousands of kilometers. In early 1974, NEROC completed a three-year task funded by the Advanced Research Projects Agency (ARPA) for the development of VLBI as a precise geodetic measurement technique. Relative positions of remotely situated telescopes were determined to the order of one meter out of thousands of kilometers. A new NASA sponsored NEROC project is aimed at the measurement of tectonic plate motions. Principal investigators are at Haystack and at the Department of Earth and Planetary Sciences.

Spectral-line research involving both molecular and recombination lines accounted for 34, or 76 percent, of the active radio observing programs. A large share of these are attributable to the unusual capability of the Haystack system in the K-band region (20-25 GHz) where spectral lines of water vapor, ammonia, and methanol are among those of greatest current interest.

Support from NASA for the planetary radar observations terminated June 30, 1974. Analysis and interpretation of the data, however, will continue for some time. Haystack also continues to provide Lincoln Laboratory with observations of distant satellites beyond the range of other radars. Haystack also is assisting Lincoln in the development of a new capability for high-resolution radar imaging of satellites at ranges out to synchronous altitude (40,000 km). This new radar is scheduled to be operating at Haystack by late 1976. Requirements for antenna time will be modest, and Lincoln Laboratory will provide appropriate support.

The \$2-million proposal submitted last year for the upgrading of Haystack for 100-GHz (3-mm) operation was not funded. A much more modest proposal is nearing completion, with the goal of achieving effective operation up to 50 GHz. This involves replacement of the upper three-fifths of the radome membranes with lower-loss material, and a second round of readjustment of the present antenna reflector surface. Although less attractive than operation at 3 mm, achievement of the 6-mm goal would keep Haystack a leading radio observing facility for some years to come.

The basic Haystack system includes the 120-foot diameter radome enclosed precision antenna, a 1.2-megawatt high-voltage transmitter power supply, precise hydrogen maser frequency standards, and a flexible wiring network for power and signal distribution. Two medium-size digital computers have been installed, one of which controls station operations, including antenna pointing, while the other is devoted to both real-time and off-line processing of experimental data. Critical elements of the radio astronomy and radar instrumentation are contained in interchangeable environmental enclosures or "boxes" designed for installation directly behind the Cassegrainian focus of the antenna. Each is 8 x 8 x 12 feet in size, and can hold up to two tons of equipment.

The development of Haystack first was proposed formally by Lincoln Laboratory early in 1958, soon after the Millstone Radar Facility began operations, as a significant next step in the development of the technology of high-performance microwave systems. Its design, originally centered around the requirements of a high-performance ground terminal for satellite communication research, provided also for use as a high-resolution radio telescope and a very-long-range measurements radar. These latter roles assumed increasing importance as advances in space technology shifted more of the elements of the typical communications link into the satellite itself, reducing the need for large, sophisticated ground terminals. Today, at a time of few new additions to the United States roster of major astronomy instruments, Haystack Observatory is an important scientific resource, comprising an advanced computer centered radio telescope which can operate effectively from 1,300 MHz to beyond 35,000 MHz.

The Northeast Radio Observatory Corporation was brought into being on June 22, 1967, for the purpose of designing and building a very large (440-foot diameter) fully steerable radio/radar antenna as a regional facility for the Northeast. With substantial support from NSF, it developed a unique design for an antenna enclosed in a radome. A proposal to build this new instrument at a cost of just under \$40 million was submitted to NSF in June, 1970, just when limitations in funding led to the postponement of many capital projects. During this period, faculty from member institutions of NEROC, at the invitation of Lincoln Laboratory, had begun using the Haystack antenna for their own research. In 1969, NEROC was given part-time access to the Haystack facility, and in 1970, NEROC actually began operating Haystack as a regional university observatory. For over two years, Haystack has been available for research observations, essentially on a 24-hour-per-day, seven-day-per-week basis, except for reasonable periods for maintenance and improvements. Research proposals may be submitted by any scientist, and allotment of time is handled in a manner generally similar to that employed at the national radio astronomy observatories.

PAUL B. SEBRING

Operations Research Center

The Operations Research Center conducts a variety of academic and research programs in operations research at M. I. T. The academic staff of the Center is drawn from a number of departments, including the Sloan School of Management, the Departments of Urban Studies and Planning, Electrical Engineering, Aeronautics and Astronautics, Mathematics, Civil Engineering, and Ocean Engineering. Currently about 20 students are in various stages of

the operations research doctoral program, and a comparable number are in the master's program. The trend in recent years has been for students, especially those in the doctoral program, to come to M. I. T. specifically to study operations research. Such students comprise at least 80 percent of this doctoral group.

During the past academic year, members of the academic staff and associated faculty of the Center have participated in a wide range of research activities. Some have done their research primarily in their departments, some at the Center, and many in both. A common theme in the professional activities of the staff has been the development or application of one or more of the major operations research methodologies, including mathematical optimization, probabilistic models, and decision analysis.

Research in methodological areas has proceeded at a lively pace. In mathematical programming, substantial emphasis has been given to nonlinear programming, combinatorial optimization, and large-scale systems. Computation has been an important focus, with considerable effort being devoted to large-scale, interactive mathematical programming systems that permit researchers to build up their own packages from individual modules. Probabilistic models have received continuing attention. Specific work has included hypercube queuing models and stochastic discovery processes. A project on decision analysis investigated the problems of decision making with multiple conflicting objectives. The statistical issues of operations research models have been examined freshly with modern tools of data analysis and robust statistics.

Applications oriented research continues to prosper. The largest single project in the Center is the Innovative Resource Planning Project sponsored by the National Science Foundation (NSF). This work deals with urban emergency services, particularly police and medical care. The focus is on performance measures, analytic tools, and the impact of the methods being developed on the systems under study.

Another major applications project deals with multilevel logistical systems. Its goal is to organize knowledge about such systems and to deliver it to systems designers via interactive computer models. A key task is determining effective ways to accomplish the partitioning, linkage, aggregation, and disaggregation of the decision processes in large-scale production-distribution systems.

Transportation is another area of activity, with staff members especially involved in traffic signal optimization, air traffic control, and airline crew scheduling.

Students and staff of the Center have been engaged in research in a variety of other areas including housing, marketing, insurance, facilities location, library operations, the use of frozen blood in blood banks, and state government operations. With the recognition of energy as a serious national problem, several staff members have become more involved. A major project that will draw heavily on operations research methodologies is in the proposal stage. More detail on these studies is available in the Center's Annual Report and in reports on specific projects.

A particularly notable event of the past academic year was the award of the Lanchester Prize to Professor Richard C. Larson of the Department of Urban Studies and Planning, for the best publication in operations research during 1972. This is the highest award in the field, and was given in recognition of Professor Larson's book, Urban Police Patrol Analysis.

Support for the Center's research during the past year has come from varied sources, including the National Science Foundation, Public Health Service, Office of Naval Research, Army Research Office-Durham, General Motors Corporation, and the Commonwealth of Massachusetts.

JOHN D. C. LITTLE

Project MAC

Project MAC is an interdepartmental laboratory for computer science. The laboratory includes four separable but interacting divisions, staffed by approximately 270 people, including faculty, students, and staff members. The four divisions and their respective leaders are: Fundamental Studies, Professor Jack B. Dennis; Computer Systems Research, Professor Jerome H. Saltzer; Programming Technology, Al Vezza; and Automatic Programming, Professor William A. Martin. The academic members of Project MAC are mainly from the Departments of Electrical Engineering, Mathematics, Architecture, and the Sloan School of Management.

Project MAC now is engaged in a major new effort aimed toward automatic programming. The purpose of automatic programming is to make the use of computers by laymen more feasible. The work on automatic programming is progressing toward the development of techniques that will allow communication with computer systems to be made in the form of desires and goals, stated in a "natural" language, instead of the present method of specifying the solution to the problem in terms of algorithms. In cases where the system does not have a good method for dealing with problems, the user should be able to introduce, test, and verify algorithms which would be added to the system's repertoire of expertise. Communication difficulties with the computer would be eased, because the computer system, with expert knowledge of the field under discussion, would exhibit common sense in communicating with the user. A first prototype automatic programming system, incorporating many new ideas, has been designed, and a good portion of it already has been implemented. This work derived much benefit from work on other systems such as MACSYMA, PLANNER, CONNIVER, and LISP, done at Project MAC and at the Artificial Intelligence Laboratory. The MACSYMA system, which has expert knowledge in specialized areas of mathematics, can perform such tasks as the factorization of polynomials or integration of algebraic expressions symbolically. It recently has become an important aid to research in plasma physics. Research is under way, with support from the National Institutes of Health (NIH), to use this advanced computer technology in the formulation of better theories of the cognitive process in medicine. Such theories, in turn, will speed greatly the day when computer systems, expert in certain areas of medicine, can be introduced into the health care system. The ongoing work on clinical decision making draws on the work of the Automatic Programming division and that of the Artificial Intelligence Laboratory.

The Computer Systems Research division is participating in a cost-sharing contract between Honeywell Information Systems, Inc., and the United States Air Force for support of a new project to develop simpler structures for computer operating systems. Simpler structures are an essential prerequisite for improved reliability, maintainability, and also for the certification of correct implementation. Certification of correctness in turn is necessary if computer systems are to protect the privacy and security of the data they store. The Division also attached the new Honeywell 6180 (MULTICS) computer system of the Information Processing Center to the ARPA computer network. This is a useful link for exchanging ideas, programs, and data with other academic research groups.

The research of the Programming Technology division is focused on three distinct but related areas: automation of the technology of programming -- the development of programs to aid humans in the composition, documentation, debugging, and maintenance of programs; computer networking -- experimentation and implementation of protocols and programs to facilitate communication between programs resident at geographically distributed computers connected via a store and forward communication network; and graphics -- the development of a system for the visual presentation of computer models of programs and of physical and behavioral phenomena.

A program of basic research on computational complexity, algorithms, the structure and semantics of programs and languages, language based computer architecture, and asynchronous switching circuits, is conducted in the division of Fundamental Studies.

Professors Fischer, Meyer, and Pratt and their students have developed general mathematical methods for proving that certain computational problems cannot be solved efficiently by any algorithm whatsoever. The main examples come from mathematical logic, and reveal that general theorem-proving procedures, even for very short formulas involving very restricted logical notation, require resources exceeding the capacity of the known universe. Research is continuing on methods for design analysis, proofs of correctness, and proofs of optimality of a variety of basic computational algorithms.

Professor Barbara Liskov of the Department of Electrical Engineering is directing the development of CLU, a programming language designed with new features to support the writing of well-structured programs. Programs prepared using CLU are expressed as collections of modules, each of which encapsulates an abstraction -- an operation or data type -- required for the problem to be solved. Professor Dennis and his students have advanced the generality of program representations based on the flow of data. This form of program representation is well suited to highly parallel implementation, and concepts for the organization of computers that can achieve highly parallel execution of programs represented in data-flow form have been extended. Professor Suhas S. Patil of the Department of Electrical Engineering has developed a new and very general scheme for realizing control structures of digital systems in a standard array of asynchronous logic elements. His ideas extend the notion of microprogramming to processors having asynchronously operating parts, such as computers implementing overlapped instruction, fetch, and execution.

During the period of this report there were nine visiting professors and one visiting scientist at Project MAC. They were: Professor Hiroshi Watanabe, Miyagi Technical College, Japan; Dr. Alfonso Miola, Instituto per le Applicazioni del calcolo, Italy; Dr. Uwe Pape, Technische Universitat Berlin, Germany; Professor Eiiti Wada, University of Tokyo, Japan; Professor Joseph E. Stoy, Oxford University, England; Professor Michael Paterson, University of Warwick, England; Professor Maurice P. Nivat, University of Paris, France; Professor Arnold Schönage, University of Tübingen, West Germany; Dr. V. M. Briabrin, Academy of Sciences of the USSR, USSR; and Nathaniel Rochester, International Business Machines, Inc., Cambridge.

The major financial support for Project MAC came from the Information Processing Techniques Directorate of the Advanced Research Projects Agency (ARPA), and the National Science Foundation (NSF), which supported the research in the Fundamental Studies division. Several projects at Project MAC were funded by other agencies, notably the Office of Naval Research and International Business Machines, Incorporated.

Professor Edward Fredkin will retire from the directorship this summer to return to full-time teaching and research. Professor Michael L. Dertouzos of the Department of Electrical Engineering will become head of the Project. Professor Dertouzos will share his duties and responsibilities with Professor Joel Moses, also of the Department of Electrical Engineering, who will serve in the newly created post of associate director.

MICHAEL L. DERTOUZOS

R.O.T.C. Programs

The Institute's three R. O. T. C. Programs (Army, Navy, and Air Force) reflect national trends and influences. The suspension of the draft and the conversion to all-volunteer

services, in combination with other factors, have lessened sharply student interest in the military as a career. Nationally, R. O. T. C. enrollment figures have dropped by some 50 percent during the past several years; a decline also has taken place at the Institute.

The numerically shrinking total defense force has resulted in a much lower need for newly commissioned officers. The number of R. O. T. C. units in the country has not decreased comparably, however. This fact, coupled with increasingly constrained defense budgets and economic inflation, makes each commissionee more expensive to the services. Many R. O. T. C. units, including the three at the Institute, are not cost-effective, by criteria presently applied. For this reason, a number of units at low-producing schools around the country already have been deactivated. M. I. T. should recognize this in considering the future of its own R. O. T. C. programs.

In other respects, M. I. T. 's Programs are not typical. As the three service statements which conclude this report indicate, a very high proportion of M. I. T. 's enrollees have earned full-tuition scholarships, which also include payments for books and living expenses. Their military assignments after graduation almost invariably coincide with their expressed preferences, and their performances in these assignments typically are superior. The morale of the M. I. T. units is high and the enrollees exhibit enthusiasm. The dropout rate is low; their engagement in optional activities is high.

The Institute continues to adhere to a policy whereby special curricula are required of these students -- they receive no degree credit for the exclusively military subjects taught by the assigned service personnel -- but over 80 percent of the curricula is comprised of regular subjects presented by regular faculty. This situation, too, is unusual compared to national R. O. T. C. policy; it has evolved from sustained academic and professional collaboration between M. I. T. and the services over many years.

In a broader sense, the entire topic of R. O. T. C. in the national context of higher education appears to warrant, and need, a comprehensive review. The last time this was done, several decades ago, it produced valuable and useful results. However, the social, economic, political, and educational changes since then have been profound; at times such as this, swift, new formats, greater flexibility, a quicker response capability, and indeed perhaps a significantly different philosophy should be sought. This statement is not meant to criticize the services or the Department of Defense; within the constraints with which they function, their accomplishments in R. O. T. C. are impressive. Yet the need for fundamental changes exists, and M. I. T. 's attempts to contribute at the local level will be continued. A year from now, the R. O. T. C. Committee hopes to report more substantively on some of these changes, which currently are under study and awaiting experimental implementation.

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

U.S. Army R.O.T.C.

A total of 48 cadets were enrolled in the Military Science Program at the completion of academic year 1973-74. Of these, 12 were freshmen, 18 sophomores, nine juniors, and nine seniors. Increased interest in R. O. T. C., as evidenced by letters from prospective freshmen, makes the prospect for increased enrollment encouraging.

Thirty-seven cadets currently attend M. I. T. on Army R. O. T. C. scholarships; 32 have four-year scholarships, the others two- and three-year awards. Scholarship prospects for 1974-75 also appear good. Advance information indicates that at least 11 freshmen will be entering M. I. T. with four-year Army scholarships.

During this past year, eight cadets received commissions. All commissionees received their first choice of military branch: two Armor, two Signal, two Corps of Engineers, one Military Intelligence, and one Medical Service Corps. Of those commissioned, two received Regular Army commissions and five received Reserve commissions. Three of the commissionees have been assigned to four years of active duty. The remainder have been assigned three months active duty for training. There were no significant changes in the R. O. T. C. curriculum, or in academic and administrative procedures. Efforts of the staff have been directed toward improving the quality of instruction and insuring maximum accommodation of the cadets. To further cadet interest and to improve their proficiency in drill and field exercises, two full training days were held at Fort Devens. The cadets were highly receptive to the field training program, and both days were well attended.

In other R. O. T. C. related activities, cadets participated in a series of orientation trips to military installations during the January Independent Activities Period. Points visited included the Army Materials and Mechanics Research Center at Watertown, Massachusetts; the Natick Laboratories, Natick, Massachusetts; and the District Engineers at Waltham, Massachusetts. The M. I. T. chapter of the National Society of Pershing Rifles continued to show strong growth in its second year. Members of the chapter's Tactical Platoon spent 11 weekends on training exercises during the academic year. The Pershing Rifle Drill Team performed at a number of functions in the Boston area, including service as the color guard at New England Patriots and Boston Celtics games.

Two M. I. T. cadets attended the basic airborne course at Fort Benning, Georgia. Two cadets also participated in the Army Orientation Training Program (AOT) during the summer of 1973. The AOT program allows cadets to serve as junior officers with an active duty unit for a period of two weeks. The M. I. T. Cadets trained with the 10th Special Forces at Fort Devens, Massachusetts. Both airborne training and AOT were received well by the cadets.

There have been several changes in the military staff. Departures through July, 1974, include Colonel Joe F. Elliott, Sergeant Major Rowan Smith, and Master Sergeant John R. Eldridge. Replacement personnel already assigned include: Colonel John S. Kark, PMS, Captain Edward H. Leekley, and Master Sergeant Rushen L. Baker, Jr.

U.S. Navy R.O.T.C.

The current enrollment in the N. R. O. T. C. Program consists of 18 freshmen, five sophomores, three juniors, and one senior, for a total of 27.

This unit owes its recent retention success to the attractiveness of the scholarship program. The future viability of the Program may well be dependent upon this program. Not only was this the first full year of operation under the all-volunteer concept, but it was only the second that M. I. T. 's N. R. O. T. C. has participated in the National Scholarship Program.

This year saw a record low seven College Program students remain through the entire year. All eventually were granted scholarships, except for two who were physically unqualified.

As predicted in last year's report, the first sizable class reported in the fall of 1973. Prospects for 1974 are equally encouraging; the reporting class is expected to include the first Marine Corps Option student. The number of scholarship winners selecting M. I. T. has nearly doubled from the previous year. It appears that M. I. T. is now widely known as a participating institution, and that the Institute's reputation will attract the most highly qualified scholarship applicants.

In a new development, the Navy has identified this unit as a lucrative source of Nuclear Power Program applicants. Almost every M. I. T. undergraduate meets prima facie the rigorous academic standards set for this essential Program. First screening efforts were encouraging, as 50 percent of the participating midshipmen expressed interest in this Program. Furthermore, this unit has been given permission to increase the quota of women midshipmen. There are two women presently participating, and three more are expected in the incoming fall class.

Captain Kevin J. O'Toole relieved Captain William R. Porter as commanding officer on September 1, 1973, and June, 1974, saw the departure of Lieutenants Donald P. Welch and Clinton L. Smith. If the midshipman population increases as it has in the past two years, an additional Lieutenant Technical Instructor is expected to be added to the staff in 1975.

The continued success of three seminars -- Marine Engineering Systems (Sem 13504), the Art and Science of Navigation (Sem 13506), and Ocean Vehicle Control System (Sem 2507) -- owes much to the continued cooperation of the sponsoring departments and to the support evidenced by several innovative tours to local naval facilities.

U.S. Air Force R.O.T.C.

At the conclusion of academic year 1973-74, the Air Force R. O. T. C. program had 34 cadets enrolled. They were distributed as follows:

<u>General Military Course</u>	
AS 100 (freshman)	9
AS 200 (sophomore)	6
<u>Professional Officer Course</u>	
AS 300 (junior)	12
AS 400 (senior)	<u>7</u>
TOTAL	34

While the numbers are low, the quality remains exceptionally high. Twenty-two of the 34 cadets, or 65 percent, are currently on full scholarships. In addition, two have been selected for scholarships to begin with the fall term of academic year 1974-75, and two more are on the scholarship alternate list. Thus, only eight members of the entire Cadet Corps have not received such an award. Six of these are ineligible because of academic specialty or enrollment status, one has refused a scholarship, and one has not yet qualified medically. Since these scholarships are obtained in nationwide competition, the present situation reflects highly on the caliber of students enrolling in the Program.

At midyear, this unit was advised by its headquarters that a revised viability criteria was being established for Air Force R. O. T. C. units. In the past, units were considered to be in good standing if they commissioned 15 new Second Lieutenants each year. The new standard requires a unit to have 17 members enrolled in the AS 300 class on October 31 of each year in order to be viable. Historically, this unit has not met that criterion, and (as is obvious from the above figures) it will not do so in the coming year. The low enrollment of the Program resulted in letters from General Rogers, Commander of Air University, and the Honorable John McLucas, Secretary of the Air Force, expressing serious concern. With only two two-year program applicants scheduled for entry into the

Program this coming fall, there seems little likelihood that the unit can meet the desired enrollment. However, the declining trend of recent years may be changing, and the unit's commander is cautiously optimistic about the future.

The M. I. T. Air Force unit has received an unusually large number of write-in inquiries about its Program during the past several months. Some of these individuals have been admitted to M. I. T. and have indicated that they plan to join Air Force R. O. T. C. Once the unit begins actively to inform incoming freshmen about the Air Force R. O. T. C. Program (using mailouts, cadet contacts, and so forth), it is hoped that fall term enrollment in AS 100 may exceed 20 cadets.

A recent change in Air Force R. O. T. C. scholarship policy will assist in making this hope a reality. After two years of directing nearly all three- and two-year scholarships to flying applicants, significant numbers now are being awarded to students majoring in engineering and a few scientific specialties. The revision came too late to be of any great assistance in recruiting members for the two-year program, but it is expected to be of great help in attracting qualified freshmen this fall. Four-year scholarships (awarded while the individual is a senior in high school) continue to be reserved for pilot and navigator qualified students.

There have been no major changes in the curriculum during the past year. An R. O. T. C. Committee working group, under the chairmanship of Professor Harvey M. Sapolsky of the Department of Political Science, has begun discussions which hopefully will lead to the development of a jointly taught subject for credit, involving both Air Force R. O. T. C. and the Department of Political Science. This subject will not be ready in time for the fall term, however. Changes in M. I. T. subject availability and the implementation of a revised AS 300 subject in the fall probably will make renegotiation of the Alternate Curriculum Plan approved subject list necessary in the coming year.

The fuel shortage which affected all segments of the country during the past winter hit the detachment field trip and base visit program especially hard. The Program was forced to cancel projected visits to Cape Kennedy, the Air Force Rocket Propulsion Laboratory and Flight Test Center, Williams Air Force Base, Wright-Patterson Air Force Base, and Andrews Air Force Base. A one-day visit to Pease Air Force Base and a flight orientation took place in March, 1974.

There were numerous changes in detachment personnel during the year. Shortly before the beginning of the fall term, Major Donald Carlson, Captain Goerge Vtriak, and Captain Donna Kuha joined the staff. In January, 1974, Staff Sergeant James Loiselle arrived as a replacement for Staff Sergeant Arthur Verville. Margaret Loan became secretary for the detachment in February. Finally, the nomination of Lieutenant Colonel Larry Schwartzman to replace Lieutenant Colonel Victor B. Goodrich as Visiting Professor of Aerospace Studies and Director of the Air Force R. O. T. C. Program was approved. Lieutenant Colonel Goodrich will leave the Institute in July.

FREDERICK J. MCGARRY

Sea Grant Program

Academic year 1973-74 saw the continuation and expansion of the M. I. T. Sea Grant Program into a second year of Institutional Program status. Following National Sea Grant guidelines for this status, the Program has developed significant research, education, and advisory services for furthering human activity in the oceans. Following the Institute's philosophy that engineering and technology can contribute in a major way to the solution of many of the

nation's current critical problems, the Sea Grant Program exemplifies M.I.T.'s commitment to the environmentally balanced utilization of ocean and coastal zone resources. Under National Sea Grant sponsorship, Institute faculty and staff members from a wide range of departments and disciplines have worked toward improving marine scientific and engineering methodologies, and toward understanding the social, economic, and political constraints on society's use of the seas.

Since its enactment by Congress in 1966 and its first grant award in 1968 (made to M.I.T.), the National Sea Grant Program has grown to the point at which it supports, in coastal and Great Lakes states, seven Sea Grant colleges, ten Sea Grant Program Institutions, Coherent Area Projects at nine universities, and numerous separate project grants throughout the country. An important part of the National Oceanic and Atmospheric Administration of the Department of Commerce, the Office of Sea Grant provides two-thirds of a program's funding, which is matched by one-third of the total from the grant recipient. In 1973-74, M.I.T. received from the National Sea Grant Program \$606,000; the total funding level for the Institute's Program stood at \$1,082,851. A significant portion of the matching funds came from the Henry L. and Grace Doherty Charitable Foundation, Inc. It was the initial support of this Foundation in 1970-71 which made possible M.I.T.'s participation in the National Sea Grant Program. The Sea Grant Program at M.I.T. now receives additional matching funds from over 15 industries, organizations, businesses, and state and local government agencies, as well as from the Institute itself.

On July 1, 1973, Professor Ira Dyer, Head of the Department of Ocean Engineering, became the new director of the M.I.T. Sea Grant Program. Dr. Alfred A. H. Keil, Dean of the School of Engineering and director of the Sea Grant Program since its inception in 1970, remained in close association with the Program through his position as chairman of the Sea Grant Policy Committee and of the Sea Grant Faculty Council. The capable leadership of Executive Officer Dean A. Horn, Administrative Officer James E. Grayson, and Advisory Services Officer Ernst R. Pariser continued to expedite the daily operations of the Program.

Research

The Sea Grant Program's research projects during 1973-74 aimed at answering marine related questions of local, regional, and national significance.

Under the thematic heading Massachusetts Bay Focus, faculty and staff members directed research on natural and synthetic pollution in coastal waters. The late Institute Professor Emeritus Arthur T. Ippen of the Department of Civil Engineering, ably assisted by Professor Jerome J. Conner, Jr., of the Department of Civil Engineering, led an ongoing study which is developing predictive mathematical models to describe the hydrodynamics and pollutant dispersion processes in Massachusetts Bay and other offshore waters. The Sea Grant Program and the entire Institute suffered a great loss with the death of Professor Ippen in April, 1974; Professor Conner has assumed leadership of the Massachusetts Bay Project.

Professors Dyer and Judith T. Kildow of the Department of Ocean Engineering and John E. Huguenin of the Woods Hole Oceanographic Institution collaborated, with numerous associates, in explicating the existing legal, economic, technical, and social constraints on using treated domestic sewage and power plant thermal effluents in waste-food recycling systems for aquaculture. Professor John G. Trump of the Department of Electrical Engineering, working with the Van de Graaff electron accelerator at the Institute's High Voltage Research Laboratory, studied the physical and biochemical effects of irradiating waste water and sludge with ionizing electrons, a technique that has potential application for municipal sewage treatment.

Projects on marine problems and development opportunities important to New England concentrated on aspects of the fishing industry on the aqua-culture. Professor Stephen P. Loutrel of the Department of Mechanical Engineering designed a faster, safer hookup block for the net cables used on side trawling fishing boats in New England; a prototype of the new block will be built and tested at sea during the coming year. Professor Henry S. Marcus of the Department of Ocean Engineering will continue his research on fishing and fish-processing cooperatives, to determine the factors necessary for the success of such cooperatives and to evaluate their potential for improving the economic outlook of the New England fishing industry. In the joint M. I. T. -University of Massachusetts Sea Grant effort, Professors John W. Zahradnik of the University of Massachusetts and William W. Seifert of the Departments of Civil Engineering and Electrical Engineering are examining the feasibility of large-scale, intensive oyster aqua-culture using the thermal effluent from power plants. A small oyster finishing plant has been designed and currently is in operation, which will provide biological and financial data for determining year-round growth temperatures and the economic potential of such systems.

The application of existing and emerging technology to ocean and coastal zone resource utilization, with the integration of social, economic, and political factors that control marine systems development, operations, and management, was the third general area of Sea Grant sponsored research during 1973-74. Professor Samuel A. Goldblith of the Department of Nutrition and Food Science has guided a continuing project on processed food products made from squid. Besides consumer testing of the prepared squid and a marketing survey, a prototype squid-eviscerating and skinning machine was built and tested by Visiting Professor Zeki Berk; this has elicited considerable interest from food-processing industries.

Professor Benjamin L. Averbach of the Department of Metallurgy and Materials Science began investigations, using electron and X-ray diffraction methods, to discover atomic structures of the bulk chitin and its derivative chitosan obtained from several shellfish species and processed under varying conditions. Anticipating chitin's use as films or as biological membranes, these analyses will be used to establish the physical and biochemical characteristics of this material's different configurations. Professors Joseph B. Lassiter III and John W. Devanney III of the Department of Ocean Engineering studied various off-shore mineral leasing and royalty policies to determine expected real national income, optimal lease scheduling, and the potential of competitive bidding strategies for identifying collusive bidders.

Current trends in oceanic commerce received attention in two Sea Grant projects. A comprehensive study of the future role of the Panama Canal in the world shipping trade, as influenced by such new developments as container ships and supertankers, was completed by Professor Norman J. Padelford of the Departments of Political Science and Ocean Engineering; the book resulting from this work will be published in the fall of 1974. Professor Ernst G. Frankel of the Department of Ocean Engineering concluded a two-year project on the changes required in traditional ports to facilitate their accommodation of modern shipping and cargo-handling systems. In developing a new port design and analysis methodology, Professor Frankel studied the function, operation, and design of modern ports, measured port capacity and performance, and examined decision making in port development, along with its environmental and social impacts. Professor Frankel's major new book on shipping, Ocean Transportation, written in conjunction with Professor Marcus, was published in April, 1974.

In research directed toward improving marine technology, Professor Koichi Masubuchi of the Department of Ocean Engineering completed his studies on fundamental metallurgical processes in underwater welding and metal cutting, and will apply the knowledge gained to develop new techniques and equipment for repairing metal structures in the sea. Professor

Summer Session

Frederick J. McGarry of the Department of Civil Engineering is continuing comprehensive research on the fracture mechanics of rapid, catastrophic crack propagation in the fiber-glass reinforced plastic composites used as boat hull materials.

Academic Program

Sea Grant sponsored education at M. I. T. reflected the same concern for interdisciplinary solutions to marine and coastal zone problems as Sea Grant research. The 1974 spring-term project in Professor Seifert's subject, Interdisciplinary Systems Design, focused on the development and economic revitalization of Boston Harbor through utilization of the Federal lands made available by the closure of the Boston Naval Shipyard. Students in the summer laboratory led by Professor A. Douglas Carmichael of the Department of Ocean Engineering developed a free-swimming, programmed, underwater robot capable of doing oceanographic research. Under Professor Dyer, a new subject in ocean engineering, 13.86 Sound Transmission in the Ocean, was created and taught during the fall term of 1973.

Professor John Daniel Nyhart of the Sloan School of Management is leading a two-year, joint experimental program with members of the faculty of Harvard Law School, on ocean engineering and law. Its purpose is to identify the institutions, techniques, and perspectives needed for the proper use of the sea's resources. Professors Devanney, Michael S. Baram of the Department of Civil Engineering, and Gary A. Hack of the Departments of Architecture and of Urban Studies and Planning developed a graduate-level subject on policy and planning decisions for the utilization and conservation of coastal zone resources. Supported by a significant grant from the Doherty Foundation, Professor Francois M. M. Morel of the Department of Civil Engineering was named the first Henry L. Doherty Assistant Professor of Ocean Utilization; he will pursue his studies on biological models for predicting nutrient concentrations, biomass, and dissolved oxygen in coastal waters.

Advisory Services

During 1973-74, the M. I. T. Sea Grant Program continued to augment its advisory services policy of disseminating new and useful marine technology and information to the public domain. Ongoing activities included publishing reports from Sea Grant projects and from other important marine related research throughout the Institute, conducting several subjects for professionals in the Institute's Summer Session, and operating the Marine Resources Information Center for the M. I. T. community and for the public. Sea Grant co-sponsored, with the League of Women Voters of Massachusetts and the United Nations Association of Greater Boston, a symposium in March, 1974, on the law of the sea. In June, 1974, Sea Grant hosted for the National Wildlife Federation a seminar on continental shelf oil drilling off the Atlantic coast.

Sea Grant's Advisory Services are developing in two directions. The Program is gearing its activities to the needs of marine oriented industries throughout New England and the nation, while maintaining close cooperative relationships in Massachusetts with the University of Massachusetts, the executive and legislative branches of state government, the Massachusetts Maritime Academy, and the New England Aquarium.

IRA DYER

Summer Session

From 1972 to 1973, there was an expansion in the utilization of academic capabilities in the summer term. Registration increases were comparatively small, but this favorable trend has continued since 1970.

Special Programs

Of the 50 programs planned for the 1973 Session, five had to be cancelled because of projected low enrollments. There was a total registration of 1,559 in the 45 programs, compared with a 1972 registration of 1,376 in 40 programs.

The Summer Session of 1973 was the twenty-fourth year in which M. I. T. has presented Special Summer Programs for professional men and women to keep pace with developments in their fields. Over the years, the average age of registrants has remained remarkably constant at 37. About 60 percent of the registrants come from industry, 25 percent from government, and the remaining 15 percent from the education field. Over 60 percent of the registrants have graduate degrees. The widespread geographical appeal of the series is illustrated by the following percentages for the 1973 Session: 71 percent of the registrants came from east of the Mississippi, 15 percent from the western portion of the United States, 6 percent from Canada, and 8 percent from outside North America.

Regular Subjects

Graduate students now comprise over 85 percent of the student body in the summer. The 1973 registration of 2,205 students represents a small increase from the figure of 2,121 in 1972.

Conferences

Approximately 300 people attended the International Conference on Single Cell Protein, from May 29 to May 31, 1973, which was hosted by Professor Steven Tannenbaum of the Department of Nutrition and Food Science.

Professor Gordon Brownell of the Department of Nuclear Engineering was host for the Third International Conference on Data Handling and Image Processing in Scintigraphy, which was held June 6-9, with approximately 50 persons in attendance.

Professors S. H. Chen and Sidney Yip of the Department of Nuclear Engineering conducted an Institute on Neutron and X-ray Diffraction and Related Techniques in Chemical and Biological Problems during August 6-10. The Institute was under the sponsorship of the Atomic Energy Commission, and had 44 registrants.

In addition, there were special activities conducted by the Center for Advanced Engineering Study, the Educational Research Center, the Department of Ocean Engineering, and the Sloan School of Management.

JAMES M. AUSTIN

Teaching Intern Program

The Teaching Intern Program concluded its sixth very successful year in June, 1974, with M. I. T. and Wellesley College students teaching part-time in the Cambridge public schools during the 1973-74 academic year. This Program, formally known as Institute Seminar 211, offers 12 units of credit for a seminar at M. I. T. and up to five hours of actual teaching per week in one of the Cambridge schools. During this past year, Dr. Louis Menand, Assistant to the Provost, has been responsible for the project, which was under the immediate supervision of John P. Terry and Michael Efron. The seminar at M. I. T. met weekly throughout the year, with the participation of high-school faculty. These high-school faculty members

have shown a keen interest in the teaching assistant program, and have made use of library and other M. I. T. facilities. The project has made every effort to increase the interactions between Cambridge school personnel and people and resources at the Institute.

While there have been high-level changes in school administration in Cambridge, the Teaching Intern Program has continued to receive strong endorsement from the school superintendents and the principal and assistant principal of the school involved. Some of the M. I. T. and Wellesley College students who have worked in this project also have worked with some of the same students in the M. I. T. -Wellesley Upward Bound Program. Some of the students subsequently have gone on to the Harvard Graduate School of Education or other graduate schools of education for further professional training, while others have entered directly into the teaching profession upon graduation from M. I. T. and Wellesley.

LOUIS MENAND

Upward Bound Program

The M. I. T. -Wellesley Upward Bound Program is a coeducational, multi-racial, multi-ethnic educational program for Cambridge youth of high-school age. Now in its eighth year, the Program serves 70 academically promising young women and men 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 additionally to provide them with the necessary academic and social skills needed to succeed in college. To a very 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 related closely, and has met with considerable 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, 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 a 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 student play a crucial role -- fellow students, teachers, and other program staff -- because what the student thinks he or she can do is dependent on what they think he or she can do. Consequently the student's perception of his or her abilities, and therefore what he or she will try to accomplish, is determined to a large extent by the program staff, who are often the first and only people to see real academic promise in the youngster.

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 Cambridge high-school teachers, Wellesley College and M. I. T. students, and Upward Bound alumni now attending college. Each Upward Bound student carries three classes 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 subject, and to select a third subject. Humanities offerings include reading and writing, black history, teenagers and the law, drama, the urban scene, utopias, the American Indian, and the fifties. Science subjects from which students may choose include biology, chemistry, astronomy, and Man and His Environment. The mathematics program includes: an enrichment section for students who are preparing to take

algebra II, geometry, or mathematics IV; a review section for students who have done poorly in algebra II, geometry, or mathematics IV; and computer mathematics and computer programming subjects (in BASIC) sponsored by International Business Machines, Inc. (IBM). IBM's sponsorship of these subjects, teachers, computer terminals, and couplers follows several previous years of generous contributions supporting computer subjects and of participation in this Program.

Academic Year

The academic year program, while ostensibly less intense and dramatic, is at least as important as the Summer Program. Building on the motivation and enthusiasm developed over the summer, the academic year program is designed to help the student cope with the myriad academic, social, and family problems that confront him or her in Cambridge. To achieve this, the following programs, staffed primarily by M. I. T. and Wellesley College undergraduates, have been developed and implemented.

Study Skills The M. I. T. Upward Bound offices are open four evenings per week from 7:00 to 9:30 for study. Students are asked to spend at least one evening per week at one of these study sessions. Each session is staffed by a team consisting of two leaders who are part-time staff and 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 typically are M. I. T. or Wellesley College undergraduates who arrange to meet on a mutually convenient, regular basis with the Upward Bound student, and who then report back to project staff.

Saturday Program

The goal of the Saturday program is to provide a concentrated replication of the Wellesley summer experience. Students attend regularly during the fall, winter, and spring on Saturdays from 10:30 A.M. to 4:30 P.M. The Saturday program includes an arts and crafts class, drama, and a mathematics class, plus the use of the pool and gymnasium.

College Placement

All 16 of the graduating seniors of the M. I. T. -Wellesley Upward Bound Program plan to attend four-year colleges in the fall. These colleges are: American International College; Assumption College; Brandeis University; Emerson College; Fitchburg State College (2); Hampton Institute; Massachusetts College of Art (2); Northeastern University (College of Arts and Sciences); Northeastern University (Bouve School); University of Massachusetts at Amherst (3); University of Massachusetts at Boston; and the University of New Hampshire.

JOHN TERRY

Urban Systems Laboratory

M. I. T. responded to the urban crises of the 1960s by forming the Urban Systems Laboratory in 1968. The Ford Foundation provided part of the initial funding, and many faculty members turned their physical and intellectual energies toward finding remedies and perhaps even cures for the various ills that plagued American urban communities. The Laboratory was conceived and begun as an action oriented organization. Research was carried out in the field, through direct participation in government agencies and community groups.

Although many goals have been reached, an enormous amount of work remains to be done, which will become more and more difficult to complete as resources needed to do the many jobs become scarce. Faculty interests have remained high, but the demands for faculty time made by energy problems, inflation, drought, and worldwide food shortages have caused a shift in priorities. To what extent this will affect progress in finding solutions to urban problems is unknown. However, it is certain that the problems will not disappear overnight. They will demand some solution. Hopefully, sufficient progress will continue to be made, and crises similar to those of the 1960s will be avoided.

The contribution of the Urban Systems Laboratory during the past year reflects the dedication of its faculty and research staff, as well as the innovative and creative minds of the many students who played such an important part in its various projects. The strength of the Laboratory and its projects lies with its committed faculty and involved students. As the following summary will indicate, the Laboratory was fortunate in having both ingredients during the past academic year.

Transportation and Community Values Project

This project was initiated in 1968 under Professor Marvin Manheim of the Department of Civil Engineering. It has been directed toward the broad objective of developing improved mechanisms of incorporating community and environmental considerations into transportation decision making. Project staff members have worked closely with government agencies, at both the national and state levels, assisting them in prototypical applications of the research findings and in developing the policy directives necessary for full implementation.

During the past year, two cooperative field applications in Atlanta, Georgia, and northwest Michigan were completed for the National Cooperative Highway Research Program. The final report, Transportation Decision Making: A Guide to School and Environmental Considerations, presents an integrated approach for systematically incorporating social, economic, and environmental factors into transportation planning and design. Specific techniques are described for implementing the approach, along with examples illustrating their use. The report is the culmination of five years of research and investigation into community interaction, evaluation methods, consideration of alternatives, process management, institutional arrangements and decision making, and the interrelation of system and project planning in the highway program.

Work on the implementation of Policy and Procedure Memorandum 90-4, Process Guidelines, with the Federal Highway Administration (FHWA) of the Department of Transportation, was concluded during the year. The administrative directive was developed with the assistance of project staff members in response to section 109 (h) of Title 23, United States Congress, which calls for each state to prepare an "Action Plan" describing the procedures, organization, and assignments of responsibility through which social, economic, and environmental considerations are incorporated into the planning and design of Federal-Aid Highway projects. This "process" approach to environmental policy reflects a major departure from the former concern for technical studies of individual projects. The project staff members worked with FHWA on criteria for the evaluation of state Action Plans, assisted in the evaluation of selected plans, prepared papers, and sponsored panel discussions to assist state highway agencies.

The Transportation and Community Values Project continued its cooperative relationship with the state of California. The major focus of this cooperation was the development of state and regional transportation policy and procedures necessary to implement a Department of Transportation. The preparation of a multi-modal state transportation plan and analysis of the role of programming in transportation decision making were important in this work.

Research was initiated during the year for the Environmental Protection Agency (EPA), concerning the use of transportation control plans as a means of achieving the air quality standards mandated by the 1970 Clean Air Act Amendments. The EPA work involves: 1) investigation of problems and issues associated with transportation controls; 2) identification of incentives and opportunities which could encourage positive actions to reduce air pollution from transportation sources; and 3) analysis of transportation developments and changes in traveler behavior which could have significant implications for transportation control planning.

Program in Industrialization of the Housing Sector

Under Professor Arthur Bernhardt of the Department of Architecture, this Program continued to focus on Project Mobile Home Industry for the Department of Housing and Urban Development (HUD). HUD's desire to extend the work under this contract has led to additional funds and an extension in time, and the work will be completed during the coming year.

The Program has grown to the extent that 38 persons were involved in full or part-time capacity by the end of the academic year; one-third of these were students. Professional backgrounds in architecture, computer science, economics, engineering, finance, law, management, marketing, planning, and political science were represented.

The interest in the Program is national in scope, and the staff has a unique, comprehensive capability in the areas of building production and delivery, building research, and building policy analysis and formulation. Professor Bernhardt was invited by the International Council for Building Research (CIB) to prepare two papers on the work, for presentation at the sixth international CIB Congress in Budapest, Hungary.

Massachusetts Governor Francis W. Sargent appointed Professor Bernhardt to the Governor's Advisory Committee on Mobile Homes, and the Commonwealth requested that a proposal be submitted on how the Program could aid the Committee in formulating and implementing a broad-based plan of action for the development of the mobile home industry in the Commonwealth.

Transportation Information Systems

This project continued for a fourth year, under the direction of Associate Director Henry W. Bruck and with sponsorship of the Department of Transportation. During the year a revision of the widely circulated Survey of National Geocoding Systems was completed, and a report outlining the problems of designing a converter for sub-country-level geocoding systems was prepared. Two reports dealing with a generalized structure for transportation service measure and with service measures applicable to truck and bus movements also were completed. Work outlining objectives, methodology, and data collection techniques for planning the movement of urban goods also was undertaken, and will be completed during the coming year.

Other Projects

A relatively small project focusing on delineating commodity movements into, out of, and through six Southern California counties and devising methodology for analyzing such movements was begun. The project is sponsored jointly by the California State Department of Transportation and the Southern California Association of Governments (SCAG). One of the principal objectives of the project is to develop a methodology for analysis of the movement of goods which can be used in all of California's planning regions.

John R. Lawson of the Charles Stark Draper Laboratory continued his work in the Urban Systems Laboratory, which included: an update and expansion of the Laboratory's library on innovative guideway transportation; industrial liaison with guideway transportation in North America; and a tour and documentation of European innovative guideway transportation developments and installations.

Work also was continued with the Rhode Island School of Design on Project Interface for Providence, Rhode Island. This project is concerned with the revitalization of downtown Providence.

The Effective and Affordable Medication Delivery project, under James T. King, was completed during the year. The results of the research are leading to an amendment of the law which would allow dispensing of medication through health clinic facilities. The program and its results are to be presented in the fall at the annual meeting of the Health Clinic Association in Chicago. Cooperation with Boston University, through Dr. David French, and with the Massachusetts College of Pharmacy, through Dr. Raymond Gosselin, greatly enhanced the impact of the program. This work was sponsored jointly by the Commonwealth of Massachusetts Board of Higher Education (under Title I of the Higher Education Act of 1965) and the Permanent Charity Fund, Inc.

CHARLES L. MILLER

Wellesley-M.I.T. Exchange Program

The 1973-74 academic year was the sixth year of cooperation between M.I.T. and Wellesley College in educational programs. It was the first year of operation of the Wellesley-M.I.T. Exchange Program as part of the regular academic program of the Institute, following faculty approval in April, 1973, of the original five-year experiment. In keeping with the faculty vote, administration of the Exchange Program became the responsibility of the Provost's office, with educational policy overseen by a Joint (faculty-student) Committee from Wellesley and M.I.T. President Jerome Wiesner named Professor Kenneth Hoffman, Head of the Department of Mathematics, as M.I.T. cochairman of this Committee.

The most active and visible area of cooperation continued to be student cross-registration. During the 1973-74 academic year, 337 students at M.I.T. took 416 subjects at Wellesley, and 446 Wellesley students registered for 538 M.I.T. subjects. The distribution of these enrollments followed the basic pattern of previous years, in reflecting complementarity of subject offerings in fields such as psychology or political science, and availability at one institution of fields scarcely represented at the other, such as architecture or management at M.I.T., sociology or religion at Wellesley. Compared with 1972-73, total cross-registration was up, and there were some shifts in pattern; for instance, enrollment of Wellesley students in humanities subjects at M.I.T. decreased, while enrollment in science and engineering at M.I.T. increased.

Planning and discussion for the future focused on the exploration of new joint activities, especially those which will involve cooperative faculty efforts in teaching, in curriculum development, and in student advising. The scope of such cooperative activities is small at the present time, yet some of them, such as a joint subject in archeology, have been beneficial to students at both institutions. The hope of increasing such cooperation in the future rests upon such intangibles as a new spirit of commitment to the exploration of possibilities, and very tangible factors such as the new Wellesley academic calendar, which more closely matches the M.I.T. calendar, thereby making cooperative educational offerings much more feasible.

This brief report on the Exchange Program would not be complete without an expression of gratitude to Dr. Robert A. Alberty, Dean of the School of Science, who served as M.I.T. cochairman of the Joint Wellesley-M.I.T. Committee from its inception through the spring of 1974. His leadership during this critical five-year experimental period was instrumental in the success of the Program (as reflected in the faculty endorsement of its perpetuation).

KENNETH M. HOFFMAN

School of Architecture and Planning

The academic and research programs of the two departments of the School of Architecture and Planning are under continual review and revision. Existing programs in the School, such as urban economics, housing in developing areas, history, theory, and criticism of art, and architecture and urban form are being strengthened, and new programs are being investigated. Teaching and research activities which are linked to other Schools and departments in the Institute, such as energy, law, urban politics, operations research, and the arts, continue to provide opportunities for students to explore areas of interest related to their fields.

The Department of Architecture is developing several diverse areas of interest, among them housing and services for the physically handicapped and the elderly, urban settlement design in developing countries, computer use in design, and the building of experimental environments in public spaces. There also has been continued development in the visual arts. The Visible Language Workshop, a collaborative venture among the Departments of Architecture and Humanities and the M.I.T. Press, formed in January, 1974, provides teaching, practice, and research in the verbal, graphic, and imagistic arts. The Creative Photography Laboratory and the Film Section both attracted a large number of students and organized several major presentations. The Center for Advanced Visual Studies, in association with the Department of Architecture, continued to offer an opportunity for students to work on large-scale projects related to environmental art.

The Department of Urban Studies and Planning, after much deliberation, has regrouped its academic programs and resources into three parts: social policy, urban and regional development, and environmental design. Many subjects were expanded and strengthened, including urban sociology, urban politics, public policy evaluation, and operations research. Five new undergraduate seminars also were added. Emphasis again was placed on the development of practical skills, and the number of field linked opportunities was increased. In the Special Program for Urban and Regional Studies in Developing Countries (SPURS), several new activities were undertaken, including the SPURS Seminar on Planning and Development in Developing Countries, which was organized and managed by the fellows themselves. Through the projects which the Community Fellows generated this year, that Program continued to explore problem areas relevant to the needs of minority communities. The Minority Intern Program, sponsored by the Department of Housing and Urban Development, again placed 20 minority students in work-study positions in the Boston area.

In urban studies and planning, at the doctoral degree program level, a new yearlong required seminar for all first-year candidates has been instituted. The Department of Architecture has proposed that it be authorized to grant the doctoral degree, and discussions are under way with the appropriate Institute committees. The Doctor of Philosophy program would fill the need for in-depth analytical and theoretical studies in the context of an active professional school.

The School is continuing to encourage shifts in its composition, in response to the need it perceives for minorities and women to become effective architects, planners, artists, researchers, and teachers. Of approximately 250 graduate students, nearly 20 percent are from minority groups and 28 percent are women. On the faculty and research staff, there are nine minority group members and nine women in urban studies and planning; there are

two minority group members and six women in architecture.

During 1973-74, in the Department of Urban Studies and Planning, there were 59 undergraduates, 66 students in the Master in City Planning program, and 42 in the doctoral program. In addition, each year the Community Fellows Program and the SPURS program bring to M. I. T. approximately two dozen mid-career practitioners from diverse backgrounds and life situations. In the Department of Architecture, undergraduates numbered 143, Master of Architecture candidates 91, and Master of Architecture in Advanced Studies candidates, 39. A small but growing number of students are working toward joint architecture and planning degrees in the Environmental Design Group, and toward the joint degree in urban planning and economics at the doctoral level.

Research activities continue to grow in amount and in importance to the teaching programs. In addition, several new research projects were funded. The Council for the Arts at M. I. T. awarded five grants to programs and individuals in the School this past spring. The Mellon Foundation funded a proposal by eight eastern schools of architecture -- this School among them -- for the implementation of a study and action program to improve architectural education. Overall, the School's research funding again totaled over \$1 million this year.

Much of the School's research currently is housed in the Laboratory of Architecture and Planning (L. A. P.), which was created in 1972-73. Dean William L. Porter is the director of the L. A. P. , and David Judelson was appointed the assistant director. A steering committee was formed, with membership consisting of: Dean Porter; Professors Donlyn Lyndon, Lloyd Rodwin, Donald A. Schon, Richard C. Larson, Stanford Anderson, Edward B. Allen, Aaron Fleisher, Benson Synder, and Gary Hack; Assistant Dean Ann Gordon; Mr. Judelson; Wren W. McMains; and Laura Giroux of the Operations Research Center. The Albert Farwell Bemis Fund has been assigned to the L. A. P. to promote research and develop innovative educational materials. After soliciting proposals and a careful review, the steering committee awarded grants to several interesting projects central to the educational mission of the School. The L. A. P. also is providing a range of services which assist and enrich the research activities of the School's faculty and students. A grant to support field linked education and study in the areas of regional land use and environmental planning has been awarded to the School by PACE (Planning Approaches for Community Environments), and is being administered through the Office of Field Services in the L. A. P. Other research, particularly in the field of housing policy, is being conducted at the M. I. T. -Harvard University Joint Center for Urban Studies, which is currently under the direction of Professor Bernard Frieden.

To facilitate the teaching and research programs of the School, the Rotch Library has continued to increase the number and diversity of its resources. Given the cramped space and limited number of staff, the Library has been rendering extraordinary service to users from the School and elsewhere in the Institute. To strengthen further the relationship between the School and the Library, Rotch Librarian Margaret DePopolo has become a member of the School's Development Council and Space Planning Committee.

Space again was a serious and much-deliberated problem this year. The School has been allocated space vacated by the Department of Electrical Engineering when it moved into its new building. Some funds for renovation also have been allocated, which provide for a beginning step in the improvement of the School's environment. There remains the need to raise the funds for the overall space improvement program.

Both departments of the School have been extremely active in trying to provide financial support for as many of their students as possible. Nevertheless, student support remains a high-priority item for development -- especially because of the departments' commitment to educate people who find it impossible to pay for their education, as well as those who can. In commemoration of Dean Emeritus Lawrence B. Anderson's retirement and of his significant

contribution to the School, a fund in his name has been established. At the conclusion of the fund-raising effort in 1975, it will be used to enable deserving students to undertake projects of particular personal interest, which will enrich and extend their educational experience.

Considerable changes took place in the faculty and administration of the School this year. In the Department of Urban Studies and Planning, Professor Rodwin stepped aside on June 30, 1974, after four years as head of the Department. As head, Professor Rodwin established a strong and diverse faculty. Moreover, he has been a superb teacher and has helped to bring many stimulating research and field projects to the Department. After a year's sabbatical, he will resume teaching and research activities, and will continue as director of the SPURS program. Professor Langley Keyes became the new Department head in July, 1974. He is a specialist in housing and urban development, and has been associated with the Joint Center for Urban Studies for the past ten years. Professor Lawrence Susskind was appointed to the new rank of assistant head. Professor Susskind has done extensive research on national urban growth and land use policy, and was director of the undergraduate urban studies program during 1972-74.

Early in the academic year, Professor Lyndon indicated his desire to resign as head of the Department of Architecture, a position he has held since 1967. Under his leadership, the Department has expanded its scope to include several new and distinguished arts programs. Professor Lyndon also has been involved actively in examining and developing long-range educational goals for the arts at M. I. T. After an extensive search, Nikolaas John Habraken, presently Professor of Architecture and Urban Design at the Technical University of Eindhoven, the Netherlands, was chosen to succeed Professor Lyndon in August, 1975. Institute Professor Emeritus Gyorgy Kepes, founder and director of the Center for Advanced Visual Studies since 1968, will retire from this position in October, 1974. He will return, after a year's leave, as director emeritus and fellow of the Center. The new director will be Professor Otto Piene, who has been a visiting professor of architecture at M. I. T. and a fellow of the Center.

Professor Minor White, who inaugurated the program in creative photography in 1965, retired in June, 1974. He will be away from the Institute for a year and a half, and will return to M. I. T. as professor emeritus and senior lecturer in the Department of Architecture.

This spring, Ann Gordon was appointed to the new rank of Assistant Dean for Academic Administration. Prior to the appointment, Ms. Gordon was assistant to Dean Porter and director of the Office of Field Services in the Laboratory of Architecture and Planning. In addition to her responsibilities for regular matters of academic administration, she will act as liaison between Dean Porter's office and other parts of the Institute.

The faculty, teaching programs, and research activities now at the School, along with the continued efforts to expand and enrich these resources, provide a highly appropriate and dynamic environment for education in the fields of architecture, environmental art, and urban studies and planning. It will be difficult to maintain and improve the School, given its educational style -- including studio teaching, field work, and workshops, as well as the usual seminar, classroom, and laboratory settings -- and given its commitment to a broad constituency of students and clients for research, in light of the apparent lack of financial resources outside of the Institute. Nevertheless, it is felt that with the collaboration of others in the Institute, and with the support of the School's alumni, continued growth with quality will be ensured.

WILLIAM L. PORTER

Department of Architecture

The concluding paragraphs of the Department of Architecture section of the 1967-68 edition of this Report included a section titled "Prospects," that forms a useful reference for considering the present situation of the Department.

Rapid changes in society, in technology, and in our aspirations for the environment, promise to keep the Department of Architecture in a state of creative perturbation for some years to come. We look with special interest to the augmentation of the Urban Design program now being initiated and to our expanding involvement with community development in disadvantaged areas. Computer studies by members of the Design Information Group will no doubt continue to increase, while the need for continued experimentation with actual environments is clear. Research into the requirements for a broad program in industrialized construction should be considered soon for curriculum development.

As the awareness of urgent needs presses us ever more firmly, the values of historical distance become more apparent. Our excellent program in History, Theory, and Criticism of the Arts should be expanded immediately to encompass the History of Urban Form. This, and other areas of research activity, need a channel for advanced study; early consideration should be given to the establishment of a Ph. D. degree within the Department.

In one form or another, the various themes suggested in that report reappear in the reports of subsequent years, with three significant additions. First, in every year following there have been anguished comments regarding the inadequacy of the Department's physical facilities and the tensions caused by crowding, fragmentation, and the necessity of using fundamentally inappropriate spaces. Second, in the last several years there has been a marked increase in specific attention to the various arts programs that are a part of the Department. Finally, subsequent reports express an evolving style of education that opens opportunities for students to chart their own paths, a style that requires a good deal of responsibility and determination on the part of the student, and which is rooted in the conviction that students learn best through working in situations that have real consequence.

Environmental Design

The Urban Design program, initiated in 1968 by Professors John R. Myer and William L. Porter, is now the interdisciplinary Environmental Design Program, which joins several of the Department's faculty with a number from the Department of Urban Studies and Planning, including two joint appointees, Professors Gary A. Hack (program director) and Tunney Lee. The program has students from both Departments, and offers subjects at both the undergraduate and graduate levels. It is the Department's most extensive and successful interdepartmental effort. The Department of Urban Studies and Planning's most visible subject offering this year was the "Total Studio," an advanced-level studio open to M. Arch., M. Arch. A.S., and M. C. P. students, with a coordinated sequence of mini-courses designed to examine specific topics. Professors Lee, Myer, and Philip B. Herr of the Department of Urban Studies and Planning organized the subject, with the aid of a curriculum development grant from Dean William L. Porter. A number of faculty and staff contributed to the mini-courses.

The Disadvantaged

The involvement of the Department with the special problems of the disadvantaged has changed considerably during the past seven years. The Community Projects Laboratory (C. P. L.) was established in 1968 to provide an intellectual focus and staff support for student participation in projects designed for communities not normally served by the profession. It was managed this year principally by graduate students Kevin Ruedisueli, Nicholas Elton, and Kanaan Makiya, with special assistance from Instructor John K. Bullard and guidance from Professor Dolores Hayden, who joined the faculty this year. Professor Hayden initiated two related subjects within the History, Theory, and Criticism offerings: the Architect as Activist, and the Architecture of American Socialist Communities. These, combined with her continuing attention to both the professional and the intellectual problems attendant on working in disadvantaged communities, have set a context for the very specific, often personally demanding tasks undertaken through C. P. L.

Professors Chester L. Sprague and John A. Steffian and Research Associate Sandra C. Howell, who joined the Department this year, have been instrumental in directing attention to the vulnerability of the physically disadvantaged; they have directed theses concerned with the blind, the handicapped, and the elderly. Professor Sprague's studio in the fall term and Professor Jan Wampler's studio in the spring each dealt with the special problem of building housing for the elderly. Dr. Howell and her study team completed the first year of a three-year HUD-HEW (Department of Housing and Urban Development and Department of Health, Education, and Welfare) funded research program to prepare a design evaluation of the social uses of elderly housing, as observed in field studies of a number of existing projects throughout the country.

Professor Horacio Caminos and Instructor Reinhard K. Goethert have continued their study of urban settlement design in developing countries, with the assistance of funds from the Ford Foundation. Their work has been recognized widely in Latin America and Africa, and led this year to a small planning grant from the government of Lebanon for housing studies. Alumni of this program, which has been under way since 1966, now occupy major positions of responsibility in several developing countries.

Computer Studies

Predictably, computer studies have continued to grow, principally with the stimulus of Professor Nicholas P. Negroponte's innovative research in sketch recognition, which serves as a matrix for considerable undergraduate research activity and the continued development of the School's computer facility. Research funding for the year approached \$300,000; it came from the National Science Foundation, the Office of Naval Research, and Honeywell, Inc. Professor Timothy E. Johnson and Research Associate Guy E. Weinzapfel completed work this year on an NSF grant to develop IMAGE, a space allocation system for use in the design of buildings. Professor Johnson and Mr. Weinzapfel introduced their work to design studios through a mini-course in the Total Studio. Computer related subjects offered in the Department this year included 4.20 Introduction to Information Processing, 4.201 Geometry and Computation in Architecture, 4.21 Design Information: Structures and Models, and 4.25 Machine Intelligence in Design.

Actual Environments

Since 1967 there has been a continuous series of student built experimental environments, built within the Department and various public spaces in the main group of buildings. This year, the student built structure that had occupied the main lobby space under the Building 7 dome was removed to make way for a wider range of temporary activities. It has not been

replaced yet, nor have any new mezzanine structures been built in spaces newly occupied by the Department. For the most part, this reflects the uncertainty that has been felt throughout the Department regarding the development of a long-term space plan that can accommodate its programs.

However, there have been several projects that deserve notice. Most importantly, Dean Porter's revised office, designed and crafted by Professor Maurice K. Smith and Charles Styron and Rachel Strickland, students in the Department of Architecture, illustrates the possibilities for inventive new uses of space and the pleasures that can result from a spirited and loving investment of personal attention. Furthermore, by reclaiming a previously closed entrance that opens directly onto the balcony of Building 7, Dean Porter has enabled special School-wide events to spill over directly from his office onto the balcony; he has demonstrated vividly that, with appropriate spatial arrangements and the suitable staging of events, the communal life of a School can enrich the public environment of the Institute and reveal its human face.

The Building 7 lobby also was the locus for the creation by Professor Otto Piene of an extraordinary environmental event. "Weather," as seen, studied, and symbolized in the work of scientists, engineers, and artists throughout the Institute, was the subject of a week-long exhibit that entirely filled the lobby with demonstrations, apparatus, images, and recorded sound. The assembly of exhibits and events demonstrated forcefully the potential for challenging and informative use of large-scale public space.

Professor Piene and his students of painting and environmental art also prepared color schemes for renovation of the main stair of Building 7, adjacent to the lobby. Painted mural panels have been installed at each landing.

Professor Wayne V. Andersen and his seminar prepared an outstanding exhibit for the Hayden Gallery. It indicated the nature and scope of contemporary involvement in environmental art, especially as it is manifested in large-scale, temporary interventions in the landscape.

Also, in preparing new offices for himself, and a combination seminar and workroom for the Committee on the Visual Arts and his Environmental Symbolism subject, Professor Andersen thoroughly transformed a previously derelict set of offices which faced a neglected light wall. With good judgment, strong commitment, personal carpentry skills, and a modest budget, Professor Andersen made eminently workable and pleasant offices.

In a project conducted away from the Institute, Professor Richard Britain and his fall-term studio class undertook the design and construction of a greenhouse living unit, utilizing movable insulation and high thermal mass to control solar heating. Finally, a small group of students working with Research Affiliate Hans Guggenheim developed and tested a prototype water storage cistern, both here and in Mali, Africa, using traditional African construction forms combined with ferro-cement.

Two major factors inhibit the further development of real building experimentation: the absence of an adequate shop and facilities, and the absence of indoor or outdoor space for construction. Professor Britain's class was hampered seriously by the necessity of traveling to a suburban building site. Most efforts to build within the Institute encounter logistic and procedural difficulties which, while they are in some sense educational in themselves, ultimately drain so much energy from most projects, that they no longer can fulfill their initial exploratory purpose.

Industrialized Construction

Curriculum development in the area of building construction has taken place less systematically than was intended. Elements of a broad program exist, however, and the possibilities for a coherent and powerful program are greater now than before. Professor Arthur Bernhardt's HUD financed studies of the mobile home industry have shown the necessity of considering the organizational aspects of any industrialized building system, and have served as the locus for several theses. Professor Ezra Ehrenkrantz served again this year as Bemis Visiting Professor, offering in the fall term a lecture subject on the systems approach to building. Professor Emeritus Albert G. H. Dietz, who this year received the Walter C. Voss Award from the American Society for Testing and Materials, served as senior lecturer in the spring term, and again joined with Professors William A. Litle and Robert D. Logcher of the Department of Civil Engineering to teach the construction of buildings. A series of meetings with Dean of Engineering Alfred A. H. Keil, Professor Peter S. Eagleson, and members of the faculty of the Department of Civil Engineering have identified a framework for cooperative developments in the field, and the Department expects to benefit from further collaboration.

The principal efforts in building technology this year have been directed toward consolidating and improving the subjects that serve to establish the fundamentals of the field. Professor Edward B. Allen has reorganized fully the Building Process subject, with new lectures and an improved laboratory format. Professor Sean Wellesley-Miller has developed subjects in the long-neglected area of environmental controls for buildings, and, with Professor Johnson, has initiated two research projects in the technology of solar energy use. The uses of air as a transfer medium in solar collectors are under study with support from the Cabot Fund, and NSF has funded the initial development of variable transmission solar membranes, that, if successful, would introduce new levels of flexibility in the uses of solar energy in buildings. Research Affiliate Day Chahroudi has assisted in the development of these projects and in the design of several research proposals prepared jointly with the Energy Laboratory. This is a rapidly reviving area of research and study, which promises important developments in the next several years.

History, Theory, and Criticism

The study of urban form has been an important focus for recent studies conducted by members of the faculty in this area. Professor Stanford O. Anderson, with continued support from the Grunsfeld Foundation, has given major attention to the development of a research program in urban ecology, with related seminars and a studio project that analyzed the spatial structure of streets and buildings in Cambridgeport and the possibilities for sympathetic patterns of building on the Simplex properties. Instructor Lawrence Speck assisted with these subjects. Research Affiliate Lajos Heder assisted in the development of research proposals, and initiated a study of the impact of the proposed Kennedy Library on the structure and use of communal space in Harvard Square.

In the spring term, Lecturer Gunter Nitschke conducted a seminar on the development of archetypal town structures⁴ in East Asia. Lecturer Nitschke's continuing studies in Japan of the relations among ritual, building form, and urban structure have been supported by the National Endowment for the Humanities. They also have entered into his subjects on the history of Asian architecture and the subject 4.683J Science, Technology, and Ritual, which he taught jointly this spring with Professors Nathan Sivin of the Department of Humanities and Philip Morrison of the Department of Physics.

Visiting Professor Christian Norberg-Schulz conducted a seminar in the spring examining the embodiment of genius loci, the particular sense of place in the form of several European cities,

and offered a more traditional subject in the history of Renaissance and baroque architecture.

Professor Donald A. Preziosi, who joined the faculty this past fall, offered an introductory subject on the history of architecture and an advanced seminar on the analysis of architectural form. In the spring term, he continued his studies of the language of architectural form, with the support of a Guggenheim grant.

Professors Whitney Chadwick and Judith Wechsler introduced new subjects in the history of art, and seminars on Dada and surrealism and the history and theory of caricature. Professor Wechsler also continued her much-acclaimed interdisciplinary subject, 4.603 Aesthetic Perspectives in Science and Technology. These, combined with regular offerings and Professor Andersen's previously mentioned seminar on symbolism, provided a broad range of offerings in art history.

Professor Henry A. Millon, on sabbatical leave this past academic year and newly appointed as director of the American Academy in Rome, conducted the second phase of the symposium series (initiated in 1972-73) on art and architecture in the service of politics. Professor Millon also is preparing material for a subject on the history of twentieth-century town planning in Italy.

Advanced Study

The Master of Architecture in Advanced Studies has continued to open special opportunities for students working toward a second professional degree and working in specific areas. Students in the M. Arch. A. S. program studying under Professors Horacio Caminos and Eduardo F. Catalano work within a very closely defined and concentrated program, while M. Arch. A. S. candidates in the Environmental Design Program use the diverse faculty resources of the combined program to delineate widely ranging studies, generally in the areas of design methods and environmental policy.

New opportunities will be opened for study in the M. Arch. A. S. program in the coming year, including advanced work with Professors Anderson, Piene, Negro Ponte, and the energy research group. These, combined with fellowship opportunities at the Center for Advanced Visual Studies and a growing pattern of collaboration with the Division for Study and Research in Education, make M. I. T. an exceptionally fruitful place for advanced professional studies.

However, two problems remain. The degree structure of the Department still limits advanced study to candidates holding the professional degree in architecture, a qualification that is not necessary for advanced study in the arts or in some areas of building technology. Most importantly, the two-year M. Arch. A. S. program does not offer sufficient intensity of study in those areas of theoretical research that are critical to the continued development of the field. After several years of preparation, there is now before the Committee on Graduate School Policy a proposal that the Department be authorized to award the Doctor of Philosophy. Acceptance of this proposal by the faculty will enable the Department to take advantage of outstanding faculty capabilities in history, theory, and criticism, and to fill a need within the field for disciplined analytical and theoretical studies developed in the context of an active professional school. Authorization of the Ph. D. program will be an important stimulus to the development of a vigorous research program, will attract the most intellectually able candidates in the field, and will provide a program of study that fully develops their capabilities for scholarship and research. At present, Marian Moffet is working toward a Doctor of Philosophy as a Danforth Fellow in a joint program with the Division for Study and Research in Education. Several students with architectural training and dissertation subjects in architecture are pursuing their studies through the doctoral program in the Department of Urban Studies and Planning. These facts and continued inquiries reflect the demand for such a program of study.

Arts

In the past several years, there have been a number of important developments in the arts program in the Department. Most recently, these have been spurred and encouraged by the activities of the Council for the Arts at M. I. T.

Organization of the Visible Language Workshop was one of the most promising developments of the year. Starting with the equipment that Instructor Ronald L. MacNeil had developed for his subjects in photographics, and aided by grants from Dean Porter and the Council for the Arts, the Visible Language Workshop executed a number of posters and publications for groups throughout the Institute, and sponsored two new subjects. The subject 4.014 Messages and Means was taught jointly by Mr. MacNeil and Lecturer Muriel Cooper, Media/Design/Production Director of the M. I. T. Press, who has joined the Department on a part-time basis. Words and Images was a subject offered jointly by Professors Jonathan W. Green of the Photography Section of this Department and Patricia Cumming of the Creative Writing Section of the Department of Humanities. With additional funding, not yet secured, the Visible Language Workshop can grow into a strong component of the Institute's arts program. Professor Green, who chaired the Workshop committee, recently received an award from the National Art Librarians Association for his book Camera Work: A Critical Anthology, which was named the best art book of 1973. Mr. MacNeil has been a constant inventor of processes and assembler of machines in the pursuit of his passion for printed images, and the Department is particularly grateful that Ms. Cooper and Professor Cumming have joined in this program. Each brings very special skills to this aspect of the Department, and the group adds much to the spirit of the place.

Professors Richard Leacock, Edward Pincus, and John H. Terry conducted both introductory and advanced subjects in filmmaking, and advised a number of students on individual film projects. The impact of their work and the availability of film equipment and faculty have had a noticeable effect on the style of imagery and the modes of study and presentation in the Department. Professors Leacock, Piene, and Robert O. Preusser this spring initiated a special project in multimedia presentation, with the assistance of several Undergraduate Research Opportunities Program (U. R. O. P.) students. Their work will serve as the basis for a continuing project in the Center for Advanced Visual Studies in the coming year. Professor Preusser opened the year with an exhibit in Hayden Gallery entitled "Lightworks," a series of student projects undertaken first in his classes in visual design, then extended with support from sources including the Council for the Arts.

Professor Piene, since 1968 a fellow at the Center for Advanced Visual Studies (C. A. V. S.), and visiting professor in the Department, has been appointed Professor of Environmental Art and director-designate of the C. A. V. S., to replace Institute Professor Emeritus Gyorgy Kepes on the occasion of his retirement from administrative responsibilities in October, 1974.

Throughout the year, members of the arts faculties of both the Departments of Humanities and Architecture have been conducting weekly meetings to consider long-range educational goals, and especially to develop programming material necessary to space planning for the arts programs. Professors Andersen, Green, Leacock, Wechsler, Piene, and Lyndon of the Department of Architecture and Professors John Buttrick, Albert R. Gurney, Roy Lamson, Barry B. Spacks, and Peter M. Spackman of the Department of Humanities participated. Other members included Ellen Burbank, Associate Director of the Council of the Arts; Margaret Depopolo, Rotch Librarian; Bruce MacDonald, Director of Exhibitions; Instructor Myron Guran of the Department of Architecture; and Karen Wheeler, a graduate student in architecture. Ex officio members were Provost Walter A. Rosenblith, and Deans William L. Porter and Harold J. Hanham. These meetings have provided an important opportunity to develop shared views and to learn more about the various arts programs in the Institute.

The group has worked closely with the Planning and Facilities Committee and with the staff of the Council for the Arts.

In conjunction with these meetings and with support from the Council for the Arts, Mr. Guran and Professor Lyndon, with the assistance of Karen Wheeler, have conducted an ongoing study of arts facilities and their program requirements. In the spring term, this material became the basis for an advanced design studio, in which a small number of students worked out various possibilities for modifying existing buildings or converting presently underutilized space on the main campus for use by arts programs and their attendant public activities.

Creative photography, a program which has been in strong demand since its inception by Professor Minor White in 1965, has continued to be much sought after and again was unable to meet the full enrollment demand.

This academic year marks the last year of full-time teaching for Professor White, who retired at the end of the year. He will be on sabbatical photographing in the coming year, but will return in the following year as a senior lecturer. This year, Professor White also participated in a special Independent Activities Period (I. A. P.) project funded by the President's office. Professor White, Mr. Guran, and ten students spent the January period in Rome preparing a photographic study of the interaction between people and buildings. The resultant exhibit, "Interface," was on display this spring in the Building 7 lobby. With Professor White's retirement, certain aspects of the teaching program are diminished irrevocably. He has been one of the country's leading photographers and one of the Institute's great teachers. He has embodied a rare combination of personal purpose, intellectual and emotional candor, and the vigorous disciplines of outstanding professional stature.

Educational Style

The commitment to educational patterns in which students choose their own path within a broad set of subjects and project choices has not abated, nor has the determination to have students learn by working in contexts of real consequence, either through engagement in real situations or by participation in the evolution of forms and processes that can be projected as models for subsequent work.

Professor Smith's design studio work again examined specific elements of building form that can be assembled to suit site conditions and to increase users' ability to enjoy their environmental surroundings more fully, improvising new patterns of use and arrangement within an established framework.

Professor Richard Tremaglio's studios worked to develop organizational patterns and prototypical urban space and building designs for a projected East Campus bordering Kendall Square. Professor Imre Halasz conducted a studio that prepared illustrative designs for new athletic facilities on the West Campus. These latter two studies were carried out with the cooperation of O. Robert Simha, Director of the M. I. T. Planning Office, and his staff.

Professor Halasz began a new pattern of teaching introductory subjects in the spring term, as students in their first year of design formed teams with advanced students to carry out the development of building schemes that had been initiated in the fall-term advanced studio. During his several years as visiting professor, he has contributed powerfully to the program in architecture; he will join the faculty in the coming year as full professor. Professor Julian Beinart, who has served a variety of roles in the Environmental Design Program, also has been appointed full professor, beginning in the coming academic year. Professor Beinart's work this year included highly successful service as program coordinator of the International Design Conference at Aspen, Colorado. He was assisted in this task by Florian von Buttlar, Roger Goldstein, and Suzanne Weinberg, former students in the Department.

This past academic year, the Department was especially fortunate to have Dean Emeritus Lawrence Anderson teach one of the introductory design studios, bringing to that class his wide experience in the field and his discerning professional judgment. He was assisted by Instructor Maria Ogrydziak, who was responsible also for increased instruction in drawing, and who assisted Professor Smith in the conduct of 4.26 Built Form Observations.

Throughout the year, there has been an increased emphasis by students and faculty on the necessity for developing basic professional skills and establishing more effective linkages between education and practice. A faculty committee chaired by Professor Halasz with the assistance of Ann Gordon, Assistant Dean for Academic Administration, developed several possible schemes for internship and job placement programs, some of which will be implemented in the coming year. Paul Lipof managed a career placement inquiry for graduating students that was mailed to all alumni. Also initiated this year was a Deferred Residency Option, which allows M. I. T. undergraduates who have been admitted to the graduate-professional program to work in the field for a year or more before continuing their work here.

Several student managed events have added spirit to the Department's enterprise, most notably the Friday lecture series organized by Susan Myers, Adrienne Albert, and Rosalia Ennis. These gatherings were supplemented on Wednesdays by Baked Form, a splendid School-wide lunch offering prepared each week by Ann Beha and Michael Harris. Played Form, a music group with Julian Smith, Aron Faegre, and Marian Moffet, graced many of the Department's public events.

The availability this year of Federal work-study funds for graduate students made it possible for the Department to engage students in a wide variety of support activities, thereby providing approximately \$50,000 in additional student support.

It is impossible to describe adequately the educational style of the Department without mentioning the ubiquitous activities of Professor Leon B. Groisser, Executive Officer and head counsellor. Professor Groisser's appetite for offering wisdom, advice, and knowledgeable support is insatiable. He is a great resource for students and faculty alike, and his ministrations have served the Department very well.

Harvard-M.I.T.

The Harvard-M. I. T. joint lecture series was the first and most evident product of a new round of discussions regarding collaborative programs between the School of Architecture and Planning and the Harvard Graduate School of Design. Professors Lyndon, Smith, Bernhardt, Lee, Beinart, Lawrence Anderson, and Stanford Anderson, Dean Porter, and Mr. Nitschke lectured in Gund Hall at Harvard, and Professors Anselevicius, Kallman, Bakanowsky, Soltan, Stull, Stifter, Zeybekoglu, Tzonis, and Zeisel of Harvard participated in the lecture series at M. I. T. Professor Wampler's exhibit, Imprint, prepared first for the Hayden corridor gallery from material gathered during a leave of absence (with support from a Wheelwright Traveling Fellowship) was exhibited in the Harvard Graduate School of Design.

At the close of the year, Professor George Anselevicius, Chairman of the Architecture Department at Harvard, and Professor Lyndon prepared a proposal for a collaborative interdisciplinary studio that would take place at each School during alternate terms. This would augment the already active cross-registration of students with a program of collaborative teaching involving the faculty of the two Departments.

Enrollment

Enrollment patterns in the Department in 1973-74 were similar to those of the previous year, with 143 students registered for the Bachelor of Science in Art and Design, and an almost equal number of graduate students; both figures are up slightly over recent years. The number of women and minority students continues to increase, although this year (for the first time in recent years) there was a drop in the number of women applicants.

Pressure for admission to the professional Master of Architecture degree program remains very intense. There were 448 applications for graduate study, the great majority of which were for this degree. A total of 80 were accepted, and 66 new graduate students are expected to enroll in the fall. This will produce an increase in the Department's graduate enrollment for 1974-75, and there are signs that there again may be increases next year in the number of undergraduates who designate majors in the Department.

Space

Departmental reports have been marked for many years by expressions of pain and frustration regarding inadequate space and various attempts to find more satisfactory surroundings.

The year 1973-74 began with great optimism, because the School of Architecture and Planning was assigned a sizable amount of the space vacated by the Department of Electrical Engineering. Funds for renovation of this space were not provided, however, and almost no space revisions were undertaken. Sensible use of this amount of new space called for an examination of the long-range plans for the School and its location during the next several years. These studies were initiated with Dean Porter's energetic leadership and with staff support from the M. I. T. Planning Office. Unaccountably, the study has been frustrated at every turn. By the end of this past academic year, the Department had only begun to see resolution of its long-term plans. Virtually no renovation has taken place; tempers are frayed, and classes in the coming year again will take place in discarded spaces. The Department looks forward to a time when it can secure an environment that more nearly reflects the processes and qualities it professes.

Prospects

What are the longer-term prospects for the Department, as seen in 1974? The Department community is much larger than it was in 1967-68. There were then 154 students majoring in the Department; next year there will be almost twice that number. In 1967-68, the faculty and academic staff numbered 45, with 11 teaching and research assistants; now there are 58, with 23 assistants. In fiscal year 1968, \$116,284 was expended in sponsored research; in fiscal year 1974, the figure will be \$270,000. The Department also must assume that there will be a resolution of the space issues that will demonstrate the seriousness of purpose in architecture and the arts that M. I. T. has proclaimed.

Three major committee studies undertaken this year will affect future developments strongly. Professor Wechsler, with the assistance of James Czajka, studied thoroughly the undergraduate program leading to the Bachelor of Science in Art and Design. As a result of her studies and deliberation by the Educational Council (consisting of Professors Allen, Lawrence Anderson, Stanford Anderson, Beinart, Chadwick, Eduardo Catalano, Green, Groisser, Leacock, and Lyndon, Dean Porter, Margaret Depopolo, and student members Julian Smith, Roger Goldstein, David Gressel, Dennis Roth, and Jorg-Dietram Ostrowski), three new subjects were introduced to the curriculum, in order to provide students with a better understanding of both the diversity and the unity of the Department and with the opportunity to learn more directly the basic skills requisite for architectural studies. Also as a result of their recommendations, an entirely new advising system was designed for implementation in the coming year.

A major study of the design curriculum, undertaken by a committee consisting of Professors Caminos, Beinart, Allen, and Halasz, with Professor Sprague as chairman and Marian Moffet and Cynthia Howard as graduate student staff, is still under way. Preliminary recommendations have resulted in a reconsideration of class scheduling procedures, and a promise of renewed guidelines for design subject coordination. The intent of these recommendations will be to establish a more coherent framework for the succession of design subjects and a better articulated context for a student's choice of educational program.

Finally, Professor Stanford O. Anderson has chaired ably the search committee for a new head of Department, which consisted of Professors Green, Wechsler, Sprague, Groisser, Myer, and Smith, and James Czajka, William Miner, Julian Smith, and Rachel Strickland. They conducted a wide-ranging, thorough search which considered the nature of the position and alternative structures of governance; they interviewed a number of candidates. The candidate they recommended, Professor Nikolaas Habraken of Eindhoven Technical University, will become Department head in the fall of 1975. He will bring to the Department an outstanding record of research and administration, a uniquely pertinent set of intellectual and social concerns, and a pleasing personal manner. Professor Habraken's research, in his pursuit of housing patterns that allow for personal differentiation and change in the environment, could not match more nearly the underlying basic themes of the Department, yet he has extended these concerns to the full system of housing production more fully than the Department has been able to do.

With Professor Habraken as Department head and the research that he will bring, with the authorization to grant the Doctor of Philosophy, with the undergraduate and graduate programs already being formed, and with expanded and vigorous programs in the arts, the prospects for the Department are for a period of outstanding achievements.

DONLYN LYNDON

Department of Urban Studies and Planning

Over the past four years, the Department of Urban Studies and Planning has doubled the size of its student body and faculty and greatly expanded its research activities. It has created several joint degree programs and has formed effective ties with other departments and centers of the Institute. A new undergraduate program was added in 1970, which currently has over 70 majors; a Community Fellows Program was created in 1971, which now has over 30 alumni in key positions in various minority communities around the country; and the Special Program for Urban and Regional Studies in Developing Countries (SPURS), originally adjunct to the Department, is being integrated into its regular operations.

In the past year, significant progress was achieved in the areas of affirmative action, curriculum development, financial aid, and decentralization of Departmental decision making. The Department also participated in the development of a long-range space plan for the School of Architecture and Planning, and in the establishment of the new Laboratory of Architecture and Planning. One of the very able and popular members of the faculty, Professor Langley Keyes, was chosen to head the Department, and the highly gifted Professor Lawrence Susskind was selected to serve as assistant head.

In short, the Department has undergone four years of significant expansion and transformation. Although it faces very real and difficult problems of funding and articulation of aims in the future, it now has an impressive faculty and staff, a capable body of students, a solid reputation, and promising prospects. This has been accomplished with the assistance of both the M. I. T. administration and members of the Departmental faculty. Their combined efforts are appreciated.

Affirmative Action

During the past four years, the Department added eight minority faculty members and six women to its teaching staff -- thereby meeting almost all of the affirmative action commitments spelled out in its original (1972) proposal, and moving into the forefront of M. I. T.'s efforts in this all-important area. Of the 105 students admitted to the Master in City Planning program since 1971, 60 are black, seven are Mexican-American, three are Puerto Rican, and two are American Indian. At the doctoral program level, there are six minority students and 16 women enrolled in the Department at the present time (out of a total class of 42). Just three years ago, there were no minority students and only six women in the doctoral program.

While these numbers are important in some respects, they do not tell the whole story. Under the careful scrutiny of a joint student-faculty task force, the Department has mounted an extensive minority recruitment drive. Among students, the Department is recognized as an especially hospitable and supportive place for minority students interested in studying for a professional planning degree. Under the leadership of Professor William A. Davis, Jr., the minority internship program sponsored by the Department of Housing and Urban Development (HUD) has continued to place 20 minority students each year in part-time work-study positions in the Boston area. M. I. T. students and faculty spearheaded a strong educational campaign in Washington this past year that helped to stave off a Federal budget cut that surely would have killed the program.

Curriculum Development

Curriculum development needs have received a great deal of attention this year. After much debate, a decision was made to group the teaching and learning resources of the Department into four parts: social policy, urban and regional development, public systems, and environmental design. Clusters of students and faculty, called program groups, devoted much time and energy to reorganizing current subject offerings and setting priorities for further growth and development.

Social Policy The social policy group experimented with a new studio format. Some of the most active members of this group were Professors Bernard J. Frieden, Keyes, Martin Rein, Donald A. Schon, and Arthur Solomon. They sought new and better ways of teaching "generic skills" (e.g., the synthesis of problem formulation, program design, policy analysis, and implementation strategies). This year the focus was on how to facilitate home ownership for low-income families in the city of Boston. Subject offerings in health planning were expanded considerably with the addition of three new seminars: 11.548 Client Perspectives and Experiences in Medical Care Institutions (Lecturer Charlotte G. Schwartz); 11.546 The Human Life Cycle: Institutions, Agencies, and Unmet Needs (Lecturer Robert Buxbaum); and Health Advocacy and Community Based Planning (Lecturer Alana Cohen). The addition of Professors Gary Marx and Francine Rabinovitz (the latter a joint appointment with the Department of Political Science) helped to bolster the graduate and undergraduate subject offerings in urban sociology, urban politics, and public policy evaluation.

Urban and Regional Development At first it seemed that the urban and regional development group and the SPURS program would be hit hard by the concurrent absences of Professors John Harris and Lisa Peattie, who were on leave for the 1973-74 academic year. However, three visiting staff members -- Professor William Mangin and Lecturers Peter Marris and Thomas Vietorisz -- filled in admirably. Professors Karen Polenske and Ralph Gakenheimer served as co-associate directors of the SPURS program for the year, and effectively utilized the vast professional experience of the SPURS fellows as a supplement to the regular teaching program. The activities of the urban and regional development group were

marked this year by a tentative merging of two previously separate groups: the developing countries group and the inner city development group. With the assistance of Professors Bennett Harrison, Donald Turner, Susskind, and Polenske, the two groups worked jointly to analyze common interests and to explore collaborative teaching possibilities.

Professor Turner completed work on the study supported by the Agency for International Development of technology transfer and housing policy for developing countries. Professor Lloyd Rodwin, with the assistance of Instructor Tim Campbell and Teaching Assistant Lou Slesin, introduced a new research seminar (also supported by AID) which focused on the environmental consequences of urban growth. This effort brought together an outstanding group of professionals from around the world to deal with the impact of urbanization on environment.

Public Systems This year the public systems group further sharpened its program and self-awareness. Its principal concern is with quantitative methods of improving public decision making. Faculty members specializing in operations research, management science, urban and regional economics, and statistics give this group a solid interdisciplinary focus. In part, the formation of the group is an outgrowth of the Innovative Resource Planning in Urban Public Safety Systems project, funded by the National Science Foundation and headed by Professor Richard Larson. This two-year effort involves five members of the Department's faculty and numerous student assistants.

The public systems group devoted a great deal of its time this year to the design of a new six-part undergraduate mini-course sequence entitled Quantitative Modeling of Social and Urban Systems. Its aims are: 1) to provide urban studies majors with the prerequisite modeling and analytical skills for a broad range of more advanced subjects in urban studies; 2) to provide sufficient methodological detail to make urban studies majors more educated consumers of quantitative subjects offered elsewhere at M. I. T. ; and 3) to demonstrate how calculus and physics concepts learned during the freshman and sophomore years can be applied to the analysis of various urban and social problems. The new sequence will be introduced in the coming year. A team of faculty members will share responsibility for the mini-courses dealing with simple static (linear) models and dynamic probabilistic models for studying population mobility, epidemiology, and the merits of contingency vs. master-planning.

Environmental Design The environmental design group has expanded its subject offerings in several different directions. A new version of Components of the Urban Environment brought together Grady Clay (a journalist), Arthur Krim (a cultural geographer), and Michael Woldenburg (a regional scientist). Lecturer Ed Wood offered a new seminar on environmental impact analysis, and Professor Tunney Lee headed a student-faculty team that presented a new Total Studio (another version of the integrated problem-solving approach) which coupled a specific client related task with a series of back-up mini-courses taught by leading practitioners. The participation of Robert Gladstone (of Gladstone Associates) and other planners in the field helped many of the students to develop a better grasp of the ways in which the techniques they learn at M. I. T. will be useful to them in practice.

Undergraduate Program

Five new undergraduate seminars were added this year: The Legislative Process (Lecturer Mel King); Experiencing Housing in Boston (Instructor Rachel Bratt); Dissecting the City (Instructor Phil Clay); Planning and Design in Boston (Instructor Roger Simmonds); and Work in America (Instructor Lee de Cola). A student-faculty undergraduate advisory committee, under the leadership of Professor Marx, met throughout the academic year to assess the entire undergraduate experience in urban studies. In an effort to give the undergraduate program more structure, they recommended the emphasis of subject offerings in five core areas: environmental design; public systems and urban management; urban planning and development; law, urban institutions, and social change; and human resource development

and health care delivery. A sixth "design your own program" option, subject to faculty approval, also will continue to be available.

Graduate Program

At the doctoral program level, Professor Aaron Fleisher and the rest of the Ph.D. committee instituted a new yearlong required seminar for all first-year candidates for the Doctor of Philosophy. This seminar, which deals with the logic and techniques of research in urban studies and planning, will continue next year.

Field Linked Activities

Professors Leonard and Suzann Buckle helped to streamline the ever-expanding assortment of fieldwork, internship, and tutorial options at the undergraduate level. Through their competent administration of U. R. O. P. (Undergraduate Research Opportunities Program), A. M. P. S. (Aid to Minority Planning Students), U. L. S. P. (Undergraduate Legal Services Program), and other programs, Departmental review and evaluation procedures have been improved, thereby ensuring more effective and satisfying learning experiences for both students and community agencies. Many of the ideas and approaches to field linked education may be revised as a result of the searching examination of teaching and learning in the field now being conducted by Professor Schon.

Although substantial progress in defining educational objectives at each degree level was made this year, additional work along these lines definitely will be required. Professors Keyes, Susskind, and Schon will lead a student-faculty effort this summer to prepare a more detailed curriculum development agenda for the coming academic year. Substantial strides toward a more articulated array of subjects and teaching experiences have been made, and the stage has been set for a shift in emphasis during the next few years from a previous focus on expansion to the current preoccupation with the quality of teaching and learning in the Department.

Financial Aid Policy

The academic year 1973-74 was the first year of a major experiment involving financial aid policy in the Department. This new student aid policy was adopted in the spring of 1973, at the recommendation of a student-faculty committee created specifically to review the experience and problems associated with this aspect of the program. The equal distribution of Departmental resources to all students in need of financial assistance was set as a goal. However, students receiving tuition assistance or a stipend from the Department now are asked to assume research or teaching duties in areas congruent with their educational interests and goals. The new policy assumes that students will report their financial status accurately and will not request funds if other possible sources of funding are available.

So far, because of the cooperation of all members of the Department, the system has worked. A total of \$390,639 was awarded to students this past year. During the fall term, 82 students received an average of \$2,460. In the spring, 79 students received an average of \$2,402. The remaining students did not request aid, either because they had funds from other sources (typically, externally administered fellowships) or because they held research or teaching assistantships in other M. I. T. departments.

One aim of this new policy is to make the financial aid process more transparent. The previous system was abandoned because it awarded large fellowships to a few students, but left much less or nothing at all for others; this created great inequities and tension. With the current ratio of applicants to admittees (about 15 to 1), any student admitted to the Department is "worthy" of financial aid, and all distinctions besides need are probably invidious. It is generally felt that the new system will work as long as the current level of student aid funds can be maintained and as long as the Department can attract students of the desired caliber.

Research Activities

Including support for SPURS and the Community Fellows Program (but not funds coming into the Joint Center for Urban Studies), the level of sponsored research in the Department this year topped the half-million-dollar mark, for the first time ever. Besides the NSF Innovative Resources Planning Project and the AID Environmental Impact of Urban Growth Project already mentioned, three other activities deserve special note.

Professor Susskind received a grant from the New England Consortium on Environmental Protection to prepare background materials and to offer a seminar on issues and policies in state land use planning. The seminar was open (on a noncredit basis) to guests from various Federal, state, and local agencies in the Boston area. Students from almost a dozen departments at Harvard and M. I. T., as well as more than 30 officials (many of them in high-level environmental policymaking roles in the Commonwealth) attended.

Professor Harrison was awarded a contract from the National Institute of Mental Health for a study of earned family income. One of the objectives of this project is to see whether various urban problems are rooted in a shortfall in earned family income. In conjunction with the Research Center for Economic Planning at the New School for Social Research in New York, Professor Harrison will focus especially on the concept of dual labor markets in major American cities.

Professor Polenske received a major grant this year from the Department of Transportation. She is carrying out a multi-regional input-output study of U. S. commodity freight shipments. This is an extension of her teaching and earlier research on techniques for regional economic analysis.

With the creation of the new Laboratory of Architecture and Planning, research may shift in part from Departmental to School-wide auspices. In either case, however, the funding level of contract research in urban studies and planning should continue to climb in the years ahead.

Other Activities

A number of faculty members received promotions during the past academic year. Instructors Thomas Nutt and Leonard and Suzann Buckle were promoted to the rank of assistant professor, and Professors Turner and Susskind were promoted to associate professor. (Professor Turner also was awarded a Ford International Career Development Award.) Several faculty members were the recipients of significant honors this year. Professor Kevin Lynch received the American Institute of Architects' Allied Professions Medal; Professor Davis was awarded a Mellon Fellowship in the Humanities from the Aspen Institute for Humanistic Studies; and Professor Kent Colton was named a White House Fellow for 1974-75.

Professor Richard Larson won the Lanchester Prize for his recent volume entitled Urban Police Patrol Analysis (M. I. T. Press, 1974). Other recent publications include Professor Harrison's Urban Economic Development (Urban Institute, 1974); Professor Arthur Solomon's Housing the Urban Poor: A Critical Evaluation of Federal Housing Policy (M. I. T. Press, 1974); the volume coedited by Professor Robert Hollister entitled Neighborhood Health Centers (Lexington Books, D. C. Heath, 1974); and Professor Polenske's State Estimates of Technology, 1963, which is Volume 4 of a six-volume work entitled Multiregional Input-Output Analysis (Lexington Books, D. C. Heath, 1974), edited by Professor Polenske.

In the course of any academic year, there are often special occasions that add zest and provide inspiration. The presence of Lewis Mumford, Visiting Institute Lecturer, can be placed in this category. His lectures and special seminar this spring inspired a great many persons, in this Department and elsewhere in the Institute, who share his deep concern for human values and his abiding interest in socially constructive applications of science and technology. The Department is honored that he has agreed to return next spring as the first Charles Abrams Visiting Professor.

The Independent Activities Period once again proved markedly successful. Under the leadership of Instructor Thomas Nutt, an extensive series of mini-courses, special events, and student-faculty activities went off smoothly.

A host of guest speakers throughout the year further enriched the Department's program and contributed to the intellectual ferment of the field.

Decentralization and Future Leadership

Professors Keyes and Susskind are likely to follow up the initial effort made this year to decentralize decision making and governance in the Department. An experiment in program budgeting (involving something along the lines of open budget hearings), while not altogether successful, set a precedent. A faculty committee on appointments drafted new procedures for reviewing candidates for appointment, promotion, or tenure. Although final decisions on such matters ultimately rest with the head of the Department and the central administration, more effective techniques for involving students and younger staff members in this process undoubtedly can be devised. The emerging focus within the Department on issues of quality (e. g., the effectiveness of alternative teaching approaches; diagnosis and evaluation of individual student needs; the sequencing and packaging of subject material) seems altogether appropriate.

There are sure to be economies that can be achieved through a careful reappraisal of the Department's teaching methods, a reconsideration of its admissions policy and the overall size of its entering class, and an amalgamation of the topics in which the Department proposes to provide first-rate coverage. While every effort should be made to come to grips with these problem areas, it would be a serious mistake to impose a strict moratorium on future growth of the Department of Urban Studies and Planning. The aspiration expressed several years ago by many people at M. I. T. -- that the Institute ought to move toward a more significant focus on social and environmental needs and the application of advanced technologies to the problems of the poor and the disadvantaged in both this country and abroad -- has been realized only in part.

LLOYD RODWIN

Laboratory of Architecture and Planning

Dean William Porter established the Laboratory of Architecture and Planning in the School of Architecture and Planning in July, 1973. The Laboratory was created to enrich the resources for education in the School and to develop a style of research and professional practice which is both innovative and responsive to the most important evolving issues of society. The Laboratory and several projects are housed in newly renovated quarters in Building 4.

The idea of the Laboratory and of the distinctive style of research and practice for which it stands has three major characteristics: areas of concern; use of representations or modeling; and involvement in purposeful intervention.

The "areas of concern" are an underlying involvement with the quality of the physical and social environments and how people interact with each other and with these environments. These concerns will determine the aspects of the physical and social environments which it is important to observe, research, and attempt to change, and they will spur an interest in the social and organizational processes which accompany change. The Laboratory is a place where such areas of concern can be brought to light, subjected to criticism, and examined for their consequences for research and academic activities in the School.

The second characteristic is the use of representations, or modeling. The Laboratory can be thought of as a place well equipped to experiment in order to learn, both at the elementary or introductory level, and at the advanced level where the frontiers of the fields of architecture and planning are being explored. The representations can take many forms. The physical models and drawings which architects use to represent their buildings and to study alternative configurations prior to their construction are perhaps the most widely known; increasingly, though, as more is known about society and the processes of social and environmental change, researchers have become interested in representations which take other forms. For instance, computer models of transportation systems and of social and public service systems, verbal descriptions of life-styles, role playing or gaming of social situations by groups of individuals, and many other techniques make explicit aspects of experience which have become included in the normal course of thinking of the environmental professional.

The third characteristic of the Laboratory's research and practice style is direct and expert involvement in purposeful intervention in the processes of change in the social and physical environments. The necessity of including this characteristic derives from the nature of the roles of architects and planners, as distinct from other fields. For example, the roles played by social scientists, who try to understand existing social systems, do not necessarily lead to, or necessitate, purposeful interventions. However, unless the people in the architecture and planning fields are involved actively with purposeful and socially useful change, some of the characteristics of the environment which are of fundamental importance may never emerge. Insofar as their roles involve being agents of change, the members of these fields must be concerned with sensing opportunities, points of leverage, and mechanisms for change, and with ways of monitoring change.

A style of research and practice which has the characteristics described above should bring these three components together. Involvement with purposeful intervention should modify the types and uses of representation which are designed; it also should inform the areas of concern, raising new issues and perhaps suggesting new strategies. Further, an integrated style of research or practice would modify any one of the characteristics as a function of the others. The results should demonstrate a mode of behavior in research and practice characterized by social concern, reflection, and purposeful action. The Laboratory as a whole can be seen as a place to explore and to clarify alternative research and practice styles within this mode of behavior.

The Laboratory already houses three projects which are in keeping with the ideas outlined above. The Innovative Resources Planning Project for Urban Public Safety Systems, conducted by Professor Richard Larson, is using advanced representation techniques and limited interventions into law enforcement, ambulance, fire, and other systems. Public Urban Space, a project directed by Professor Stanford Anderson, is studying the design professional's representations of public space, urban form, and human activity. Professor Benson Snyder is conducting a study of Professional and Group Behavior, an investigation of the mental models which professionals construct of their professional-client situations, especially such situations as those related to professional education in this School. Other projects, not housed physically but served administratively by the Laboratory, also include elements of these ideas, and will be informed further by exposure to the Laboratory's explorations of these ideas.

The Laboratory also offers several kinds of services in order to foster research activities and to reinforce the style of research described above. The Office of Field Services, which was directed this year by Assistant Dean Ann Gordon, assists those whose projects engage them in purposeful interventions in the social and physical environment. Among other activities, the Office of Field Services assisted Lecturer Justin Gray in establishing the Cambridge City Council Project, an innovative program in which students serve as staff to City Council members. Because of the centrality of the computer to research, and the complexity and difficulty of access, especially for the new user, the Laboratory includes an Office of Computing Services, directed by Lecturer Wren McMains. Its main function is to acquire and to maintain software and to facilitate its use by means of documentation and special instruction. The Laboratory also includes an Office of Research Administration, directed by Laura Giroux, which provides assistance in the budgetary matters of proposal preparation and identification of potential sources of new funding.

Finally, in keeping with its overall purposes, the Laboratory offers several other services and facilities which attempt to integrate its research activities with the academic environment of the School and the Institute. These include lectures, seminars, and conferences, a program of visiting fellows, publication support, a small research library, and certain specialized media equipment. Such services and facilities will come under the auspices of the Office of Educational Services, directed by David Judelson. In addition, this Office explores selected new areas which might be included in the School's educational and research programs, and administers some research seed funds to bolster the central mission of the Laboratory.

This year the Laboratory funded 19 faculty and student sponsored projects from the Albert Farwell Bemis Fund, which had been redirected toward the development of research and educational innovation within the School. This was the first in a series of annual solicitations.

Proposals were solicited in the spring from members of the School for projects to be conducted during the summer and fall of 1974. The Laboratory Steering Committee, whose function is to help set priorities and directions for the Laboratory, developed a procedure for reviewing these proposals. Each proposal was reviewed initially by the staff and two or three Committee members whose interests matched the proposal. It then was discussed before the whole Committee, which made the final funding decisions. Proposals were judged on the basis of their appropriateness to the purposes of the Laboratory, their potential for increasing the effectiveness of the School's educational program, their potential for additional outside funding, and several other criteria generally related to the quality of the proposals and the abilities of the researchers.

Among the projects funded was Professor Gary Hack's development of six case studies in environmental design, to be used as the basis for a new subject. The cases would be on the design, renewal, and management of the physical environment, and would incorporate innovative types of teaching/learning devices, such as video and slide tapes, role playing, and gaming.

Professor Lawrence Susskind's Rockport Planning Project, in which he and 16 students worked with a citizens' group in Rockport, Massachusetts, developed three models of the town -- tourism and town finances, housing and land use, and environmental resource analysis. These can be used to test public policy alternatives under consideration by the town. In addition, the project has made significant contributions to the understanding of ways of involving citizens in planning and of providing students with a very rewarding educational field experience.

Najwa Makhou, a graduate student in the Department, studied the self-help process by which an extended Palestinian family in Israel managed to create a new village for itself, in the face of continuous governmental interference.

Professor Charles Libby is developing a set of software which will allow visual interaction with, and manipulation of, data which is or can be represented spatially. He is coordinating many of the facilities already developed within the School, including the color display system, the DISCOURSE language, and the Architecture Machine; he is using satellite imagery as input. This project is likely to receive outside support in the next year.

The Laboratory is directed by Dean William Porter, and David Judelson is assistant director. They report to the Laboratory Steering Committee, which meets regularly throughout the year.

Plans for the next year include a thorough evaluation of current fieldwork and new educational programs in the School, an effort to increase the research volume of the School through an information service to be established in the Office of Research Administration, and another round of Bemis Fund projects. Ann Gordon, now Assistant Dean for Academic Administration, will be replaced as director of the Office of Field Services by Professor Leonard Buckle of the Department of Urban Studies and Planning. Several new projects will be starting up in the Laboratory. These include: the Overlap Project, which will extend some work of the Cambridge Project and introduce a new area of research on the drawing of inferences from large data files, with Dr. Joseph Markowitz, John Klensin, Robert Wallace, Oliver Selfridge, and Lecturer Wren McMains as principal investigators; the Architectural Education Study, under the general direction of Dean Porter and Maurice Kilbridge of Harvard University, one of the major studies of which will be conducted by Professor Julian Beinart; and a project entitled Simulation of Inter-Area Migration, with Senior Research Scientist David Birch as principal investigator.

WILLIAM L. PORTER

School of Engineering

The School of Engineering's primary goal is to further the evolution of the engineering profession -- the state of the art of engineering and the foundations upon which engineers build -- through research and education. Therefore, its programs must be responsive to the present and anticipated changing needs of the profession. In the following paragraphs, before the School's activities for the academic year 1973-74 are discussed, some thoughts on the changing scope of the engineering profession are presented. It is only in this light that the School's activities can be seen in their proper perspective.

The scope of the engineering profession is expanding to encompass the aggregate of three types of activities:

1. The development of the engineering sciences and of technology.
The transition from scientific progress to its actual use continues to require an extensive "applied science" effort to develop the foundations for the complex analysis of practical problems as well as for advances in the hardware and software aspects of modern technology.
2. The conception and development of reliable and economic technical solutions.
Efforts to develop such solutions concentrate on the actual conception, design, and development of well-engineered, reliable "products" and the integration of these products into technical systems. Related is the advancement of manufacturing and construction processes which are required in order to deliver these products more economically and on a more timely basis. This requires a continuous effort to facilitate transition from advanced technology into the profession and of advanced products into the marketplace.
3. The study of sectors serving society and the development of systems.
Activities concentrating on the use of technology in the provision of services to society require the interlocking of technological opportunities with societal needs as well as with constraints imposed by social acceptance, and economic and political feasibility.

The thrust of the engineering profession as usually understood has concentrated on the first two of these classes of activities. During recent years, however, this thrust has begun to expand to include consideration of the role which technical solutions play in the various functions required by society. Specific sectors of human endeavor have developed over the ages to meet society's needs. The development of these sectors, from a historical point of view, began with the need to provide food and shelter. In today's society, which has become so strongly dependent on the use of science and technology, the number of sectors has increased greatly. Examples of some sectors with which society interacts today are: 1) the energy sector, which provides the various forms of energy society utilizes; 2) the food sector, which produces the various forms of food; 3) the materials sector, which provides the wide spectrum of materials on which our society now depends; 4) the manufacturing sector, which is coupled strongly to the materials sector and provides process engineering for the delivery of materials (metals, plastics, concrete, fuels, chemicals, and so forth) and the manufacturing of goods (parts, machinery, household appliances, and so forth);

5) the transportation sector, which provides the means to meet the transportation needs of individuals as well as the transport of raw materials, manufactured goods, and food; 6) the construction sector, which provides the wide spectrum of constructed facilities such as industrial plants, housing, and public works; 7) the education sector, which provides the spectrum from primary to advanced education and which must address the need for continuing education; and 8) the health care sector, which provides the spectrum of services from preventive medicine and public health to the treatment of disease and rehabilitation.

These sectors, which in large measure depend upon each other, provide the link between the application of science and technology and society's needs. Their development is influenced by what science and technology can offer and by the aspirations and values -- such as quality of life, economic development, preservations of resources -- which society adopts. An understanding of these sectors and their interrelation is a crucial base in the search for "responsible uses of science and technology." The process of technology assessment, the development of policies, and the execution of broad-scale planning must build on this base.

Problem solving in the context of these sectors and the design of possible solutions clearly requires going beyond the issues of scientific and technical feasibility. It must and does include consideration of the extent to which real needs are met, the impact of such solutions on the social and natural environment, and the steps necessary to bring about feasible solutions.

It is important to recognize this broadened perspective in the engineering approach to the development of solutions, since it implies that a rapidly extending base is to be used in the practice of engineering. Therefore, substantial, broadening changes are required in the engineering profession and in engineering education. The development of the research and educational programs of the School must be seen against this background and in this perspective.

Educational Programs

Trends

During the past year, several particularly noteworthy trends in the School's educational programs have developed. They include: an increase in the attractiveness of the cooperative work-study programs of several departments; a new School-wide program introducing students to the "innovation" process; increasing faculty and student interest in the interface of law with the utilization of technology, particularly in the Departments of Civil Engineering, Ocean Engineering, and Aeronautics and Astronautics; and an increasing interest on the part of engineering students in management. This last trend is indicated clearly by the number of engineering students who take management subjects as electives or who supplement their engineering education with study leading to a subsequent degree in management, and by an increasing number of engineering subjects which cover individual sectors of technology, including the associated management aspects of problems. Examples of such subjects are found in transportation economics, construction management, and nuclear fuel management.

In addition, systematic efforts continue in the resynthesis of broader fields in order to develop areas which span the disciplinary bases of individual departments. This will provide educational programs which are more effective, as illustrated by the School's present efforts in the fields of materials science and engineering, computer science, bioengineering, acoustics, and systems engineering.

Undergraduate Education

Undergraduate enrollment in the School of Engineering for 1973-74 was 1,268 (second, third, and fourth-year students) -- an increase of 100 over that of 1972-73. Thus, 44 percent of those M. I. T. undergraduates who had elected departments were in the School of Engineering. The School found it particularly gratifying that the number of second-year students pursuing engineering degrees during the 1973-74 academic year was the highest in the past seven years.

The number of women enrolled in the School's undergraduate programs rose to 92 (7.2 percent) for the 1973-74 academic year. This represents an increase of 39 percent over the enrollment for 1972-73, as compared with an increase of 32 percent for the previous year. A review of the enrollment data for women in the School for the past six years indicates a growth of 22 percent compounded annually.

With regard to ethnic minorities (U. S. citizens of black, Spanish, or Asian ancestry) in the School, enrollment has reached 123 undergraduates, approximately 10 percent of the School's undergraduate population. Foreign undergraduate students totaled 192 (15 percent) for the past year.

This past year also saw the return to a "seller's" market for engineers -- demand for engineers exceeded the supply of engineering graduates. Some of the School's graduates had as many as 20 job interviews and received as many as eight job offers. Nationwide, the pattern of demand outstripping supply is predicted to continue through at least 1978. By that time, undergraduate degrees will have decreased from the 42,000 degrees awarded nationwide in 1973-74 to approximately 34,500. Thus, the national aggregate of engineering schools is experiencing, and will continue to experience, a period of excess capacity. This is not the case at the Institute, where the undergraduate engineering enrollment did not decrease to any substantial degree and actually began to increase significantly last year.

After 1978, the number of engineers produced each year is expected to increase. This will result from high-school students, who now see a high demand for engineers, electing to study engineering in college.

During the past year, many engineering faculty members expressed concern over the School's opportunities to interact with first-year students. This concern arose because the School offers only one undergraduate subject which satisfies the Institute's first-year requirements, 3.091 Introduction to Solid-State Chemistry, which is one of the alternatives for satisfying the Chemistry/Biology Requirement. During the past year's first term, 308 first-year students enrolled in this subject. The second term's enrollment was 48.

In response to faculty concern, the School made special efforts to provide subjects which would familiarize first-year students with a full spectrum of the challenge of engineering as well as with engineering efforts. The results of these efforts were significant: first-year student registrations in subjects other than 3.091 offered by the School numbered 426 for the first term and 720 for the second. Thus, the total number of subject registrations by first-year students in engineering exceeded the number of first-year students. Introductory computer subjects accounted for nearly one-half of the second-term registrations; another 20 percent were in introductory electronics subjects; and the remainder of the students were distributed over approximately 50 additional subjects.

In addition to registration in the School's regular subjects, 166 first-year students also enrolled in undergraduate seminars (46 percent of total registrants) offered by the School's faculty, and nine first-year students enrolled in the Undergraduate Research Opportunities

Program (24 percent of first-year registrants) with School of Engineering supervisors. While these figures indicate a degree of success in contacting first-year students, the School is planning more effective and concerted efforts in the future.

In last year's report, the Dean of Engineering indicated that one of the educational highlights of the year was the work of Professor J. Herbert Hollomon's Task Force on Engineering Education. This task force consisted of: faculty and staff members from the School of Engineering at M. I. T. ; engineering faculty from three other universities; and representatives of industry. Its completed study was published under the title "Engineering Education: System Response to a Changing World" during the 1973-74 academic year. The study analyzes the nature and causes of changes in engineering education in the United States since World War II, and recommends changes in the educational system which will be necessary in order to meet the anticipated needs of society in the near future. The National Science Foundation has made funds available for its nationwide distribution.

The task force's report draws particular attention to the tremendous impact which research support policies of the Federal government have had on the style and content of engineering education since World War II. It argues that these policies and their related public perception of needs led to an undue emphasis on the science and analysis aspects of engineering at the expense of engineering design. It further argues that design in its broadest sense is really the essence of engineering, and is clearly the element which distinguishes engineering from science.

The report then makes several recommendations which the School of Engineering is in the process of implementing. Among the most important are:

1. Educational experience in design should be provided as early as possible for the student and should be available as an integrated part of the engineering program.
2. Clinical experience should be provided as a significant and integral part of engineering education.

It is interesting to note that students in the School of Engineering at M. I. T. appear to have reached similar conclusions independently of the report. Student interest has grown rapidly in subjects which have a design orientation, which provide tactile experiences, or which involve work in industry. Of particular note in this respect have been: 1) the increased enrollment in the design subjects offered by the Department of Mechanical Engineering; 2) the student interest shown in opportunities for invention and entrepreneurial activities which are being provided by the Innovation Program; 3) the continued use of the January Independent Activities Period by students to obtain training in areas such as machine shop, drafting, surveying, glassblowing, and so forth, which presently are not represented in the regular subject offerings of the Institute; and 4) a renewed interest in cooperative education.

The School currently is examining ways to provide further support for design and project-type work as an integral part of the engineering education for larger numbers of students, and expects to broaden the availability of cooperative opportunities within the next year.

The preceding discussion indicates the School's desire to supplement the engineering/science based education with a stronger emphasis on exposure to the realities of engineering practice as well as the utilization of its engineering/science base. This objective is consistent with the view that the School's research activities should be in both the area of applications and in the continued development of the engineering/science base. Just as the School is not organized optimally for the multi-disciplinary needs of research in the functional applications areas, there are also organizational difficulties imposed by these new

educational objectives. Present departmental structures and reward systems, plus the past two decades of emphasis on the engineering/science base, have created a climate which makes the incorporation of multi-disciplinary applications oriented activities into the educational process difficult. This difficulty is compounded by the fact that, as the task force's report correctly notes, all changes in the educational program must be effected during a period of limited or zero growth in resources. Thus, the School's new educational objectives must be achieved for the most part with its present faculty. In order to deal with this constraint, the School is encouraging its faculty to develop closer interactions with industry and to spend their sabbatical leaves in industry, as well as supporting the institution of the faculty position of adjunct professor. Through this new position, distinguished individuals from industry, heretofore not part of the educational process, would be brought on campus to interact with M. I. T. students.

To facilitate the development of the School's educational programs, Professor Frank E. Perkins of the Department of Civil Engineering was named, early in the 1973-74 academic year, special assistant to the Dean of Engineering with responsibility for this area. As a special assistant to the dean, Professor Perkins: 1) provides a focal point for the development of new programs and for the guidance of School of Engineering students; 2) encourages joint teaching efforts in subjects where two or more departments have common interests; 3) develops new undergraduate programs having a School-wide rather than a departmental emphasis; 4) strengthens interactions and cooperation with other Schools at M. I. T., especially the School of Humanities and Social Science; and 5) strengthens the role played by the School of Engineering in the education of first-year students.

Graduate Education

The School's graduate educational program continued vigorously during the 1973-74 academic year. The enrollment remained essentially constant (1,556 students, compared with 1,531 for 1972-73). Thus, 46.3 percent of M. I. T.'s graduate student body were pursuing graduate engineering degrees. While 216 (14 percent) of these students were self-supporting, the remainder received support from a number of different sources.

1. 636 (41 percent) were research assistants.
2. 238 (15 percent) were teaching assistants or instructors.
3. 52 (3 percent) were M. I. T. fellows.
4. 75 (5 percent) were National Science Foundation fellows or trainees.
5. 102 (7 percent) received support from other United States government agencies.
6. 101 (7 percent) received support from American industry.
7. 136 (9 percent) received support from other miscellaneous sources.

M. I. T. continues to have a substantial number of foreign students enrolled in its Graduate School. This is also true for the School of Engineering, where the number of foreign students enrolled for the 1973-74 academic year was 495, or 32 percent of the School's total graduate enrollment. The number of women graduate students in engineering has increased to 66. Likewise, the number of minority students in engineering graduate programs increased to 136 for 1973-74.

The several graduate educational programs are coupled closely with research areas reported by the departments and therefore are not discussed here. Attention is called to the

interdepartmental programs such as biomedical engineering, environmental studies, instrumentation, operations research, and materials, as well as to other opportunities which exist through numerous interdisciplinary centers and ad hoc groups, and as the result of individual student initiatives. Examples of these programs are included in the section on research which follows.

Special Educational Programs

Continuing education programs of the School were maintained under the auspices of the Center for Advanced Engineering Study. This year saw an increase (from 31 in 1972-73 to 54) in the number of organizations using the Center's self-study materials and an increase from 1,550 to 2,089 in the number of students taking self-study subjects. There were 36 C. A. E. S. Fellows on the campus during the year, involved in either the Advanced Engineering Study Program or the Federally sponsored Education for Public Management Program. Next year (1974-75) the enrollment in the Center's on-campus programs is expected to exceed 60. Further details on the Center's activities are found in its section of this report.

During the 1973 Summer Session, 45 special summer programs were offered at the Institute. Twenty-four of these programs with 927 registrants (out of a total of 1,559 for the Institute) were presented by faculty of the School of Engineering. The School's faculty also participated actively in the symposia sponsored by the Industrial Liaison Program. Seven of the 12 symposia presented in the past year were conducted by faculty members from the School of Engineering.

International Educational Activities

Faculty members from the School continue to participate in a wide range of activities relating to educational programs abroad. For example, one group of faculty members has been advising on the development of a technical university in Iran; another group has been exploring, in association with a group of M. I. T. alumni from Spain, the possibility of the establishment of a new technical university in that country; others have participated in the continuing exchange program with the Technical University of Berlin; and C. A. E. S. self-study programs are marketed now in Japan.

Research

The key to the strength of the School's graduate programs is research performed by its faculty and students. This research is supported by research contracts from government agencies, grants from foundations, and the combination of grants and research contracts from industry.

The research volume of the School of Engineering has been increasing steadily and is expected to exceed \$18 million for the 1973-74 year, compared with \$15.9 million for the preceding year. The faculty's research to advance the engineering sciences and to develop advanced technology continues vigorously. Also, the broadening scope of faculty efforts has led to a significantly broadened spectrum of research support. In both these types of research, there has been a turn to group projects in which a group of faculty have proposed jointly a coordinated attack on either an engineering science or advanced technology problem area, such as magnetohydrodynamic technology, enzyme technology, or fusion technology, or an area where technology and society meet, such as the impact of offshore oil and gas wells on the coastal environment or the study of increasing life-cycle service productivity for home appliances.

The School's research activities in engineering science and advanced technology have been discussed in previous reports, and they are discussed in the individual reports of the School's

departments. It therefore seems appropriate to turn to some of the broader research activities within the school.

Technology and Public Service

Studies relating technology to public services are increasing both in number and diversity. These studies are related to specific problem areas where clarifications and perspectives are needed urgently. In order to be effective, they must be completed under significant time constraints, and they require special, strong commitments by the participating faculty members. Such studies offer a unique opportunity to participating students by giving them a "clinical experience." The investigation of the impact on the New England environment of oil and natural gas discoveries off George's Bank is an example of such a study. It ranged from the impact on the coastal environment to the impact on the economic development of New England, and was performed in 13 months by a task force consisting of seven faculty members and seven participating students. An extension to other locations on the continental shelf was carried out at the request of the President's Council on Environmental Quality, which used the results in formulating its recommendations on oil explorations and drilling on the Atlantic and Alaskan continental shelves. This latest study by the M. I. T. task force concentrated on the simulation of hypothetical offshore petroleum developments (oil and gas), including the exploration, drilling, and delivery of oil and gas to the shore and the related impact and economics. Oil spill statistics for exploration as well as development of the fields and the transport of oil and gas were analyzed. Trajectory studies which relate the effect of an oil spill to the shoreline were used to select possible terminal sites.

Another example of such activity is the Center for Policy Alternatives' (C. P. A.) one-year study to provide perspectives for establishing long-range development strategies for the Sahel-Sudano region of Africa. It was performed for the United Nations and the United States Department of State's Agency for International Development. It pulled together massive quantities of background information, and correlated and analyzed this data in order to develop a functional understanding of the interrelation of climate, land utilization, social patterns, and habits of the population of this region. The Center's report and recommendations will become available in the fall of 1974.

A third example is the study conducted by the C. P. A. with the Charles Stark Draper Laboratory, Inc., of consumer durable products. Commissioned by the National Science Foundation's Research Applied to National Needs (RANN) program, its major purpose was to "examine alternatives for increasing appliance service productivity in the context of what the consumer pays for a product during its usable life." The study concentrated specifically on the color television and refrigerator industries, which rank first and third respectively in terms of aggregate annual expenditures by United States consumers for purchase, service, and electricity. However, its implications are applicable to the entire range of consumer appliances.

The resulting M. I. T. report, the sole purpose of which was to provide a new analysis of the system for maintaining and servicing major home appliances and electronics products, concluded that while the industry has provided the public with more reliable products at less acquisition cost, neither it nor the public is properly concerned with total costs. The study makes 11 recommendations for action by consumers, manufacturers, and the government to deal with the deficiencies and lack of information.

A fourth example is a project conducted in the Urban Systems Laboratory for the Federal Highway Administration, concerned with the development of transportation planning guidelines for the consideration of environmental factors. The purpose of this study was to provide guidelines to highway departments, Federal Highway Administration field offices, state and local officials, and other interested parties, on the processes to be followed by

state highway agencies to assure: 1) that possible beneficial and adverse economic, social, and environmental effects relating to any proposed project on any Federal-aid system have been considered fully in developing such projects; 2) that the final decisions on the project are made in the best overall public interest; and 3) that consideration of these effects is integrated effectively with the planning process.

Further examples include a study on the perspective of engineering manpower needs in the United States, which identified an increasing demand for engineers during the next decade and provided a base for Federal planning as well as for planning in schools of engineering. Another is a study on occupational health and safety which was completed with support from the Ford Foundation and which resulted in the request for and support of a broader effort by the Council for Environmental Quality.

Other research projects address specific facets of technology as they relate to societal needs. Such projects include exploration of a second generation of the "Dial-A-Bus" concept, increasing activities in bioengineering -- particularly those directed toward an improvement in health care -- studies to adapt technology to the needs of developing countries, and a Sea Grant Program of technology transfer to those sectors of United States industry concerned with a greater utilization of the oceans.

Relations with Industry

The School of Engineering always has maintained many ties with industry. Now it seeks an even closer interaction. The cooperative program of the School is growing and attracts the interest of an increasingly larger number of engineering students. Special areas of research in the energy field presently are sponsored by the utilities, either directly or through the Electric Power Research Institute. These studies include research using a physical model of power systems; specific technical problems of electric power transmission; exploration of superconducting generators; management of the construction of nuclear power plants; waste heat disposal; and reactor safety. Other broader areas concern the disposal of nuclear waste; the disposal -- or utilization -- of waste heat; research on fossil fuels; and advanced power technology.

Areas of particular interest are research on the generation of pollutants from combustion engines, related policy for pollution control, and industrial efforts to meet pollution control requirements. This research must consider the issues surrounding energy supply and demand, and the engineering problems associated with the implementation of environmental controls by industry.

The foundations have been laid for a major industry related program exploring the future of parts manufacturing. This program will consider the development of manufacturing techniques, the use of the newest computer technology, and at the same time, the social impacts on the worker. In order to gain the perspectives rapidly, a working conference was held in which representatives from United States and foreign industries as well as the Federal government participated.

The School has found that special conferences are particularly effective in establishing interaction among universities, industry, and government. Examples of conferences held during the 1973-74 academic year were the Conference on Manufacturing Technology and Productivity, held in the fall of 1973 with sponsorship by the Center for Policy Alternatives, the Center for Advanced Engineering Study, and the Industrial Liaison Program; the Conference on Energy Conservation and Recycling in the Aluminum Industry, held in June, 1974, sponsored by M. I. T. and the U. S. Bureau of Mines; and the Tenth Symposium on Naval Hydrodynamics, also held in June, 1974, with sponsorship by the Office of Naval Research and the U. S. Coast

Guard in cooperation with the Department of Ocean Engineering.

A new mode of cooperation between M. I. T. and industry was initiated this past year with the help of the National Science Foundation's Project RANN, in a research program concentrating on the manufacturing of parts from polymeric material. This program is supported in part with annual grants from an increasing number of industrial companies. Operating out of the Department of Mechanical Engineering, it concentrates on a spectrum of problems common to its supporting industries and reports its research results on a regular basis to the participating companies and in professional publications.

Faculty

The faculty of the School of Engineering shrank slightly to a total of 325 faculty members, compared to 335 for the 1972-73 academic year. This decrease continues to reflect budgetary pressures and also, this past year, the effect of several senior faculty members' electing early retirement. Although the size of the School's faculty is now 11 percent smaller than at its peak in 1969-70, the wide range of new research efforts which the faculty has launched, the increase in research volume, and the increasing number of students electing to study engineering clearly demonstrate its exceptional calibre and vitality.

At the beginning of the second term of the past academic year, Professor Louis D. Smullin, Head of the Department of Electrical Engineering for seven and one-half years, returned to teaching and research. Professors Mildred S. Dresselhaus and Robert M. Fano, who had served as associate department heads with Professor Smullin, also returned to their regular faculty activities. Professor Wilbur B. Davenport, Jr. became the new head of the Department, and Professors Paul L. Penfield and Fernando J. Corbato became his new associate department heads.

Professor Ascher H. Shapiro, Head of the Department of Mechanical Engineering for nine years, returned to his teaching and research in biomedical fluid mechanics at the academic year's end. Professor Herbert H. Richardson became head of that Department beginning July 1, 1974.

The School of Engineering was honored particularly this past spring with the election of Professors Ascher H. Shapiro, Mildred S. Dresselhaus, and Donald R. F. Harleman to membership in the National Academy of Engineering. In addition, Professors Emeriti Hoyt C. Hottel and Carl Richard Sodeberg and Lecturer Richard H. Battin also were elected to membership in this Academy. A third Professor Emeritus, Walter G. Whitman, was elected to Academy membership, but died shortly after the elections and before their announcement. Of the total of 506 members who now make up the Academy, 34 are M. I. T. faculty, staff, or Corporation members, and another 82 are M. I. T. alumni.

Numerous other honors and awards received by the faculty are reported by the several departments.

ALFRED H. KEIL

Department of Aeronautics and Astronautics

Departmental activities remained at about the same level as in the previous year. Twenty sophomores elected Course XVI, as compared to 24 in 1972-73 and 12 in each of the previous two years. Graduate student enrollment in the fall was 138, compared to 150 the previous year. Sponsored research support obtained as a result of the efforts of the Department's faculty was higher than in the previous year. However, much of this research currently is being conducted through the interdepartmental laboratories, and therefore that portion listed under the Department was only five percent higher than in the previous

year.

The drop in graduate enrollment was expected, in view of the nationwide reduction in undergraduates electing aerospace engineering, although the drop was much less than this nationwide reduction. This matter is of serious concern because of the increasing demand for aerospace engineers, not only from the aerospace industry but from other areas requiring competence in the high technology characteristic of this field. The Department's graduates continue to find professional positions without any difficulty, and the demand is far greater than the supply. It is hoped that the increasing interest in aerospace activities and the broad training in high technology which a student receives in aerospace studies will reverse the trend throughout the nation and will increase the number of students entering this important and challenging field of engineering.

In the area of undergraduate education, the new subject 16.001-16.004 Unified Engineering was presented this year for the first time and was received enthusiastically both by the students and the faculty involved. The purpose of this subject is to restructure the sophomore year so that the separate disciplines of dynamics, thermodynamics, solid mechanics, and aerodynamics are related to each other through a unified teaching program and related in turn to applications; thus these disciplines will not be learned solely in the abstract, but also as they relate to engineering. Some hands-on experiments were included to remind the student that reality is only approximately included in models. The subject was taught by Professors Eugene E. Covert, Jack L. Kerrebrock, and James W. Mar. After a careful review by the Undergraduate Committee and the Department's faculty, it was voted to accept this new sophomore study program on a trial basis for a period of five years.

This year the Department's Undergraduate Committee has searched actively for ways in which the opportunities of aerospace could be presented more clearly to high-school students and entering freshmen. In a cooperative effort with the Aerospace Department of Boston University and the Massachusetts Aviation Educational Council (a part of the Massachusetts State Education Commission), a workshop was conducted on career development for invited guidance counselors from high schools in eastern Massachusetts. This activity is an important first step in helping to stimulate the interest of secondary students in engineering as a viable and valuable career. Also, a group has been formed to provide additional career development material for high-school students, freshmen, and undesignated sophomores. A booklet entitled "Careers in Aeronautics and Astronautics" has been prepared for this purpose. The Student American Institute of Aeronautics and Astronautics (AIAA) Chapter also has provided much valued assistance in communicating with freshmen and others who may have an interest in aerospace.

Turning to the Graduate School, the downward trend in graduate enrollment is correlated closely with the number of research assistantships available, which, despite growing research support, has been reduced drastically by inflationary pressures. A reluctance to increase the percentage of foreign students much above 40 percent also limits the number of applicants accepted. Applications for admission for September, 1974, are up approximately 15 percent. The number of qualified United States applicants, however, probably will not be sufficient to fill the available research support, and the Department therefore has offered support to several students in other departments who will not appear on the Departmental roll. One downward trend was reversed this year when, after four years of decline, the number of special graduate students registered in the Department increased.

The Department continued to receive important support in the form of research fellowships from the Draper Laboratory, and personal relations between the Department's faculty and the Laboratory staff continued to be close. The Department's active participation in the School-wide and Institute-wide interdisciplinary programs continued at a high level, particularly in the areas of transportation, energy, and in the Socio-Technological Innovations

Seminar organized by Professor Yao T. Li for the purpose of introducing students to the more creative and innovative aspects of engineering. This program will be entering its second year of operation with a wide selection of students from throughout the Institute. The program is physically located in, and shares the laboratory facilities of, the Department.

Departmental teaching and research activities are interrelated closely, and may be illustrated best by the following brief descriptions of the activities of the various divisions of instruction.

Systems Division

This Division is concerned with the integration of the basic Departmental disciplines and their application to the design and analysis of operating systems. Activities center primarily in the area of space systems engineering and in air transportation systems, with the former effort concentrated on one senior and one graduate design subject in which a single topic is selected for intensive development by the class as a whole. This year a comparative study was made of various proposed space based energy systems.

Air transportation activity was concentrated in the Flight Transportation Laboratory, which cooperates closely with the Center for Transportation Studies. The development of new curricula resulted in the teaching of two new subjects on statistics, offered as part of the Center for Advanced Engineering Study (C. A. E. S.) program. In the area of research, the Laboratory organized for the third successive year a summer workshop for the National Aeronautics and Space Administration (NASA), the topic of which was "Air Service to Small Communities." It was held at Aspen, Colorado, in August, 1973, attracted over 300 attendees, and resulted in a final report which received favorable comment from many reviewers. Under a grant-in-aid, two members of the Laboratory visited Ethiopia and Sudan to review air transportation in developing countries and to advise on future policies. The Laboratory has developed several computer programs which were found to be valuable to industry and the airlines, particularly in looking at the impact of fuel restriction on airline schedules. Work using the cockpit simulator on the situation display as a means of improving traffic control continued. On the same topic, the use of Omega low-frequency navigation by general aviation is being investigated in a 50-hour flying program to obtain data on signal strength accuracy, reliability, and coverage of this system as it becomes operational.

The Laboratory also continued to be active in studying basic transportation problems, with particular emphasis on the potential of air in the very-short-haul areas as part of a total transportation system. Noise trade-off design studies continued on various Vertical Take-off and Landing (VTOL) and Short Takeoff and Landing (STOL) transport configurations.

Energy Conversion and Propulsion

This Division assumes responsibility for teaching and research on the general topic of thermal energy and conversion. The shift in emphasis from space related activities toward aircraft propulsion and ground based power continued. This trend is in keeping with the national effort to improve energy technology and may be expected to last at least several years. As a result of its involvement with gas turbines, fusion plasma physics, and magnetohydrodynamic (MHD) power generation, the Division has a considerable amount of responsibility for the supervision of students' theses from other departments, particularly the Departments of Nuclear Engineering, Physics, and Mechanical Engineering. Research programs also cut across departments both in the interdisciplinary magnetohydrodynamic program and in gas turbine research. In the former, the previous assessment effort has shifted more toward research at M. I. T. in anticipation of a cooperative program with MHD workers in the USSR. The Gas Turbine Laboratory has initiated a

program to study the structural integrity of gas turbines. Aerodynamic studies included using gas fluorescence of the mixing processes in swirling and linear shear flows suitable for gas turbine combustors; work on the behavior of general small disturbance fields generated by blade rows in strongly swirling flows; and investigation of the flow field of a large transonic compressor rotor, including numerical calculation of the inviscid flow. Also, and for the first time, techniques for studying three-dimensional effects in compressors have been extended to high loading, whereas only small-perturbation theory was possible previously.

Research continued on the following: the three-dimensional boundary layer behavior in turbines with account for thermal effects; the theoretical and experimental investigations of cooling effectiveness in subsonic flows with and without crosswise injection; and heat transfer studies of a turbine shroud and nozzle-end walls as influenced by unsteady flows, secondary flows, and centrifugal forces. Different designs of transonic bladings are being tested with and without film cooling.

In the area of noise, studies were conducted of upstream and downstream emission of higher-order acoustic modes into a moving fluid in a duct, of screech from sharp-edged orifice plates, and of sound attenuation by various duct liner configurations.

Experimental and theoretical studies are being conducted on a magnetohydrodynamic (MHD) disc generator with swirl as a nearly electrode-less device which may equal the MHD linear generator in performance. Work also is being done on the effects of combustion processes and seed injection on the effective electrical properties and performance of MHD generators. Studies also continued on a two-phase electrofluiddynamic (EFD) generator suitable for space power generation, on the physical processes in a single-cavity laser based on excitation of CO₂ in a nonequilibrium MHD generator, and on modeling of the nonequilibrium MHD generator with emphasis on detailed explanation of its behavior.

Mechanics and Physics of Fluids

Teaching activities in this Division were concerned mainly with helping in and adjusting to the introduction of the Unified Engineering core curriculum. The Department will continue to offer an introductory subject in fluid dynamics, since this topic attracts a number of students from other departments and satisfies their departmental requirements. This year saw the introduction of an Institute-wide seminar in fluid mechanics, which met weekly, drawing audiences of 40-100 students and faculty and covering a range of subjects focusing on (but not restricted to) instability, transition, turbulence, and viscous and inviscid fluid interaction problems.

Research has continued on gas surface interaction in two areas: one dealing with the reaction mechanism and reaction rate of oxygen beams on graphite surfaces, and the other dealing with the interaction of various gas beams with ice surfaces. The latter program is motivated by an attempt to understand the formation of ice crystals in the upper atmosphere, not only in order to provide a better understanding of atmospheric physics, but also in view of the potential problems introduced by high-flying aircraft. In the area of supersonic research, the plasma-wake simulator studies continued in an attempt to map the electron density and Mach number distribution in the ionized supersonic near-wake. The magnetic balance system also was used to study aerodynamic forces on rotating bodies and wake flows. Research continued, jointly with members of the Department of Mathematics, on the instabilities of rotating flows. An attempt also was made to understand the mechanism of turbulent flow and the means whereby certain fluid additives lead to reduction in friction drag. With such knowledge, control of turbulent structure and intensity may become an engineering possibility with many potential aeronautical applications.

Work also continued on an experimental study of active aerodynamic methods to accelerate aircraft wake dissipation and on the study of the fundamental fluid dynamics of flows with concentrated vorticity, stability of aircraft wakes and vortex rings, and the motion of vorticity in a nonuniform atmosphere. A program was initiated to study the aerodynamics of bird flight as a means of better understanding human flight. Experimental studies of the unsteady aerodynamic mechanisms and noise radiated by helicopters in forward flight continued.

Structures, Materials, and Aero-Elasticity

This Division continues its wide offerings in the subjects of finite element analysis, shell theory, structural dynamics, aero-elasticity, fatigue, and design with advanced composites. New areas of endeavor concern mathematical analysis of structural reliability and structural safety under severe transient loading conditions; these are of particular interest in designing to cope with aircraft engine rotor burst fragments and nuclear power plant failures. In the latter area, the Department is attempting to offer its expertise as an aid in the structural design of nuclear reactors, although it is limited severely in this area by reduction in faculty size. Work also continued on the following: the effects of dynamic stall on the response and air loading of helicopter rotor blades; the problem of blade vortex interaction, both analytically and experimentally; and on the problems of loads on buildings in the presence of high winds.

Instrumentation, Guidance, and Control

As usual, this Division served the largest percentage of graduate students in the Department, although the percentage has dropped from 41 percent in the previous year to 33 percent this year. Consistent with this fraction, the faculty has been reduced and several subjects have been dropped. A new subject has been added on computers in mass production systems. The Division continued to teach subjects in navigation systems, which hopefully may find a broader application than air navigation alone. An educational venture of somewhat new form also is being proposed by the Division. A two-year educational experience is to be provided for a group of 15 engineers from the Republic of China, as a means of increasing their competence in order to allow them to undertake engineering activities at a high technological level on their return to Taiwan. Research activities of the Division continue to be conducted, as before, in the Charles Stark Draper Laboratory, which supports the largest single group of graduate students in the Department. Divestment has had little effect on the Laboratory's close relationships with the Department.

The Man-Vehicle Laboratory is involved primarily in the problem of human spatial orientation and its related aerospace and medical implication. Work has continued on attempts to uncover the physiological basis for some of the orientation phenomena which have been modeled mathematically and on further studies of the process of human visual motion perception viewed from the theoretical as well as the applied perspective. Members of this Division are involved actively in the Harvard-M. I. T. Program in Health Sciences and Technology and in interdepartmental biomedical engineering activities.

The Measurement Systems Laboratory has experienced a reduced level of activity, but has continued work on: 1) a system for identification of hazardous vortex conditions near an airport; 2) the definition of features of aircraft trailing vortices; 3) digital autopilots; 4) the proposed experiment comparing ratios of inert to gravitational mass for different substances conducted in earth orbit; and 5) a gust-alleviation technique for light aircraft.

The Laser Technology Laboratory remained a center of activity for students interested in laser applications. Research continued on holographic techniques and on achieving high resolution using dye lasers. A resolution of 8 parts in 10^{10} is believed to be the highest

yet achieved with a tunable laser. A long-term stability of 6 parts in 10^{13} also is believed to be the highest achieved.

Miscellaneous Activities

Professor Renwick E. Curry took a leave of absence to conduct experiments on human spatial orientation at NASA's Ames Laboratory. Professor Louis L. Bucciarelli, Jr. remained on leave of absence in Washington, D. C., formulating the development of the Air Science Museum for the Smithsonian Institute. Professor Wallace E. Vander Velde served as chairman of the Graduate Committee and as Graduate Registration Officer. Professor Covert served as chairman of the Undergraduate Committee. Professor Albert Solbes chaired the doctoral degree program. Professor Henry P. Whitaker continued to supervise the engineer's degree program and served as chairman of the Freshman Orientation Committee. Professors John F. McCarthy and Winston R. Markey served as chairmen of the Department's general seminars, organizing a distinguished panel of some 20 speakers. Professor Elmer E. Larrabee supervised the conduct of the Experimental Projects Laboratory. The Department welcomed Professor Wesley L. Harris, who received a joint appointment with the Department of Ocean Engineering. Professor Shaoul Ezekiel was granted tenure.

Professor Sheila E. Widnall received a Carnegie Foundation Fellowship. Professors Theodore H-H. Pian and Pin Tong received the second prize in the von Karman Memorial Contest for outstanding contributions to aerospace structural material technology.

The M. I. T. "Burd" human powered aircraft program continues, after a mishap in which structural failure of a rear wing spar caused major damage during a taxi run. The aircraft is expected to be repaired and in flight at the end of this year in an attempt to win the Cramer competition. A prize of 50,000 pounds has been offered for the first human powered aircraft to complete a figure-eight course of one mile length.

RENE MILLER

Department of Chemical Engineering

The Department made substantial progress during the 1973-74 academic year on updating its undergraduate and graduate programs, recruiting new faculty, expanding research, and completing the fund raising for a new chemical engineering building. Progress in each of these areas will be summarized.

Undergraduate Program

The faculty approved changes in the undergraduate curriculum which were intended to make the introductory subjects more appealing and to avoid duplication of material covered in subjects offered by the Department of Chemistry. A new two-term sequence of sophomore-level subjects on mass and energy processing and thermodynamics will be offered for the first time next fall, replacing three subjects previously offered by the Departments of Chemistry and Chemical Engineering. Two freshman-level subjects are being developed, 10.07 Introduction to Polymer Chemistry, which will be offered for the first time in the fall of 1974, and 10.10 Process Synthesis, which will be offered in the following spring. Freshmen who are engaged in a choice of department will be encouraged to take one or both. Undergraduate enrollment in this Department remained approximately constant at 104 students.

This year, end-of-term student and faculty evaluations were required for all subjects in the Department. Each student was given a written evaluation by his or her instructor to supplement the letter grade and to provide more feedback. The instructor was evaluated by his or her students, using a standard evaluation form. The results then were evaluated by the

Department and used to further its continuing efforts to improve the quality of its instruction.

Graduate Program

There was renewed interest in graduate work at both the master's and doctoral level. The entering graduate class in the fall of 1973 contained 67 students, the largest since 1960. Nineteen students passed the doctoral qualifying exams, the largest number since 1965.

The School of Chemical Engineering Practice, in which students spend one term working in industry under resident faculty supervision for academic credit, continues to be an important component of the graduate program in chemical engineering. Forty-one students, including two women, elected the Practice School program during the year. This was a somewhat larger group than usual and was indicative of increased interest at the graduate level in engineering applications. In addition to the M. I. T. Practice School Stations at the American Cyanamid Company plant at Bound Brook, New Jersey and at the Oak Ridge National Laboratory at Oak Ridge, Tennessee, a Cambridge Station was operated during the spring term with the help of Artisan Industries, Inc., located in Waltham, Massachusetts. Seven students who could not be accommodated at the Oak Ridge Station attended the Cambridge Station.

At the Oak Ridge Station, Practice School groups conducted several energy related projects including studies of energy resources, solar and geothermal energy collection, and controlled fusion. Studies in the biomedical area were concerned with the immobilization of cancer antigens and antibodies on polyacrylamide gels. Other projects dealt with the corrosion of metals and chemical reactor performance. At the Bound Brook Station, projects included the following studies: organic chemical synthesis and production techniques; process design and economic evaluation; environmental control of exhaust gas emission and large-scale treatment of industrial effluents; and chemical operations management and scheduling. At the Cambridge Station, studies were conducted on chemical process equipment performance; pilot plant operation for process development; and commercial process equipment design.

The Department developed a number of new graduate subjects. Professor Michael Modell developed two new subjects on wastewater treatment processes. One was designed for students from other departments pursuing the Environmental Engineer degree, and the other was intended for chemical engineering students. Professor Herman P. Meissner developed a new subject on electrochemistry in which electrochemical theory was reviewed, and applications in the electrochemical industry were explored. Lecturer Ogden H. Hammond introduced 10.96 Seminar on Batteries and Electrochemistry. Professor Robert C. Armstrong instituted a new subject in polymer fluid mechanics, 10.51 Macromolecular Hydrodynamics, which is designed to acquaint students with the techniques necessary to handle the unique problems which arise in the polymer processing industry, one in which an increasing number of chemical engineers are employed.

Professor Robert E. Cohen has set up a Polymer Science Laboratory in the Department. This new Laboratory supplements the several lecture subjects on polymers already offered. Its purpose is to acquaint students with a selection of techniques employed in the synthesis and characterization of polymeric materials. The Laboratory, offered for the first time in the spring of 1974, proved to be very popular, and plans are under way to expand the number of its experiments and to increase enrollment capacity.

The Department participated in the activities of the Innovation Center established by the School of Engineering. Interdepartmental subjects on entrepreneurship and invention were offered under the direction of Lecturer Ogden Hammond. A new subject on artificial internal

organs was presented by Professor Clark K. Colton in association with the Program in Health Sciences and Technology. A new subject, 10.79J Nuclear Chemical Engineering, was taught by Professor Manson Benedict of the Department of Nuclear Engineering.

Faculty Recruitment

Long-range plans for the Department call for expanded activities in such fields as energy technology, environmental quality, polymers and macromolecules, surface chemistry and technology, biochemical engineering, biomedical engineering, and chemical engineering systems. This will require a significant expansion in the size of the faculty. With the new building now under construction, the pace of faculty recruiting has been increased.

Joining the Department in 1973 as new assistant professors were Robert C. Armstrong and Robert E. Cohen. Professor Armstrong completed his doctoral work at the University of Wisconsin in the field of transport phenomena with a thesis on macromolecular hydrodynamics. Professor Cohen completed his doctoral work in the field of polymers at the California Institute of Technology in 1972 and spent the following year doing postdoctoral work at Oxford University. Professors Armstrong and Cohen were awarded DuPont Young Faculty grants and will be designated DuPont Assistant Professors for 1974-75.

At the senior faculty level, the Department was fortunate in having a number of outstanding visiting professors this year, including Professors Paul J. Flory of Stanford University, J. T. G. Overbeek of Utrecht, J. R. Anthony Pearson of Imperial College (London), and Paul Rempp of Strasbourg (France).

Research

The research volume in the Department for fiscal year 1974 was \$930,000, compared with \$1,026,000 for 1973; this figure was somewhat below projection. Government interest in problems of energy, environmental protection, and resource conservation has provided new opportunities for funding chemical engineering research, and it is anticipated that the volume for fiscal year 1975 will increase. In the space available, it is possible to list only some representative examples of the research being carried out in the Department.

Research in the Fuels Research Laboratory under the direction of Professors Hoyt C. Hottel, Glenn C. Williams, Adel F. Sarofim, Jack B. Howard, and Lloyd A. Clomburg, covered the fields of combustion, generation and destruction of pollutants, carbon black formation, heat transfer and mixing in glass furnaces, radiative heat transfer, fire research, coal pyrolysis and gasification, coal combustion and ash behavior in magneto-hydrodynamic combustors, and solid waste incineration.

The American Gas Association formally announced that the Department has been designated as their LNG (Liquified Natural Gas) research center under the direction of Professors Robert C. Reid, Kenneth A. Smith, and Elizabeth M. Drake.

Professor Michael Modell in collaboration with Professors Reid and Richard G. Donnelly was engaged in several projects concerning the treatment of wastewater. Professor Charles N. Satterfield has continued his research in catalysis, applied kinetics, reactor technology, and industrial chemistry.

Professor Smith has continued his research on water desalination with Professor Sarofim, and the role of drag-reducing additives in turbulent flows with Professor Edward W. Merrill and Visiting Scientist Leighton H. Peebles. Professor Johnson E. Vivian has continued his research on the absorption of sulfur dioxide and on the effect of cellular convection due to Marangoni instability on gas-liquid mass transfer. Professor Gary J. Powers' work on

chemical process system synthesis has included studies of reaction path synthesis, energy conservation strategies, process safety studies, magnetic separation, and hydrogen storage systems.

Professor James H. Porter's research on coal utilization has included studies of advanced power cycles, high-temperature desulfurization, fluidization of sticky coal with iron addition, and coal liquefaction using paper pulping solution. His work on separation processes has included studies of ideal cascades of gas permeators, electro-reverse osmosis, and the use of pressure-sensitive reaction equilibria in absorption-desorption cycles.

Professor Merrill has continued his research in the biomedical area, including studies of the use of aerosols for therapeutic applications (in collaboration with Lecturer James B. Bunnell) and the development of polymer biomaterials. His work in polymers has included studies of the reinforcement of cross-linked polyvinyl alcohol by crystallization and drag-reduction in dilute polymer solution by the Toms phenomenon.

Professor Armstrong has been studying the rheology of dilute polymer solutions by modeling the physical behavior of individual macromolecules in solution. Professor Robert E. Cohen has conducted an experimental investigation of the mechanical and rheological properties of bulk polymers and theoretical studies of polymer viscoelasticity.

Professor Herman P. Meissner has continued his studies of the activity coefficients of strong electrolytes in solution, while initiating new work with Professor Howard in the field of coal gasification and liquefaction.

Professor Ronald A. Hites has continued his research on the application of analytical chemical techniques to the solution of environmental and energy related problems. A major effort has been concerned with identification and quantification of industrial organic pollutants in the Charles, Merrimack, and Monaquot Rivers.

Professor Lawrence B. Evans has continued his work in the fields of process dynamics and control, and computer aided design. His research has focused upon the dynamics and control of a cyclic absorption system, a methanation reactor, and a biological system.

Professor Charles M. Mohr has conducted a review of basic data on retorting oil shale with the goal of building a model of the retorting process which includes both diffusion and chemical reaction effects. Another objective has been to identify and to establish priorities for missing or inadequate information.

Professor Clark K. Colton, in collaboration with Professor Kenneth A. Smith, has initiated studies related to the genesis of atherosclerosis. Professors Colton and Raymond F. Baddour have been active in a major interdepartmental program on enzyme technology and engineering.

New Chemical Engineering Building

Construction of the new chemical engineering building, which was begun in 1973, is now well under way. Funding was completed by reaching the original campaign goal. It was sought and obtained exclusively from private sources, including corporations, individuals, and foundations. The generous alumni response was most encouraging.

The highlight of this year's campaign was the decision to relocate the Fuels Research Laboratory in the new building. A foundation responded favorably to the Department's request for the additional funding required, and plans currently are being developed to include the Fuels Research Laboratory in the new building. This new facility will encompass

approximately 18,000 gross square feet, which will allow for consolidation and expansion of the Laboratory's activities.

With the current national emphasis on energy research and related areas, it is timely and necessary to consolidate and to expand the M. I. T. Department of Chemical Engineering. The completion of this new facility will make it possible to accommodate the expanded research and teaching contribution that M. I. T. should make to a national effort.

RAYMOND F. BADDOUR

Department of Civil Engineering

This has been a year of rapid growth for the Department, as national interests and priorities continue to shift toward problems of the civil sector and as the Department's interdisciplinary research and educational efforts in project management and in the environmental area have reached critical size and have become recognized increasingly outside the Institute.

Undergraduate enrollment, up seven percent over last year, now has doubled since academic year 1968-69. Graduate enrollment, constrained only by the Department's limitations on student supervision and support, increased 12 percent in the past year. Research support is becoming increasingly difficult to obtain, however, except in energy related areas; as the work of the Department becomes more contractually supported engineering and less grant supported science, it must contend with a significantly higher administrative overhead. This is being coped with through the use of a full-time professional research staff.

Research

Improving Management Methods for Implementing Power Plants Under the sponsorship of the Rochester (New York) Gas & Electric Company (RG&E), an M. I. T. team consisting of Professors Robert J. Hansen and William A. Litle, Senior Research Associate Kenneth Reinschmidt, and two graduate students has become involved in a new project relating to the development of a power plant to be located in Sterling, New York. While the M. I. T. team has no direct responsibility in the actual development of the project, it does observe, collect information, and evaluate and document items related to the overall progress and management of the project. Concurrently, the team seeks to identify opportunities for improvement in the management of the project and to suggest approaches and techniques to RG&E for possible implementation.

Teaching Tools for Project Management Sponsored internally by the Sloan Fund of M. I. T., two complementary efforts are being directed by Professor Robert D. Logcher toward teaching the issues involved in private real estate project development.

The first of these, CREAD (Competitive Real Estate Analysis and Development), is a game in which teams of students compete in a multi-region housing market in all aspects of development. This includes market analysis, land acquisition, architect/engineer design, construction, financing, and operation. Tools are provided for financial analysis and negotiation with architect/engineer firms and banks. CREAD provides a simulation of development, with capacity and market constraints to highlight competition. It is played over a series of periods. Each period has a decision-making time, when teams use the computer to study and specify actions, and a closing time, when the computer executes the decisions, which include opening land bids, designing and constructing the projects, simulating the rental market and project operations, and producing quarterly accounting reports.

The second teaching tool, REASON (Real Estate Analysis System On-line), is an interactive design tool used to study the impacts of financial and sequencing alternatives for projects. Cash flows and decisions affecting taxes can be input as separate financial streams and combined, with scaling and offsets, for analysis. Before- and after-tax cash flows, present value, and rates of return can be produced in order to study alternative actions.

These two tools will be used during the 1974-75 academic year in subjects 1.90 Introduction to Project Management and 1.94 Analysis in Real Estate Development and Construction.

Transfer and Adaptation of Technology in the Construction Industry Directed by Professor Fred Moavenzadeh, and sponsored internally through the U. S. Agency for International Development (AID) grant to M. I. T. for the adaptation of technology to developing countries, this project has as its goal the development and evaluation of a coherent body of information which can assist policy- and decision-makers in improving the efficiency and effectiveness of the indigenous construction industry and its response to those nations' needs for constructed facilities.

This information will be collected for the heavy construction segment of the industry (excluding home building) through a comprehensive literature review, the development of several abbreviated case studies, and a series of personal interviews conducted within the industry. Data collection is focusing on identifying problems and issues related to management and organization, labor, capital, technology, and research and development.

Structural Loads Analysis and Specification Another new research effort, under the direction of Professor Carl Allin Cornell, aims to develop improved probabilistic methods for describing the load experienced by buildings, and to use these methods to set forth simple but rational loading requirements for use in design. This study considers many different types of loadings: dead load, live load, wind and tornadoes, earthquakes, and so forth. Available data concerning the statistical nature of each loading is being assembled and used to formulate consistent probabilistic loading models. Computations based upon these models will be used to determine the combinations of each type of loading that should be considered in design. This study, which began during the past academic year, is sponsored by the RANN (Research Applied to National Needs) program of the National Science Foundation.

Regulation of Marine Mining and Resource Extraction in the Coastal Zone An M. I. T. -Boston University team headed by Professor Michael S. Baram, a lawyer, is working with funding from the RANN program of the National Science Foundation to develop the legal and regulatory framework for marine mining and resource extraction in the coastal zone.

The study is focusing on hard mineral resources which have been discovered in the U. S. coastal zone, the growing industrial demand and technological capability for their extraction, and the social and environmental impacts which will accompany this process. The team is reviewing the relevant laws of the coastal states as well as Federal regulations and authorities effective within the coastal zone. In subsequent stages the project will consider citizen participation, monitoring, and enforcement methods.

Professional Education for Environmental Management With the support of the United Nations Environmental Program, Professor William H. Matthews is directing a study aimed at answering such questions as: 1) What is environmental management and what roles does it include in both industrialized and developing countries? 2) What bodies of knowledge underlie the professions of environmental management? 3) Where and in what ways are environmental managers educated? 4) What new programs and/or institutions are needed to educate environmental managers?

Planning Options for the Sahel-Sudano Zone of Africa Professor William W. Seifert is leading a multi-disciplinary team which includes Professors Paul O. Roberts and David C. Major in an AID sponsored study designed to outline alternative long-range strategies for the development of the drought stricken sub-Sahara region of Africa. This project is being conducted through the School of Engineering's Center for Policy Alternatives.

Storage of Radioactive Wastes Professor T. William Lambe has begun research, for the Oak Ridge National Laboratories, on methods for sealing boreholes proposed for the safe storage of radioactive wastes.

Second Generation Dial-A-Bus Professor Nigel H. M. Wilson is working, with the support of the Urban Mass Transportation Administration of the U. S. Department of Transportation, on research to improve the Dial-A-Bus demand-responsive transit system, which is now operative in many U. S. and Canadian communities. The improvements are expected to reduce passenger waiting and travel time considerably, and will include direct communication between the customer and a dispatching computer.

Undergraduate Program

Interest in the Department's undergraduate offerings remains high. Enrollment in the degree program is now 134, which is a seven percent increase over academic year 1972-73 and is the highest since 1956. This number includes 18 women and 10 minority students. Of particular interest is the popularity of the five core subjects, in which for the second consecutive year approximately 30 percent of the students are non-civil engineers.

The experiment consisting of dividing the former twelve-unit subject 1.10 Civil Engineering Laboratory into six-unit subjects -- one in each of six separate technical areas -- has been an unqualified success. This has made the Laboratory a more significant educational experience while maintaining its attractiveness as an elective subject. The number of undergraduate laboratory units registered for this year was 726, compared to an average of 712 for subject 1.10 during the last few years.

The Undergraduate Committee continued this year under the chairmanship of Professor Moavenzadeh, and once again completed a review of the core subjects. Two matters received detailed attention from the Committee:

1. The proposal that subject 1.11 Civil Engineering Systems form the basis of a joint School of Engineering subject to be taken as an elective by undergraduates in other engineering departments. Members of the Department are concerned that this subject continue to serve the needs of civil engineering students, for whom it is a requirement.
2. The proposal for a joint undergraduate degree program with the Department of Urban Studies and Planning, prepared by Professor Ralph A. Gakenheimer. This proposal has reached the stage at which it must be deliberated by the faculties of the respective departments during the coming academic year.

Graduate Programs

During the past year, the Graduate Committee again was chaired by Professor Logcher, and has been very active in efforts to: 1) improve continuing education for the local professional community; and 2) increase tuition income at the graduate level, without increasing the thesis supervision load or the need for financial support. It has become apparent

that both of these aims would be met by a degree program which did not require a thesis, and the Committee is debating this issue.

Regular graduate student numbers are constrained by the Department's ability to supervise graduate theses (approximately four per faculty member) and to generate student support through research assistantships (approximately two per faculty member). Accompanying a modest growth in faculty size, the Department's graduate student body has risen accordingly: it now numbers 204 and includes 11 women and 13 minority students.

Graduate Student Support

These students were supported as indicated in the following table.

Funding Source	U. S. Students	Foreign Students	Total
Fellowships and traineeships			
U. S. government	11	4	
State government	2	0	
Foreign governments	0	4	
M. I. T.	5	0	
Other institutions	6	7	
Industry	<u>1</u>	<u>3</u>	
	25	18	43
Research assistantships			
U. S. government	47	31	
State government	8	3	
Foreign governments	1	0	
M. I. T.	3	4	
Industry	<u>1</u>	<u>0</u>	
	60	38	98
Teaching assistantships	19	1	20
Other			
Engineering residents	8	0	
Government employee trainees	5	0	
Self-supporting	<u>27</u>	<u>3</u>	
	40	3	43
TOTAL	144	60	204

It is interesting to note that in the 1972-73 academic year, out of 144 U. S. students, only eight were self-supported, compared with 27 for this past year.

Project Management Program

Because of its newness, the Project Management Program deserves special mention once again. In its second year of operation, the Program has 15 regular graduate students, and applications for next year are up 70 percent. Its six subjects had an average enrollment of 27 students each.

Two of the regular graduate students are involved in a two-year project management residency program leading to the master's degree. One of these is with Mills & Jones Construction Company in St. Petersburg, Florida, and the other is with the Beacon Companies in Boston. The purpose of this experiment is to couple formal academic classroom training with "laboratory" experience of project management. During the entire period, the students are enrolled at M.I.T. and are not employed by the host firms. Their residency programs are planned and overseen jointly by a key executive of the host firm and an M.I.T. faculty member.

Environmental Engineering

The Water Resources Division has a 40 percent increase in domestic applications for graduate study. This increase is concentrated largely in the area of environmental engineering. The Department has anticipated this surge of interest with a steady growth in faculty and subject offerings over the last two academic years. There are now six graduate subjects in this area, with an average enrollment of 21 students, nine of whom are from outside the Department. Four additional subjects have been planned for the next academic year.

Continuing Education

During the special Summer Session of 1973, the Department's faculty sponsored three subject offerings, each of which was well subscribed: 1) 1.21S and 1.22S Analysis and Design of Transportation Systems (Professor Wayne M. Pecknold); 2) 1.73S Case Studies in Water Resources Planning (Professor Frank E. Perkins); and 3) 1.90S Management in the Construction Industry (Professor William A. Litle). The last of these deserves special mention. It was developed during academic year 1972-73, with the support of a grant from the U. S. General Services Administration, as a cooperative effort involving faculty members from the Sloan School of Management, the Department of Architecture, and the Harvard Business School. Thirty-nine top- and middle-management executives, representing public and private owners, developers, architectural and engineering firms, general contractors, and subcontractors, attended this first program. It is being offered again during the 1974 Summer Session.

The Department's encouragement of special student enrollment continued through this past academic year. Prior to each term, information about its academic offerings was mailed to the Boston professional community and, during the fall term, four subjects were offered outside of the normal business hours. In the fall, special student enrollment was up by 200 percent to 44 students. Spring term enrollment dropped to 22, since subjects were offered only during the nine-to-five hours.

Admissions

It has been most encouraging that interest in the Department's graduate programs has been rising rapidly. This is seen most clearly in graduate admissions applications from United States students. For study beginning in September, 1974, these applications were up 13 percent over those for September, 1973, and 40 percent over September, 1972. The Department's yield on domestic acceptances has remained at 66 percent; thus its selectivity has improved considerably in recent years. This admirable record is due to the extensive personal attention given to all preliminary admissions inquiries by the Admissions Committee, under the chairmanship of Professor Jerome J. Conner, Jr.

Faculty Changes

The Department and the entire academic community at M.I.T. were saddened greatly by the death of their friend and colleague, Institute Professor Arthur T. Ippen, on April 5, 1974. He had been associated with M.I.T. for 29 years and had been personally responsible for the development of the Water Resources Division into a leading center of

education and research. His guidance and counsel will be missed sorely. Shortly before his death, Professor Ippen had been awarded the Outstanding Civilian Service Award by the Department of the Army for his contributions to the understanding of estuarine flow.

Professor Myle J. Holley, Jr., will retire this year. Professor Holley joined the Department's faculty in 1947 and has specialized in the design of reinforced concrete structures. Professor John C. Schaake will resign to accept a position with the U. S. Weather Service, as assistant director of the Hydrology Laboratory. Technical Instructor Albert J. O'Neill will retire after 31 years of service. In recent years he has had the responsibility for laboratory instruction in construction materials.

Professor Frederick J. McGarry, head of the Department's Materials Division for a decade, is transferring his administrative home to the Department of Metallurgy and Materials Science, where he will be a part of the polymer group. Professor McGarry is responsible for developing an outstanding research group in the area of composite materials. He will retain a joint appointment in this Department.

Professor Frank E. Perkins has accepted an appointment as special assistant for educational programs to the Dean of Engineering. Professor Ignacio Rodriguez-Iturbe has replaced Professor Perkins as associate head of the Department's Water Resources Division. Professor David H. Marks has succeeded Professor Richard L. de Neufville as director of the Civil Engineering Systems Laboratory.

New appointments include Professor Ralph A. Gakenheimer, who has been on the faculty of the Department of Urban Studies and Planning since 1969; he now holds a joint appointment as Associate Professor of Urban Studies and Planning and of Civil Engineering. Professor Gakenheimer will work on problems of urban transportation and will work toward the development of joint academic programs. Professor Francois M. M. Morel joined the Department following a year as a postdoctoral research fellow in environmental engineering sciences at the California Institute of Technology. He is working on the chemistry of water quality. Professor Bryan R. Pearce has been promoted from research associate and will continue his field activities related to near-shore oceanography and marine coastal processes. Professor Mohsen M. Baligh joined the Department after a year in industry, and will work in the area of theoretical soil mechanics. Three of the Department's recent graduate students have joined the faculty. Professor Moshe E. Ben-Akiva is working on the modeling of transportation demands; Professor Stamatia Frondistou-Yannas will continue her work on construction materials, including economic and management problems; and Professor Guillermo J. Vicens is helping to fill the sudden void in the area of water resource systems.

Honors and Awards

Professor Donald R. F. Harleman was elected to membership in the National Academy of Engineering, while Professor Thomas W. Lambe, also a member of the Academy, was elected to the British Institution of Civil Engineers.

For the second time, Professor Marks received the Department's annual Conspicuously Effective Teaching Award. Professor William A. Little was cited by Engineering News Record as one of the men who "made a mark" on the construction industry in 1973. Professor Matthews has been appointed as Arthur D. Little Professor of Environmental Sciences and Engineering for a term of one and one-half academic years.

Professor Morel has been named M. I. T. 's first Henry L. Doherty Professor of Ocean Utilization for a term of two years. Professor Michael S. Baram has been named vice-chairman of the American Bar Association's Environmental Law Committee. Professor

Cornell has been awarded a Guggenheim Fellowship to study structural safety during his coming sabbatical leave.

Professor Jerome J. Conner's text Fundamentals of Finite Element Techniques for Structural Engineers has been published by Butterworth. Professors Marks and de Neufville have had their book System Planning and Design: Case Studies in Modeling, Optimization and Evaluation published by Prentice-Hall. Professors Robert V. Whitman and Cornell visited Moscow as guests of the USSR Academy of Sciences in connection with the new US-USSR Earthquake Program to exchange views, information, and technology concerning seismic risk. Professors Harleman, Paul O. Roberts, Marks, Baram, and Matthews, along with Professor Peter S. Eagleson, constituted the majority of an M. I. T. team which participated in a joint conference on environmental problems and environmental engineering education at the Technical University of Berlin.

PETER S. EAGLESON

Department of Electrical Engineering

The single most noteworthy event during the past academic year has been the adoption of a new "common core" in the undergraduate curriculum -- a set of four subjects that is common to both electrical engineers and computer scientists. This ended a series of discussions extending over the past several years. Previously, there had been two almost separate curricula for Course VI-1 and Course VI-3 students, with VI-3 students required to take subjects from the VI-1 curriculum, but not vice versa. There developed a feeling among Course VI-1 faculty members that their students had insufficient exposure to computers and concepts related to computation. Simultaneously, Course VI-3 faculty members felt that several of their students were not grounded enough in traditional engineering to understand the systems in which computers are found. This could hold true especially in the future, as digital/logic central processing units (CPUs) become more pervasive. The final solution to this problem was the introduction of a set of four introductory subjects dealing with electrical networks, computer languages, computer architecture, and signal processing. It presently is required of all students in the Department, and the remainder of the two curricula build upon this set.

Faculty

After almost eight years as Department head, Professor Louis D. Smullin decided to return to teaching and research. On February 1, 1974, he was replaced as Department head by Professor Wilbur B. Davenport, Jr., previously director of the Center for Advanced Engineering Study. At the same time, the two associate Department heads, Professor Mildred S. Dresselhaus (for electrical science and engineering) and Professor Robert M. Fano (for computer science and engineering) asked to step down; they have been replaced by Professors Paul Penfield, Jr. and Fernando J. Corbato.

Promotions in the faculty include Professor Robert S. Kennedy to professor, and Professors Barry A. Blesser, Clifton G. Fonstad, and H. Steven Colburn to associate professor.

Three faculty members have received chairs during the past academic year. Professor Marvin L. Minsky was named Donner Professor of Science, and Professor Peter Elias was named Edwin Sibley Webster Professor of Electrical Engineering. At the same time, Professor Richard B. Adler was selected as Cecil H. Green Professor of Electrical Engineering. This latter chair normally is used to support faculty members temporarily, to allow them to learn a new discipline. In this case, Professor Adler wishes to apply his talents to problems in bioengineering.

The Department was saddened greatly by the deaths of two of its active members. Professor Lan Jen Chu, internationally known authority on electromagnetic fields and antennas, died on July 25, 1973. Professor Samuel J. Mason, an expert in circuit theory, feedback theory, and computer based optical character recognition systems, died on March 10, 1974.

Graduate Education

The graduate student population during the last academic year was approximately 460, not greatly changed from recent years. This figure includes approximately 30 graduate students in the cooperative program.

Outstanding teaching by graduate students was recognized by teaching awards of \$500 each to Susan Kruger (the Carleton E. Tucker Award), and Donald M. Dudley, Robert W. Freund, Daniel K. Jackson, and Jeffrey T. Millman (Supervised Investors Services Awards). These awards were announced in May, 1974, when five of the Department's graduate students were promoted to the rank of instructor, in recognition of outstanding service to the Department: Jack M. Aiello, Donna J. Brown, Richard J. Feiertag, Irene G. Greif, and Ronald LeFever.

Undergraduate Education

Electrical engineering (including computer science) continues to be the most popular major at M. I. T. During the past several years, the Department experienced a drop in enrollment. This came at a time when engineering job opportunities were reported widely to be on the decrease. However, during the past two academic years, interest in electrical engineering has rebounded, and this past year almost one-quarter of M. I. T. sophomores selected Course VI. In fact, if those sophomores who deferred course selection are disregarded, 27 percent chose Course VI, compared with figures of 22, 23, and 24 percent for the preceding three academic years. Well over half of the undergraduates in the School of Engineering are enrolled in Course VI.

A new annual award, named after the late Professor Ernst A. Guillemin, has been established to honor the author of the best undergraduate thesis. This year it was awarded to Robert M. Elkin, for his thesis entitled "An Evaluation of Computer-Assisted Display-Ads Layout in an Operating Newspaper Environment."

The cooperative program, Course VI-A, has attained new levels of popularity among students. This past year, of the 115 students who expressed interest, participating companies were able to take only 65.

Research Results

Most of the research by members of the Department of Electrical Engineering is performed in Departmental or interdepartmental laboratories. A few research results are noted briefly here. For further details, or for more complete information on research carried on by members of the faculty, the reader is referred to those portions of this report dealing with the following laboratories: the Electrical Power Systems Engineering Laboratory (E. P. S. E. L.), the Research Laboratory of Electronics (R. L. E.), Project MAC, the Artificial Intelligence Laboratory, the Energy Laboratory, the Electronic Systems Laboratory, the Operations Research Center, and the Center for Materials Science and Engineering (C. M. S. E.).

Polymeric-Semiconductor Smoke Detection Professor Stephen D. Senturia and his students have established the feasibility of the concept of a smoke detector based on the change in electrical resistivity of certain polymeric semiconductors. During the past year, several

device configurations have been investigated, and a working model based on one configuration has been made. In a series of tests, the device was shown to have a resistance change easily detectable by low-cost instrumentation when a very small amount of smoke was encountered. The expectation is that this class of materials can be used in low-cost early-warning smoke detectors and (as in the tests) can be effective for smoke levels so low that the smoke is not yet visible.

Energy-Momentum Tensor for Moving Ferromagnets Professor Frederic R. Morgenthaler has developed a more complete form for large-signal energy and momentum in ferromagnetic material. The new energy-momentum tensor, besides being consistent with the theory of special relativity, is consistent with the currently used small-signal energy conservation theorems. One interpretation of the new results involves momentum flow of an unexpected sort -- namely, that due to quantum-mechanical exchange of electrons between sites with unequal energy.

MACSYMA System for Symbolic Algebraic Manipulation Professor Joel Moses continues to lead the effort to enrich the Project MAC Symbol Manipulator (MACSYMA) system, a symbolic algebraic manipulation, adding significant new features for factoring and the determination of the greatest common divisor. The system has allowed Professor Abraham Bers to take new theoretical research approaches in the area of plasma physics. In addition, the system, which currently operates on both a DFC PDP-10 computer in Project MAC and the Multiplex Information and Computation Service (MULTICS) system on the Honeywell 6180 computer, has been used by research workers nationwide. One notable achievement has been the discovery of new solutions to classical problems in the field of special relativity.

Subsurface Probing The understanding of the propagation of electromagnetic waves through and near stratified media has been enhanced by Professor Jin A. Kong. He has employed new tools, including the symbolic computer language MACSYMA, to obtain results in cases that previously would have been too difficult to describe analytically. The results were tested by interpreting data collected on field trips to glaciers. The techniques have possible application to subsurface electromagnetic probing for a variety of purposes.

Information Theory of Data Processing Systems Professor Peter Elias has begun the application of information-theory ideas to computers. Three basic costs of maintaining a data base (storage, access, and update) can be minimized simultaneously for some simple data structures. In more complicated cases, the fundamental limits and possible trade-offs are under investigation.

Theory of Computation The Theory of Computation Group within Project MAC, involving Professors Michael J. Fischer, Frederick C. Hennie, Albert R. Meyer, and Vaughn R. Pratt, has worked in three major areas. The first of these involves the complexity of decision procedures for various logical and linguistic problems. This work has provided important new results and techniques with potential applications to many aspects of the theory of computation. The second area is concerned with the development and evaluation of algorithms for performing computational tasks of practical interest. This work is providing a better understanding of the complexity of the so-called Cook-Karp problems, and has produced some interesting results about matching and editing problems. The third involves the generation of compilers, and work in this area has led to a new way of systematizing the writing of compilers that appears to have significant advantages over more conventional approaches; this method already has found application in existing systems.

Digital Network Analysis A general-purpose computer aided scheme for defining and analyzing digital networks has been developed by Professor Alan V. Oppenheim and Ronald E. Crochiere. The scheme can be used for network analysis and synthesis. The effect of

finite word length can be studied. Sensitivity analysis has been done, and various digital filter structures have been compared with respect to effect of word length.

Vision, Manipulation, and Micro-automation Professors Patrick H. Winston and Berthold K. P. Horn of the Artificial Intelligence Laboratory are leading a group which is studying machine vision. Their goal is to develop a system to the point where they can say comfortably that the computer "can see." Because perception in general, and vision in particular, cannot be divorced from general knowledge and intelligence, this is not a well-defined, isolated task. To exhibit these ideas, a micro-world of the Electronic Repairman is being created. It is already possible to scan and "understand" well-controlled scenes involving objects with neat geometric shapes, some aspects of standard printed circuits, and some moderately complicated shadow situations.

Computer Assisted Medical Diagnosis Professor G. Anthony Gorry, working in conjunction with Professor William Schwartz, Chief of Medicine at the Tufts New England Medical Center, and others at Tufts, has created computer programs which implement decision analysis techniques in diagnostic medicine. Successful results have been achieved in relatively narrow areas such as that of kidney disease. Work continues in the generalization of these techniques to include properly directing patients who are entering a clinical environment. One of the results of the decision analysis research has been to suggest that there should be a larger and more analytical approach to the diagnostic training of physicians. Papers by Professors Gorry and Schwartz on this subject have been discussed widely during this past year.

Radiology Diagnosis In order to understand better the requirements of a computer program to scan and analyze X rays and to make at least tentative diagnoses, Professor Barry A. Blesser has studied the reading errors made by human radiologists. Five professional radiologists read a set of 100 films. On the average, there was more than one significant disagreement among the radiologists on each of the films. Moreover, many of these disagreements ultimately could not be resolved. One possible conclusion from this study is that human performance is far from reliable; a possible corollary is that a computer system, even if it made occasional errors, might be as reliable as a highly skilled human.

Audible Noise from Power Transmission Lines Undesirable audible noise sometimes has been a problem associated with high-voltage power transmission lines during rain. Experiments and theoretical studies have identified the cause of this noise and pointed the way toward the design of noise-free lines. Corona is the chief source of noise at low frequencies. The noise is dominated by harmonics of 60 hertz caused by the collision of charged particles with air molecules. At high frequencies, the cause is local heating of the air near streamers formed at intense corona sites. The noise is most noticeable when the line is wet; this is because water drops grossly increase the local electric field, and hence the amount of corona. This work was done by Professors Gerald L. Wilson and Inge Johansen and their students.

Fast Particle Removal The Continuum Electromechanics Group, under Professor James R. Melcher, has developed a new technique for removing submicron particles from a gas. Conventional precipitators require about 10 seconds for the particles to be removed, but with this new technique, which makes use of electro-fluidized beds, only 0.1 second is necessary. It is possible that this technique can be used as the basis for a new generation of small industrial air pollution control devices.

Structured Programming and Programming Correctness The focus of much of the research at Project MAC is reducing the high cost of software. One approach is through better understanding the relationship of program structure to program correctness, and applying this understanding to the design of a better programming language. Professor Barbara Liskov

and a group of graduate students have used this approach in the design of a language called CLU, which permits the stepwise development of programs through the use of abstract data types. This work has attracted widespread interest.

Computer Architecture Professor Jack B. Dennis and his students have developed new concepts for computer architecture, based on the flow of data rather than on the flow of control. These concepts are a natural idea for the stream oriented signal processing involved in speech or music synthesis, and are related easily to axiomatic definitions of programming constructs.

Privacy and Security within a Computer Utility Professors Jerome H. Saltzer and Michael D. Schroeder are pursuing research involving the identification of the minimum mechanisms that are required intrinsically to support a comprehensive computer utility of the MULTICS class. The approach being used is experimental and incremental to the commercial MULTICS system. A major objective of the work is to create a system which could be audited for security.

WILBUR B. DAVENPORT, JR.

Department of Mechanical Engineering

This has been a year of steady progress, fueled by a sense that the Department is in the mainstream and that its image among students and in the outside world never has been better. Not only is the economic picture looking up for engineers, but the kinds of research activities and related educational activities in which they are engaging seem to be of central significance. Undergraduates are coming to view the Department's style and programs as among the most exciting, and its enrollment of sophomores reached a level greater than in any of the past 20 years. Although the faculty has decreased in size over the past few years because of budgetary stringencies, it is clearly of the highest quality, certainly equaling if not surpassing that of the faculty group which, in the last two rating surveys in the past ten years of the American Council on Education, ranked foremost in the country among mechanical engineering departments.

The Departmental organizational structure has continued to evolve, with the Undergraduate Executive Committee functioning for a second full year, and the Undergraduate Office being established this last academic year. A broad curricular revision was adopted to take effect for all undergraduates in the Department beginning with the fall term, 1974.

The joint civil engineering-mechanical engineering computer facility experienced its first full year of stable operation. While the initial outlook for the facility was depressing because of various start-up problems, there emerged -- thanks to Professors Daniel E. Whitney and Richard S. Sidell -- a strong and viable facility supplying the needs of 600 students, 18 academic subjects, and 60 research projects. The latest hardware technology has been combined with a concentrated software development effort to produce this result. The facility provides students with experience in digital, analog, hybrid, and interactive computing, including on-line graphics.

A new student lounge with most interesting architectural features has been established in an open space off the corridor on the first floor of Building 3. It is adjacent to the new Undergraduate Office of the Department and hopefully will become a focus of student life, a place where all undergraduates will gather at least once a day. This will tend to compensate for the far-flung nature of the Department's laboratories and facilities.

In last year's report, mention was made of the work of an ad hoc committee on the space requirements of the Department. Although the committee produced detailed proposals for three major space changes which were considered highly vital to the well-being and future of the Department, these were not approved by the M. I. T. Committee on Space Planning. Nevertheless, these needs remain strong and it is hoped that the future will see them satisfied.

With the announcement that there will be a major M. I. T. development fund drive, an ad hoc committee was established within the Department. It consisted of Professors Nathan H. Cook, Ronald F. Probst, and Henry M. Paynter, each representing one of the three divisions of the Department. This ad hoc committee sought ideas from every faculty member of the Department and developed them into a package of suggestions that has been delivered to the administration. These suggestions are in three classes: 1) capital requirements for items of interest to virtually every department at M. I. T. ; 2) capital requirements for items of particular interest to joint activities within the School of Engineering; and 3) capital requirements for activities mainly concentrated within the Department of Mechanical Engineering.

Acknowledgement is made to the three division chairmen this past year -- Professors Ernest Rabinowicz, James A. Fay, and Herbert H. Richardson -- and the three other members of the Steering Committee -- Professors Ali S. Argon, Joseph L. Smith, Jr., and David G. Wilson -- for their extensive efforts in those policy deliberations and actions relating to appointments, promotions, and tenure.

Undergraduate Program

Enrollment

The growth of interest among undergraduates in mechanical engineering has been striking. In October, 1973, the Department had 189 undergraduates enrolled, including 76 sophomores. By comparison, only two years ago, in October, 1971, the total number of enrolled undergraduates was 128, of which 34 were sophomores. It will be two additional academic years before this major growth of sophomore enrollment is reflected in the enrollments of the third and fourth years. When this occurs, and even assuming no further increase in sophomore intake, the projected total undergraduate enrollment for the Department, in October, 1975, is 255. Should the sophomore intake continue to rise even modestly -- as might well be the case in view of the image now occupied by the Department in the minds of undergraduates -- the total undergraduate enrollment shortly could exceed 300, compared with the previously mentioned figure of 128 for October, 1971. All this is occurring in conjunction with a decrease of 13 percent in the number of faculty members in a period of about five years. Should the enrollment trend continue as projected above, the faculty soon will be overloaded very heavily.

The 76 incoming sophomores in October, 1973, included three blacks and eight women. Course II-A, the undesignated degree program, remains stable with approximately 25 students, or about 20 percent of the combined junior and senior enrollment. Professor Rabinowicz, who supervises Course II-A, has elaborated the advisory system by reducing the average number of students per faculty advisor; this is especially important because of the widely varied programs of the individual students within Course II-A.

In recent years, very few students have registered in Course II-B, the cooperative program. In the past year, however, there has been a considerable revival of interest, which members of the Department have been encouraging.

Undergraduate Executive Committee

In its second full year of operation, the principal activity of the Undergraduate Executive Committee was to develop further and subsequently to implement the plans for a revised undergraduate curriculum that had been drawn up during the summer workshop in mechanical engineering in June, 1973. This past year, the various topics and issues were discussed at great length with individuals and groups of faculty members. It was hoped that should a new curriculum be adopted, it would be substantially by consensus and with overwhelming approval, so that the faculty would both understand the intent of the proposed changes and act positively in executing them. The revised curriculum will take effect for all undergraduates in the Department beginning with the fall term, 1974. It pulls back slightly from the trend toward engineering science that occurred in the years following World War II, and substitutes a greater emphasis on engineering, and on economic, political, and social issues. The new curriculum of the Department is divided into two parts: a so-called universal core; and a set of restricted electives, which gives students greater freedom to focus in one direction without sacrificing breadth or balance.

Undergraduate Committee

This was the first academic year in which the Undergraduate Committee functioned in its newly structured form. The central role of the Committee is now to provide a broad policy forum for matters concerned with undergraduate education in the Department -- for instance, questions regarding undergraduate curriculum, student environment, student-faculty relationships, subject evaluations, student advising, and so forth.

Strong student participation, with lively and useful interactions between students and faculty members of the Committee, indicates that a need for a forum of this kind exists, and that the present committee format does fulfill this need effectively.

Undergraduate Office

During the fall term, 1973, an Undergraduate Office was established in the Department to focus the myriad activities associated with the undergraduate program in one location. These include maintenance of undergraduate files and records, coordination of undergraduate registration, administration of Course II-B, assistance in summer employment, back-up support for Pi Tau Sigma and the American Society of Mechanical Engineers (ASME) Student Section, arrangement of student class dinners, maintenance of files on the bulletin board listing jobs and opportunities for graduate study, and other items of interest to undergraduates.

Professor Stanley Backer was appointed undergraduate officer of the Department and devoted a substantial part of his time to this activity. Dorothy Eastman was appointed as full-time administrative assistant in the Undergraduate Office, which is located on the first floor of Building 3, next to the newly created student lounge.

Subjects of Instruction

Apart from the usual improvements in subjects of instruction already offered, relatively few new undergraduate subjects of instruction were introduced during the past academic year. The efforts of the Department were directed mainly toward the new undergraduate curriculum, which will require the development of a large amount of new subject material in the academic year 1974-75. Accordingly, 1973-74 was basically a year of planning. Some of the new curricular material will be developed through concentrated effort during the summer of 1974; some changes will occur during the academic year 1974-75, and will be reported next year.

The most interesting development in undergraduate subjects is the offering, for the first time, of three related subjects in biomedical engineering: 1) 2.791J Quantitative Physiology:

Cell and Tissues; 2) 2.792J Quantitative Physiology: Organ Transport Systems; and 3) 2.793J Quantitative Physiology: Sensory and Motor Systems. These new subjects, offered jointly with the Department of Electrical Engineering, are the products of the efforts of some 15 faculty members. The contributors from the Department of Mechanical Engineering included Professors Ioannis V. Yannas, Ernest G. Cravalho, Borivoje B. Mikic, Igor Paul, Robert W. Mann, C. Forbes Dewey, Jr., and Ascher H. Shapiro. The subjects are based on the very substantial knowledge of physiology and biomedical engineering that is shared by these faculty members. The treatment of these subjects is novel in that it represents an attempt to present the elements of human physiology using the style, methods, and outlook that are characteristic of engineers as they try to understand a phenomenon through quantitative means. It was known from the beginning that these subjects would be very difficult to develop and to offer. The results of the first try were more than respectable, and the faculty members concerned are looking forward enthusiastically to the second offering because of the substantial improvements they envision. Some of these improvements will be effected by the concentrated curriculum development efforts made during the summer of 1974.

During the Independent Activities Period (I. A. P.) in January, 1974, students were offered the opportunity, through the cooperation of the Charles Stark Draper Laboratories, to take a mini-course in drafting and illustrating. During the past two decades, graphics and drafting had all but disappeared from undergraduate studies. This year, reflecting the shift in interest of the past three or four years, the mini-course attracted a large attendance. Because of continued student response, a further course in engineering graphics and geometric dimensioning and tolerance was offered as part of 2.733 Special Projects in Design.

Student Life

There is high morale among the undergraduate student body and a general feeling of goodwill between students and the faculty. The Department seems to have developed successfully a reputation of sensitivity to the needs of undergraduates and an image of caring for their concerns. The two student organizations, the ASME Student Section and the honorary society Pi Tau Sigma, both have contributed mightily to these feelings of goodwill. The Department also has gained a reputation among the student body for the way in which it has encouraged women and black students to enter the profession of mechanical engineering, and for the special efforts that it has made to ensure their well-being in what seem superficially to be adverse circumstances.

Women have emerged as a vital force among mechanical engineering students. The president of the ASME Student Section this past academic year was Patricia R. Callahan, and one of the Department's women undergraduates, Carol McGuire, was elected president of her fraternity.

Quality of Teaching

With the help of the Pi Tau Sigma evaluations of instructors and subjects, and with the interest shown in all quarters of the Department in effective teaching, it is felt that the quality of teaching in the Department never has been higher.

Graduate Program

Enrollment

The graduate enrollment in September, 1973, was 232, an increase of about five percent over the previous academic year. The total number of applications received was about the same as in the previous year, approximately 270, from among which the Department enrolled nearly 100 new graduate students. About one-third of the Department's graduate students received their undergraduate education abroad. Of the 69 percent receiving their

undergraduate education in the United States, approximately 27 percent were M. I. T. undergraduates. The remainder came from other universities in the United States.

During academic year 1973-74, the Department awarded 82 Master of Science degrees, 12 Mechanical Engineer degrees, and 27 doctorates.

Although the number of fellowships available from the Department decreased from 23 to 10, the number of research assistantships that became available from sponsored research increased from 116 to 121. Approximately one-half of all graduate students in the Department were supported by research assistantships. The next highest category was made up of those who were self-supported, and the remainder were distributed among teaching jobs, fellowships awarded by M. I. T., fellowships awarded by government agencies, fellowships awarded by industry, and foreign fellowships.

Subjects of Instruction

Professor Woodie C. Flowers is a contributor to the joint subject 2.942J Entrepreneurship. The subject is offered in conjunction with the M. I. T. Innovation Center, which is a new project supported by the National Science Foundation. The subject serves as an introduction to the various issues faced by technical innovators who are interested in becoming entrepreneurs, including technical, business, and legal aspects. Innovative ideas of the students are sought and used as study topics.

Professor Richard H. Lyon offered the new subject 2.095 Noise Legislation Seminar. Its object was to present the existing state of affairs with regard to noise legislation in various areas and to describe the reasons for the approach to legislative control taken in those years.

Professor Paynter offered the new subject 2.155 Dynamics and Control of Thermal Fluid Processes and Systems. This subject entails a unified study of the dynamics and control of systems of interconnected heat and mass transfer components, such as those found in power and propulsion plants, petrochemical and manufacturing processes, and other industrial systems.

Professor Whitney offered the new graduate subject 2.158 Advanced Automation Systems, the object of which was to acquaint students with manufacturing automation as an emerging area of engineering research and employment.

Professor Richardson, with the collaboration of Professors Wilson and Yau Wu and Instructor Larry Sweet, offered the new subject 2.120J Transportation Technology, one of a triad of subjects offered by the Center for Transportation Studies. This particular subject in the sequence is concerned with the engineering and hardware aspects of new forms of transportation systems.

A new graduate program of study and research in the mechanical processing of polymers was developed during the past year. It derives its strength from extensive Departmental research in the areas of processing of polymers in both bulk and fibrous form, in biopolymers, and in the physics of deformation and fracture. The program is administered jointly by Professors Backer, William J. Shack, Nam P. Suh, Yannas, and Argon, and will offer four new graduate subjects. In addition, the program will serve to relate and coordinate the research activities in the Department in the area of polymers. One of the subjects, 2.922 Mechanics of Fiber Processing, offered by Professor Backer, is intended to equip the polymer engineer with an understanding of, and competence in, dealing with material-machine interactions in the forming, deforming, and structural arranging of fibrous materials. Another subject, 2.923 Mechanical Behavior of Fibers, is intended to provide an understanding of structure-property relationships in polymeric fibers; it will treat the fine-structure basis of mechanical properties of both natural and synthetic fibers,

as well as the effect of structural geometry of fiber assemblies on their behavior in processing and in end usage. The new subject 2.921 Polymer Deformation and Fracture was offered by Professors Yannas and Argon to provide a comprehensive survey of deformation and fracture of plastics, fibers, and rubbers as a basis for process and performance design.

Professor Thomas B. Sheridan collaborated in the presentation of 11.161 Failure of Human Systems, a novel subject in which were compared failure mechanisms in human institutions, individual persons, and biological and physical systems.

Research

The research volume in the Department for the fiscal year 1974 is, at this writing, projected at \$3.00 million, compared with \$2.81 million for fiscal year 1973. This is an increase of about 6.5 percent, roughly the same as the increase in the cost of living; thus the volume of research in real dollars has remained approximately the same. It now has reached a level which is close to the maximum that the faculty can raise without seriously interfering with their teaching activities.

The scope of the Department's research efforts is so broad that it is almost impossible to present a fair summary. For this the reader is referred to the complete annual report of the Department for 1973-74, which will be published separately. The following provides a glimpse of the breadth of research activities without any attempt to be all-inclusive, and without implying that those activities mentioned are more important than others presented separately in the full annual report.

Professor Shawn Buckley has originated Thermics, a new control field which uses temperature to control heat flow, analogous to electronics, which uses voltages to control current, and to fluidics, which uses pressures to control flow. He is developing the new concept for solar energy systems, which is perhaps the most important application of thermic control systems. Professor Buckley also is doing research to develop a scheme for inspecting machine parts by using the change in phase of acoustic waves.

Professors Stephen H. Crandall and James H. Williams, Jr. are investigating the possibility of reducing earthquake damage by mounting buildings on friction controlled slip-pads.

Professor Stephen P. Loutrel, working under the Sea Grant Program, is designing and testing an improved hook-up block to be used by fishing vessels when side trawling.

Professor Whitney is working on the design and control of high-performance mechanical manipulators that may be used for industrial automation. In related studies, he has attacked the problem of directing a machine tool to cut an arbitrary contoured surface.

Professor Williams is working on the structural applications of advanced fiber composites. He also is trying to develop a method for nondestructive stress testing by means of acoustic emissions.

Professor Cook, with Instructor George Foote, Jr., is working on welding by means of high-powered lasers. With Professor Suh, Professor Cook also is working on the surface treatment of cemented carbide tools in order to increase their life. Professor Suh also has developed a new delamination theory of wear, and is exploring new polymer processing techniques in the context of the M. I. T. Industry Polymer Processing Program, which he began.

Professor Sheridan is working on technological improvements of community dialogue, and is experimenting with electronic voting and other graphic technology as aids to group dialogue and decision processes.

Professor Mann, together with his colleagues Professors Paul and Flowers, continues to work on various problems of the neuromuscular system and on aids to the handicapped. Professor Roger E. Kaufman, working with Professor Mann and others, has helped to develop creative technological aids for the occupational therapy of handicapped children, particularly those with skeletal and neuromuscular diseases.

A variety of acoustics related activities in the Department includes the work of: Professor Huw G. Davies on sound propagation in urban and industrial environments; Professor D. Graham Holmes on sound propagation in suburban areas; and Professor Lyon on acoustical modeling for site evaluation, on the effects of vegetation on outdoor sound propagation, and on the effect of wind on noise barrier performance.

Professors Ronald F. Probst and Ain A. Sonin continue their work on water purification. This includes such topics as ultrafiltration of macromolecular solutes and salt-rejecting porous membranes, and such related topics as electrostatic charging in fuel filtration and sludge separation.

Professors Dewey, Douglas E. Kenyon, Mikic, and Shapiro continue their efforts in a variety of biomedical engineering problems based on fluid flow and mass transport, including efforts directed toward understanding the mechanism of atherosclerosis, blood oxygenators, and the development of thermal methods for the differential diagnosis of human tumors. Research Associate Peter W. Scherer has worked on fundamental problems relating to the prevention of deep venous thrombosis by means of external pneumatic compression of the legs. Professor Cravalho continues his important work on the preservation of blood at very low temperatures.

As might be expected, there are a great many activities relating to various aspects of the energy problem. Lecturer Leon R. Glicksman, with his colleagues, is studying the improvement of the environmental and economic characteristics of cooling towers. Professor John B. Heywood, together with Professors John P. Appleton and Fay, works on various problems of emissions and pollution both from automobile engines and from aircraft exhausts. Professor Heywood also is working on other problems of internal combustion engines, including the relationship between automobiles and fuel demand, and research on stratified charge engine performance. Professor Peter Griffith is working on the application of solar energy to reduce the power requirements of heat pump systems. Professor James C. Keck, with Professor Heywood, is working on the emissions and performance characteristics of Wankel engines. Professor Fay is investigating the safety hazards of liquefied natural gas spills. With Professor David P. Hoult, Professor Fay also is working on the dispersion characteristics of emissions from automobiles.

Staff

During the academic year 1973-74, the Department had a total of 50 full-time regular faculty members: 25 full professors, 15 associate professors, and 10 assistant professors. Of the 50, 30 were tenured, making for a tenure ratio of 60 percent.

During this past year, the Department's first regular full-time woman faculty member was appointed, Professor Prabha I. Sridharan. Professor Guiliana C. Tesoro was also on the Department's staff as a visiting professor.

One of the Department's most loyal and effective faculty members, Professor Douglas P. Adams, retired in June, 1974. The following faculty members resigned during academic year 1973-74: Professors Michel Y. Jaffrin, Thomas J. Lardner, and Daniel E. Whitney.

Professional Activities and Awards

Professor Stanley Backer was named to honorary fellowship in the Textile Institute of the United Kingdom for his contributions to fiber science. This is the highest award that an individual in his field can hold.

Professor Stephen H. Crandall served as chairman of the U. S. National Committee for Theoretical and Applied Mechanics. He was a member of the General Assembly of the International Union of Theoretical and Applied Mechanics, and an invited lecturer at the meeting of the Acoustical Society of America and at the Seventh National Congress for Applied Mechanics.

Professor James A. Fay served again as chairman of the Massachusetts Port Authority and as a member of the Governor's Emergency Energy Technical Advisory Committee. Professor James C. Keck was elected to fellowship in the American Academy of Arts and Sciences. Professor Robert W. Mann was appointed Uncas A. Whitaker Professor of Biomedical Engineering.

Professor Henry M. Paynter was invited to give the annual Robert Henry Thurston Lecture at the ASME winter annual meeting in Detroit. Professor Ronald F. Probststein was elected a fellow of the American Physical Society. Professor Ascher H. Shapiro was elected to membership in the National Academy of Engineering. Professor James H. Williams, Jr. was appointed Esther and Harold E. Edgerton Assistant Professor of Mechanical Engineering. He also received one of the Ralph R. Teetor Awards of the Society of Automotive Engineers.

ASCHER H. SHAPIRO

Department of Metallurgy and Materials Science

The academic year 1973-74 was one in which small but steady growth occurred. It was also a year in which the Department devoted a lot of effort to reorganizing its programs and laying plans for future development.

Undergraduate Programs

The past academic year was the first in which a full schedule of subjects in the new undergraduate program in metallurgy and materials science was offered. The total number of students (excluding freshmen) enrolled in the program increased from 35 in 1972-73 to 48 in 1973-74. This is, of course, a smaller increase than was hoped for in the first year of the new program. It is encouraging, however, that 16 sophomores registered in the program. The Department will continue to make strenuous efforts to attract more undergraduates into metallurgy and materials science. The enrollment in 3.091 Introduction to Solid State Chemistry again was more than 500 students. It was expected that 3.141 Science of Materials, a subject designed to interest students in mechanical engineering and other engineering departments, would suffer a decline in enrollment because of the many competing attractions offered by the Department of Mechanical Engineering. This did not happen, however, and more than 45 students enrolled in it. Three undergraduate laboratory subjects were offered for the first time, but it soon was discovered that the number of credit hours covered by these three subjects was much larger than the students needed to complete a satisfactory program; subsequently, the laboratories were consolidated into two subjects. This seems to have been received well by students, and the registrations are now satisfactory.

Graduate Programs

Between 1963 and 1968, the graduate student population of the Department held steady at a figure between 155 and 170. The number then dropped continuously and rapidly from 162 in 1968 to 120 in 1973. During the past academic year, it started to rise. There were 125 graduate students registered in the Department in the fall of 1973. It estimates that the number of students registered in the fall of 1974 will be close to 140. This upturn has been achieved by attracting a larger proportion of the students admitted, and by increasing the size of the pool from which they are selected. The pool increased from 71 in 1972 to 108 in 1974. The Department continues to attract its students almost exclusively from the departments of metallurgy, ceramics, or materials science and engineering at other universities.

At the present time, the Department is able to accept a much larger proportion of students with high grades than any other department in the country. It has been estimated that of the students who reach its admission standards, the Department registers four times as many as its nearest competitor, Stanford University. Nationally, more than 60 percent of the good students seeking admission to departments of metallurgy and materials science come to M. I. T. If the Department is to increase its selection pool still further in the years ahead, it will have to attract students from other sources. Last year the Department began to explore ways in which it could interest students from departments of chemistry, physics, or chemical engineering. This coming year, the Department will increase its efforts to reach students in science departments and will include students in engineering who might be attracted to the program in materials engineering.

During the past academic year, the new graduate programs were put into effect. A multiplicity of programs was replaced by five interrelated but clearly defined ones: ceramics, metallurgy, polymeric materials, materials engineering, and materials science. Details, described in terms of the requirements of the general examination, together with a list of the faculty associated with each program, are attached to this report. Each member of the faculty of the Department of Metallurgy and Materials Science is a member of the faculty panels of at least two programs. At the start of the spring term, 1974, students who were partway through their graduate studies were given the option of either continuing in the program in which they were registered or transferring to one of the new programs. As anticipated, most of the students took the general examination in the program on which they had been working for some time. All 43 graduate students who were in their first year elected to register in the new programs. Metallurgy continues to be a popular choice; ceramics is increasing rapidly in popularity; and the newest of the materials areas, polymeric materials, has gotten off to a good start. Approximately six students now are taking this program, and there is every indication that this number will increase sharply in the years ahead.

Only half of the 12 faculty members who constitute the panel in polymeric materials are members of the Department of Metallurgy and Materials Science. The others are from the Departments of Mechanical, Chemical, and Civil Engineering. The panels in the other four areas were organized largely from members of the faculty of the Department, but in the case of polymeric materials, it became evident that there is a great deal of talent among faculty members in other departments of the School of Engineering and that in order to launch a strong program the Department's efforts should be integrated completely with those of others in the School. The cooperation of faculty members has been magnificent. Through the Materials Council of the School of Engineering, the details of the program have been coordinated with those of programs in the Departments of Mechanical Engineering and Chemical Engineering. Members of the School's faculty who are interested in polymers have met together frequently under the chairmanship of Professor Morris Cohen to discuss

collaborative research efforts and Institute-wide programs of instruction. This has been undoubtedly the most successful of the collaborations initiated by the Materials Council.

The Department's effort to develop teaching and research activities concerned with the analysis of the impacts of technological innovations on materials systems was an important factor among those which led to the establishment of the new materials engineering program. Students registered in this program are advised to take some subjects in materials systems, computer simulation, economic systems, or optimization theory, in addition to subjects selected from a wide range covering many different aspects of the technology of materials. Two of the systems subjects are offered by faculty members of the Department of Metallurgy and Materials Science, but most of them on the list of electives are regular subjects in the Departments of Civil Engineering or Economics or in the Sloan School of Management. There have been a number of meetings with the Dean of Management and several faculty members of the Sloan School of Management about establishing a joint appointment in metallurgy and management; however, the negotiations and search have been unsuccessful so far.

During the years when the graduate student population in the Department was declining, the research volume continued to increase markedly. The dollar value of grants and contracts reached a high point of \$2.25 million in academic year 1972-73. The research volume in 1973-74 was \$2.5 million. Thus, when the effects of inflation are considered, there was a small increase in real terms. There were some shifts in funding between different groups within the Department which caused a little local and transitory hardship. As in previous years, many members of the Department were active members of the Center for Materials Science and Engineering, but less than one-quarter of the research funding coming into the Department came through the Center.

As part of a continuing plan to reduce the administrative costs of the Department, it closed the machine shop in Building 8 and transferred an instrument maker and much of the work of the shop to the Center shop in Building 13. Another instrument maker, John Huska, retired after 27 years at M. I. T. The foreman, Robert Huston, has been appointed to the position of technical instructor. He will supervise the instruction of students in the small instructional shop which will remain in Building 8.

Research dollars per faculty member (approximately \$86,000) has stayed at a remarkably high figure, which is good evidence of the unusually high productivity of Departmental faculty and the importance of their work. These figures do not reflect the very large increase in proposal writing which took place during the last academic year. With the greatly increased emphasis in Washington and elsewhere on the need for research related to energy and materials, new opportunities for research support have become available. The Department's faculty have responded. The number of research proposals from individuals and from groups of faculty members has increased sharply. There are high expectations that the Department will receive support for many of these proposed projects, and consequently, it is confidently predicted that the dollar volume of its research support next year again will show a marked increase. A substantial number of transient postdoctoral scientists and engineers continue to be employed in the Department, and no significant decline in this population is anticipated. More graduate students could be supported at the present time, but the intake is limited by the number of well-qualified students who apply and not by the research support which is available.

Faculty

Professor Bernhardt J. Wuensch's promotion to full professor became effective in academic year 1973-74. He spent the fall term of 1973 on sabbatical, working in the Crystallography Laboratory of Professor Karl F. Fischer in the Universitat des Saarlanders, West Germany. Also during 1973-74, the appointments of Professors Regis Pelloux and H. Kent Bowen to

associate professor were approved. The senior faculty of the Department were unanimous in their support of each of these appointments, and were very pleased that it was possible to reward these young members of the faculty for their outstanding contributions to the teaching and research programs of the Department.

Professor Merton C. Flemings was appointed assistant director of the Center for Materials Science and Engineering, further strengthening the important and happy interactions between the Center and the Department.

During the past academic year, Professor Frederick J. McGarry transferred from the Department of Civil Engineering to the Department of Metallurgy and Materials Science. Professor McGarry is a distinguished engineer who over the last decade and more has worked extensively on polymeric materials and composites containing polymers. By joining the Department, Professor McGarry has added greatly to the strength of its research efforts in polymeric materials. The transfer also has given the Department an opportunity to collaborate with the Department of Civil Engineering in presenting a number of graduate and undergraduate subjects. Professor Koichi Masubuchi of the Department of Ocean Engineering also joined the Department's faculty at the start of the 1973-74 academic year. Professor Masubuchi has taken over responsibility for the welding laboratory, and is collaborating with Professors Carl F. Floe and Michael B. Bever in developing a subject in materials for selected students in the Department of Ocean Engineering. At this point, mention must be made also of Professor Ali Argon of the Department of Mechanical Engineering, who during the past year has strengthened further his unofficial ties with the Department. For some years, two graduate subjects on the physics of deformation and fracture of solids, which Professor Argon offers, have been important components of several of the Department's graduate programs. Next year these subjects will be offered jointly by the Departments of Mechanical Engineering and of Metallurgy and Materials Science. Professor Argon's cooperation in this important area is appreciated greatly.

Professor J. Bruce See, who has been in the Department for the past four years, resigned to accept an appointment in South Africa.

At the beginning of the 1973-74 academic year, it was decided to try to fill the vacant faculty slots in the Department with assistant professors specializing in corrosion and electrochemistry, high-temperature applied chemistry, or polymeric materials. Faculty search committees were formed in each of these three areas, widely distributed descriptions of the vacancies were published, and an energetic search for young people was undertaken. In polymeric materials, the search is continuing from among more than 40 applications. In the area of high-temperature applied chemistry, the pool of candidates has been much smaller, and a few candidates from among the Department's own graduates are being considered. The search for faculty specializing in corrosion and electrochemistry was much more successful. Dr. Ronald M. Latanision from the Research Laboratory at Martin-Marietta Corporation was appointed an associate professor effective July 1, 1974. Professor Latanision has been awarded the Humboldt Foundation Fellowship to work at the Max Planck Institute in Düsseldorf, Germany, for one year. He will be taking up his duties at M. I. T. when he returns at the end of the summer of 1975. It is expected that Dr. Latanision then will take over many of the activities which for a long time have been carried out by Professor Herbert H. Uhlig, who retired a few years ago. Professor Uhlig's appointment as a lecturer will be discontinued at the end of the coming academic year.

Honors and Professional Activities

The faculty continued to receive many honors and distinctions and to take part in many important activities of national scientific and professional organizations. The following is a partial listing.

Professor Benjamin L. Averbach served as chairman of the Electrical, Magnetic, and Optical Committee of the American Society for Metals (ASM) and as president of the International Conference on Fracture. Professor Walter A. Backofen delivered the Campbell Memorial Lecture of the ASM and was appointed a fellow of that Society.

Professor Arden L. Bement continued to serve on many important technical committees, including the Editorial Advisory Board of the Journal of Nuclear Materials, the Publications Committee of the American Society for Testing and Materials, and the Financial Committee of the Boston chapter of the American Society for Metals. He was also team chairman of the US-USSR Cooperative Scientific Exchange on Magnetohydrodynamic (MHD) Power Generation; cochairman of the US-Japan Scientific Exchange on Radiation Effects in Metals; and technical advisor to the Metallurgy and Ceramics Division of the United States Army Research Office.

Professor Harvey K. Bowen served as a member of the Task Force on Magnetohydrodynamics set up by the Office of Coal Research and also as a member of the Cooperative Scientific Exchange on MHD Power Generation with the USSR. He also served as editor of the Ceramic Education Council's Review Papers. Professor Robert L. Coble was appointed to the Federal Materials Research Council.

Professor Morris Cohen served as chairman of the Committee on the Survey of Materials Science and Engineering of the National Academy of Sciences; as a member of the Steering Committee of the Joint National Academy of Sciences-National Academy of Engineering Meeting on National Materials Policy; as a member of the Steering Committee of the Advanced Research Projects Agency (ARPA) Materials Research Council; and as a member of the Report Review Committee of the National Academy of Sciences. He was also a member of the Council of the American Society for Metals, Materials Science Division; a member of The Metallurgical Society-AIME (American Institute of Mining, Metallurgical, and Petroleum Engineers) Education Committee; and a member of the Editorial Advisory Board of the Journal of Materials Science and Engineering.

Professor John F. Elliott delivered the Yukawa Memorial Lecture at the annual general meeting of the Iron and Steel Institute of Japan in April, 1974, and was made an honorary member of that Institute. He was also a visiting professor with the Japanese Society for the Promotion of Science, during which time he lectured at Tohoku University.

Professor Merton C. Flemings received the Howe Medal of the American Society for Metals at the Materials Congress in Chicago in October, 1973. He also gave the Howe Memorial Lecture of AIME in the spring of 1974. In addition, he was a member of the Mathewson Gold Medal Committee of AIME, the Committee for International Metallurgical Reviews of ASM, and the Certification Committee of AIME.

Professor Harry C. Gatos was appointed to the National Materials Advisory Board of the Division of Engineering of the National Academy of Sciences, to the Ad Hoc Subcommittee for the Review of Investigations on the Apollo-Soyuz Test Program Mission, to the Visiting Committee of the Materials Research Laboratory of the Pennsylvania State University, and to the Executive Committee of the American Association for Crystal Growth. He continued to serve on many societies of the American Electrochemical Society, and served as chairman of the Evaluation Panel for the Office of Standard Reference Data of the National Bureau of Standards, the Numerical Data Advisory Board of the National Academy of Sciences, and the Executive Committee of the Academy Panel of the National Academy of Sciences.

Professor Nicholas J. Grant served on the National Aeronautics and Space Administration's Research Advisory Committee and was appointed chairman of the National Science Foundation-Materials Research Laboratory Directors Group. He continued as chairman of the

American Society for Testing and Materials (ASTM) Research and Technology Planning Committee.

Professor Roy Kaplow served as a member of the Advisory Board of the Northeastern Academic Science Information Center of the New England Board of Higher Education. Professor Thomas B. King was a member of the Physical Chemistry Committee of The Metallurgical Society of AIME.

Professor Walter S. Owen gave the Williams Lectures at M. I. T. and was the Sauveur Memorial Lecturer at the Philadelphia chapter of the American Society for Metals. He was appointed to the Board of Trustees of Acta Metallurgica and served on a number of committees of ASM and The Metallurgical Society-AIME.

Professor Robert M. Rose received the 1973 Kappa Delta Award of the American Academy of Orthopedic Surgeons. He also served on the Executive Committee of the Boston chapter of ASM and on the ASM Metals Handbook Subcommittee.

Professor August F. Witt served on the NASA Advisory Committee for Materials Research and was a member of the Electronic Materials Committee of AIME.

Professor Bernhardt J. Wuensch served as a member of the Basic Science Editorial Committee, chairman of the Educational Committee, and chairman of the Nominating Committee of the Basic Science Division, all of the American Ceramics Society.

International Activities

During the year many of the faculty of the Department made short trips abroad to help with various technical missions or to take part in international conferences. Professor Bement served for a month as a technical advisor to the Instituto Nacional de Energia Nuclear in Mexico City. He was also a member of the Joint US-USSR Scientific Exchange on MHD. Professor Bowen also served on the Joint US-USSR Scientific Exchange on MHD.

Professor John W. Cahn was a participant in the International Discussion Meeting on Studies of Lattice Distortions and Local Atomic Arrangements by X-ray, Neutron, and Electron Diffraction, in Kernforschungsanlage Jülich, Germany.

Professor Coble served as a visiting professor with the Japanese Society for the Promotion of Science for one and one-half months, during which time he lectured at the University of Tokyo and at the Tokyo Institute of Technology.

Professor Cohen was a participant in the International Conference on Strength of Metals and Alloys in England.

Professor Elliott attended the twelfth Annual Canadian Institute of Mining and Metallurgy (CIM) Conference of Metallurgy in Canada. He also attended the annual general meeting of the Iron and Steel Institute of Japan. During his visit to Japan, Professor Elliott was a visiting professor at Tohoku University.

Professor Flemings delivered the American Exchange Lecture at the International Foundry Congress in Moscow, and also was in Moscow as a member of the US-USSR Technical Exchange Commission in the field of electrometallurgy. He was part of the M. I. T. team that held discussions in Iran concerning M. I. T. -Iranian cooperation in the area of technical education. Professor Flemings was the organizer of a conference entitled Energy Conservation and Recycling in the Aluminum Industry. The conference, which was held at M. I. T., was well attended by engineers from all the major aluminum industries in the United States and Canada,

and by many senior engineers from foreign countries, including France, Germany, and the United Kingdom.

Professor Keith H. Johnson was a participant in the First International Congress on Quantum Chemistry, in France, and in the International Conference on Computers in Chemical Research and Education, which was held in Yugoslavia. He also attended the Fifth Canadian Conference on Theoretical Chemistry.

Professor Owen visited Italy where he had discussions with persons at Fiat Research Laboratories, Olivetti Research, and Centro Sperimentale Metallurgico. He also attended meetings of the Institution of Metallurgists in London, England.

Professor Regis M. N. Pelloux was a participant in a conference on the prospects of fracture mechanics, held in the Netherlands.

Professor Wuensch was a visiting professor in Germany at the University of the Saarland.

Research

It is impossible in the space available to give more than a brief and incomplete description of the many and varied research programs which were under way in the Department during the academic year 1973-74. A more detailed report of the work in metallurgy, materials science, and polymers may be found in the Annual Report of Research in Materials Science and Engineering prepared by the Center for Materials Science and Engineering, January, 1974.

Physics of Solids Professors Averbach and Kaplow have continued their detailed study of the structure of amorphous and polycrystalline thin films of zinc oxide, arsenic-selenium glasses, and rare earth cobalt permanent magnet materials. Electron diffraction, X-ray diffraction, and neutron diffraction techniques have been used. The results of this work are beginning to show clearly the relationships between the optical and electrical properties of these thin films and the fine structure. Models of the atomic arrangements developed, using a computer generated Monte Carlo procedure in conjunction with atomic radial distribution functions, have proved to be particularly successful.

Mössbauer spectroscopy was applied to the study of low-temperature transformations in iron alloys with carbon, boron, and nitrogen. Studies of carbon martensite have shown significant agglomeration of carbon atoms into high-carbon regions at room temperature. With nitrogen alloys, room-temperature aging appears to stabilize the martensitic phase significantly. This is consistent with the previously proposed atomic reconfigurations on aging in martensite coupled with the known relative stability of Fe_4N compared to Fe_4C . The results of magnetization and neutron diffraction measurements have been correlated with electronic structure of the three-dimensional "bands" in iron-nickel alloys.

Professor Johnson, in collaboration with Professor J. C. Slater, Institute Professor Emeritus, has developed a new approach to calculating, from first quantum-mechanical principles, the electronic structures of poly-atomic molecules and complex solids in terms of a spin unrestricted self-consistent-field cluster model. Based on the use of multiple-scattered wave formalism and the X-alpha statistical theory of exchange correlation, the method leads to the accurate determination of electronic energies, wave functions, and charge and spin densities, but requires only moderate amounts of computer time. This and similar techniques have been applied to a wide variety of problems including the determination of localized electronic excitations in transition metal oxides, the electronic structure and optical properties of ferrocene, the electronic structures of transition metal carbonyls, and the bonding of ferrous iron to sulphur and oxygen in tetrahedral coordination. Perhaps one of the most

interesting new extensions of these ideas is to the determination of those features of electronic structure common to both heterogeneous and homogeneous catalysis which may be related to the observed catalytic activities, specificities, and stabilities. Electronic structure calculations by the self-consistent-field-X-alpha scattered wave method have been completed for platinum-olefin and titanium-olefin complexes as models for the first stages of olefin catalysis. Similar calculations have been made for enzyme phosphate binding and biocatalysis. The results of these calculations, in conjunction with X-ray crystallographic studies by Cotton and others, are believed to have fundamental importance in structural biochemistry.

Physical Metallurgy An extremely interesting development in the theory of the martensite transition occurred when Greg Olson, one of the graduate students supervised by Professor Cohen, presented new arguments and a new theoretical model relating to the embryonic stages of nucleation. This model is likely to be important in the study of many practical problems such as the work hardening produced by strain induced martensitic transformations and autocatalysis. Martensitic transformation is being studied also in alloys in which the damping capacity increases significantly because of the transformation or premartensitic phenomena. These effects are being investigated in nickel-titanium, iron-platinum, and copper-aluminum-nickel alloys with measurements of electrical resistivity, heat capacity, dynamic Young's modulus, internal damping, X-ray diffraction, and microscopy. The aim of this research is to determine the origin of the high damping capacity that is associated with martensitic transformations, as a means of developing sound-absorbent materials of high strength. The work is being supervised by Professors Cohen and Owen. It has been found that in nickel-titanium alloys, the damping anomaly sets in above the transformation range and may be related to soft-mode precursor effects. Nevertheless, the high damping persists during the martensitic transformation.

Professor Cohen also has continued his interest in strengthening mechanisms in steels. It was found that high-purity titanium, like iron, undergoes extensive strain hardening during the severe deformation imposed by wire drawing. The strength is controlled by the transverse cell size. The angular misorientations across the cell walls, as revealed by high-voltage electron microscopy, indicate that the sub-boundaries are characterized by large angles as well as small. The strain-hardening law can be deduced from a combination of two strengthening mechanisms based upon the effects produced by the two different types of boundaries.

The first-principles calculation of the void nucleation rate in irradiated materials (particularly stainless steels) as a function of the concentration of vacancies, self-interstitials, and gaseous or nongaseous impurities has undergone further developments during the year. Professor Kenneth C. Russell has shown how these calculations now can be extended to predict the effects of a particular alloy addition, change in irradiation conditions, or a concentration of transmuted gas on void nucleation and the associated swelling. The equations promise to be even more important in fusion irradiation, where the concentrations of helium are expected to be extremely high, and capable of inducing a large amount of swelling.

High-strength low-alloyed steels in which control of the final structure is accomplished by the partial solution of niobium carbides during the austenitizing treatment are being studied by Professors John B. Vander Sande and Cohen. These steels are currently one of the few basic research topics of major interest to the big steel industry. A replica-extraction method has been developed to identify the carbides present and to study their morphology by electron microscopy and diffraction. It appears that the niobium exerts its main influence on hardenability through its influence on the amount of carbon it dissolves in the austenite. The secondary hardening effect also has been examined and found to be caused by the precipitation of niobium carbide from the ferrite matrix.

Professor Vander Sande has continued his efforts to improve the resolution of electron microscopy and to extract other useful information by this technique. As problems in materials science become increasingly more complex, the ability to improve detection techniques also must increase. To this end, a research project has been initiated to utilize a scanning transmission electron microscope (STEM) for X-ray analysis with high spatial resolution. A specially built STEM has been completed, and work has begun on correcting and predicting background X-ray noise and producing and modeling systems for initial analysis. The aim of the project is to analyze chemically particles of the order of 100 angstroms in size. At the same time, Professor Vander Sande has continued his studies of the cyclic deformation of magnesium single crystals, of augite exsolution lamellae in enstatite, of the crystallization of amorphous copper-zirconium alloys, and of the early stages of precipitation in aluminum-zinc-magnesium alloys. In these studies, he has been able to exploit very profitably the sophisticated electron microscope techniques which he has helped to develop over the past few years.

Two items of research completed during the past year by the group working on high-temperature materials under the direction of Professor Grant deserve special mention. The first is concerned with property control through structure control by means of rapid quenching of the melt (splat cooling). Extreme grain refinement, coupled with suppression of segregation, has resulted in large improvements in the hot workability of metals and alloys to the extent that alloys originally designated only for castings are now readily hot and cold formable; many, including highly alloyed cobalt and nickel base super-alloys, are super-plastic (elongations from 500 to 1,000 percent at fracture).

In the extreme, rapid quenching of the melt produces amorphous metals, metallic glasses in the absolute sense. A copper-40 percent zirconium alloy shows fracture strengths up to 200,000 psi. It is anticipated that an unheard-of fatigue limit approaching 200,000 psi will be achieved -- or specifically a fatigue stress which approaches the fracture stress -- in contrast to values of 30 to 50 percent of the tensile stress for crystalline metallic materials.

The other project completed by the high-temperature group is concerned with super-plastic behavior. Utilizing conventional two-phase alloys of aluminum-copper and lead-tin, a new testing procedure which takes into account the strain dependence of stress shows that instead of the S-shaped log stress-log strain rate plot, one obtains straight line plots. This means that the slope of the curve at any strain rate, instead of varying from 0.2 to 0.9, is correctly a constant, with the slow strain rate values averaging about 0.5. Since the "m" value was assumed to be a measure of the degree of diffusional creep during super-plastic behavior, the constant slope indicates that diffusional creep is not the controlling factor in super-plastic behavior. Indeed, it is found that neither the slope nor the measured ductility at fracture reach a transitory maximum. In both alloys, ductility continued to increase down to strain rates as low as 10^{-7} per second, far lower strain rates than ever are reported by the "change-load" method of testing. Grain boundary sliding appears to be the controlling factor in super-plastic behavior, with diffusional creep playing a minor role perhaps in the earlier stages of deformation.

Professor Pelloux's primary interest has been in the fracture of metals. The fractured surfaces of metals which fail by micro-void coalescence show a network of zig-zagging ridges parallel to the crack front in the plane-strain region of the fracture. It is now possible to describe the form and scale of these ridges, to correlate their size to mechanical properties of the alloy, and to formulate a theory of ductile fracture to account for their presence. Most of this work has been done on a variety of steels and aluminum alloys. The fatigue strength in corrosive environments is, of course, a subject of special concern. In various aluminum alloys, it was found that relative susceptibility to stress corrosion cracking and to corrosion fatigue at low growth rates in the short transverse direction is the same. Thus, it is thought that a measure of the longtime susceptibility to stress corrosion cracking

can be provided by short-time corrosion fatigue tests. If this proves to be correct, it could well form the basis of an important engineering test.

The influence of important physical and metallurgical variables on the fatigue fracture of aluminum alloys and steels is being studied systematically. The cyclic stress-strain behavior and Bauschinger effect of high-strength aluminum alloys, fatigue crack growth rates in aluminum alloys, the effects of various casting and isostatic pressing techniques in alloys developed by powder metallurgy, and the influence of strain induced martensitic transformation on the fatigue crack growth rate in stainless steel are all under active investigation.

Chemical and Process Metallurgy Part of the research in chemical metallurgy has dealt with the technology of submerged gas injection in steel-making. Experiments have been carried out under the direction of Professors John B. See and King in which air-water modeling has been used to examine the physical behavior of gas injection into liquids. Particular attention has been paid to high-velocity jets with Reynolds numbers in excess of 10^5 . It is apparent that the behavior changes dramatically from separate, large bubble formation at low Reynolds numbers to "jetting" at very high Reynolds numbers. Attempts presently are being made to determine the gas-metal interfacial area developed with high-velocity jets.

Professor John F. Elliott has continued to direct a wide range of important research concerned with the thermodynamics, kinetics, and physical chemistry of steel-making and other metallurgical extractive processes. Work on the thermodynamic properties of the bcc and fcc phases in the iron-chromium-carbon system has been completed, as have measurements on the activity of manganese in iron-manganese-carbon alloys. New experimental work to extend the measurements on the activity of silicon in bcc and fcc iron-silicon-carbon alloys is now under way. Good progress has been made during the year in measuring the surface tensions at 1,350 to 1,450^o centigrade of gamma-iron, liquid iron, and the liquid oxy-sulfide phase in the iron-sulfur-oxygen system. Measurements of density and of the surface tension of the copper-iron sulfides also have been obtained. Equipment has been assembled to measure the interfacial tension between the pairs of phases in the iron-sulfur-oxygen system. The method employs X rays to determine the shape of the interface.

An extended study has been completed of the kinetic factors that control the rate at which sulfur dioxide is liberated from the surface of a hot slag exposed to oxygen-bearing gases. The rate has been found to be controlled by diffusion in the gas-boundary layer at low oxygen pressures (when PO_2 is less than 0.25) and it is half-order with respect to sulfur in the slag at higher oxygen pressures.

Work is in progress on the oxidation of calcium sulfide.

An extensive study is in progress of all the available information relating to phases of importance in the pyrometallurgy of copper. The location of the slag-matte miscibility gap in the FeS-Cu₂S-FeO-SiO₂ system and the extent of the oxy-sulfide field at 1,100^ocentigrade to 1,300^ocentigrade are being studied. The work includes measurements of the activities of FeO, FeS, Cu₂S, and Cu₂O in the surfaces of this field that are saturated with copper, iron, FeO, SO₂ (1 atm), and Fe₃O₄.

Some work on materials systems is also under way in the Department. Professor Elliott has developed a computer model of the United States steel industry that predicts the future requirements of scrap, ore, fluxes, and fuels of various kinds. The model is being used to explore the effects of technological change on these needs.

Professor Bever is carrying out research on the economics of engineering materials, with special emphasis on the production of materials from secondary sources. Research and development work also was conducted for an exhibit on world metals resources at the Boston Museum of Science.

Professors Flemings and Robert Mehrabian supervise a major joint M. I. T. -industry research activity which is aimed at introducing radical innovations to the steel casting process. Current emphasis of the work at M. I. T. is on the casting of semisolid alloys, electromagnetic levitational containment, and transport of the molten or semisolid alloys. In addition to this large and important activity, the group has other projects under way. All of them are concerned with processing in various forms. They include research on the crystal growth of "composite" crystals and the study of crystals grown in the complete absence of convection in the liquid. Other research comprises analytical and experimental studies of macro-segregation in ingot solidification. An important component of the program is on heat flow and solidification behavior of ferrous castings and ingots made by electro-slag remelting. Emphasis is on techniques of improving directionality of solidification, reducing dendrite arm spacing, growing aligned composite structures of high-temperature alloys, and making shaped castings using electro-slag remelting.

In other work, the influence of solidification heterogeneities on the properties of wrought aluminum alloys is being studied. It has been shown that by careful control of solidification and thermal mechanical processing, significant improvement in properties of wrought aluminum alloys can be obtained. In work designed to improve understanding of the deformation and flow behavior of partially solidified alloys, the flow properties of low-melting-point alloys have been measured with specially constructed viscometers. A practical objective of this study is to understand the conditions necessary to develop a process which would permit casting alloys in the "semisolid" state. Yet another program is aimed at developing new ways of refining aluminum scrap that will cost less and result in reduced pollution. Current work concentrates on processes involving melting and partial solidification.

Electronic Materials The research of Professors Gatos and Witt continued through the past academic year at an even greater intensity than previously. The most spectacular achievement was the growth of an InSb crystal under zero gravity, as one of the Skylab experiments. It was established that ideal diffusion steady-state conditions, never accomplished on Earth, were achieved during the growth of a tellurium doped InSb crystal in Skylab. Surface tension effects led to a nonwetting condition under which free surface solidification took place in confined geometry. It further was found that, under forced contact conditions, surface tension effects led to the formation of surface ridges (not previously observed on Earth) which isolated the growth system from its container. In addition, it was possible, for the first time, to identify unambiguously the origin of segregation discontinuities associated with facet growth, the mode of nucleation and propagation of rotational twin boundaries, and the specific effect of mechanical-shock perturbations on segregation. The results obtained prove the advantageous conditions provided by outer space. Thus, fundamental data on solidification, thought to be unattainable because of gravity induced interference on Earth, is now within reach.

Within the space available, it is possible to mention only three other items relating to electronic materials. Professor Rose, in collaboration with Professor Margaret L. A. MacVicar, has made some significant advances in developing practical superconductors. Together, they have developed a high-temperature superconductor by eliminating almost all of the porosity from $\text{Nb}_3\text{Al}_{0.75}\text{Ge}_{0.25}$ ribbon fabricated by a special process, with the results that J_c is approximately double for all temperatures and fields and the ribbon is stronger and more resilient but still quite brittle. They also have produced zirconium doped Nb_3Al ribbon which at 4.2° Kelvin has a J_c at all applied fields up to 150 kOe. By control etching and oxidation, they have fabricated high-quality tunnel junctions in the surfaces of rolled niobium sheet.

Professors Gatos and Witt have carried out a successful study of current controlled crystal growth and dopant modulation. The interface demarcation technique using thermoelectric cooling (Peltier effect) associated with current transport across a growth interface has been modified to achieve current controlled crystal growth in liquid-phase-epitaxial systems of III-V semiconductors, under conditions whereby the temperature of the overall system remains constant. In addition to growth, current transport across growth interfaces in ternary systems leads to pronounced modulation in dopant segregation and composition. This new approach to solution growth originally applied to InSb now has been extended successfully to GaAs and GaAlAs. Another interesting aspect of work on crystal growth is the demonstration that interfacial demarcation, achieved by transmitting current pulses across the growth interface combined with spreading resistance measurements, is suited uniquely to the quantitative investigation of facet growth and associated dopant segregation behavior. Applying this technique to Czochralski growth of gallium doped germanium, it was found that facet growth and segregation are more complex phenomena than assumed in the accepted theoretical models.

Professors Gatos and Witt also have directed their attention to semiconductor thin films. The study of the growth of epitaxial alpha (6H polytype) silicon carbide on alpha silicon carbide substrates by chemical vapor deposition from the silane-propane-hydrogen system was continued. It was found that the optimum growth temperature was 1,600° centigrade. To obtain SiC layers of good quality, a silicon:carbon ratio greater than one is required. The best layers were grown on the A(0001) silicon surface of the alpha-silicon carbide substrates. The growth of epitaxial silicon carbide was found to be an activated process, which could be described in terms of adsorption-desorption kinetics, where adsorption of silicon is the rate-limiting step.

Ceramics A substantial proportion of the total research effort of the Department is concentrated in the group of faculty members concerned with ceramics. Broadly, the current research work of Professors Bowen, Coble, Robert W. Hopper, William D. Kingery, Donald R. Uhlmann, and Wuensch can be described as including: 1) research on the kinetics of phase change, diffusion, and the development of microstructure in ceramics; 2) the relationship of properties to composition, crystal structure, and microstructure; 3) research on the structure and properties of thin films and noncrystalline solids; and 4) materials synthesis and preparation.

Recent studies have focused on the importance of grain boundaries in a variety of phenomena in ceramic materials. There are several processes in which the transport of material is controlled by lattice, grain boundary, surface diffusion, or a combination of these. Solid-state reactions, oxidation, permeability of membranes, sintering, hot-pressing, diffusion creep, and dissolution of refractories into glasses or slags are some processes which have been analyzed by Professor Coble and his colleagues. These processes are of two types: those in which the physical boundaries do not move as diffusive transport occurs, and those in which motion of the crystalline boundaries themselves changes the effective length of the diffusion path. It has been shown that for some of the processes which have been analyzed, the traditional quasi-steady state solutions are inadequate, and an additional term, which accounts for the position of the observer moving through the concentration distribution, is necessary.

A practical application of grain-boundary studies has stimulated Professor Bowen to extend his work on the mobilities of grain boundaries in alkali halides. This group has shown that polycrystalline alkali halides can be strengthened by strain induced recrystallization without degradation of the optical properties; this is a discovery of great importance to the development of laser windows. Professor Bowen and his colleagues now are studying the effects of residual strain, grain size, and dopants on the stability of the microstructure.

Another important aspect of grain boundaries is the associated electric charge. Previous measurements of the charge have been restricted to dislocations and a low-angle dislocation network boundary in sodium chloride. Professor Kingery has carried out measurements on grain boundaries in a variety of halide and oxide samples by observing the bowing of grain boundary segments (pinned at inclusions or at three-grain junctions) in an electric field. The experimental results indicated a positive boundary charge in Al_2O_3 (containing some MgO) and a negative charge in MgO and in all samples of NaCl. The work will be extended to include a detailed evaluation of the field distribution within the sample, including the effects of impurities.

Much of the work of the ceramics group is of direct import to the analysis and design of reactor fuel elements. Some current studies in this category are thermal gradient studies in UO_2 and $(\text{U}, \text{Ce}) \text{O}_2$ under the direction of Professor Bowen; the growth of UO_2 single crystals by chemical vapor transport; and the studies of self-diffusion and transition-metal ion diffusion in oxides, which are being supervised by Professors Coble and Wuensch.

Polymers and Glasses The deformation of amorphous and semicrystalline polymers is being investigated by Professors Uhlmann and Hopper. They are interested particularly in the relationships between the mechanical properties and various structural and micro-structural characteristics of polyethylene, polypropylene, polycarbonate, polyvinyl chloride, polymethyl methacrylate, polyethylene terephthalate, and polyvinylidene fluoride (PVDF). New, translucent, cold-drawn forms of polypropylene and PVDF have been made. In addition, the effects of several crystallization treatments on the mechanical behavior of semicrystalline polymers are being investigated. Particular attention has been directed to the process of crystallization under conditions of flow, and to the effects of various process variables, including the extensional component of flow, on the resulting microstructure and the mechanical properties of the materials. Highly transparent rods and sheets of polyethylene and PVDF have been produced in this way. The mechanical properties are being investigated, and the study is being extended to include other polymers, more detailed characterization of the oriented microstructure, and mechanical tests under a variety of stress conditions.

The technique of ion exchange (chemical) strengthening offers particular promise for producing glasses with exceptionally high strength. The full exploitation of this technique is limited by the depths of the ion exchanged layers which can be obtained in reasonable time without excessive relaxation. Professor Uhlmann, in collaboration with Professor Bertram E. Warren (of the Department of Physics) is studying the structural state of the common modifying cations in oxide glasses and their effects on the overall network structures, with the object of developing more satisfactory glasses than the alkali aluminosilicates commonly used for this application.

WALTER S. OWEN

Department of Nuclear Engineering

The Department of Nuclear Engineering and the entire nuclear profession are in the midst of an accelerating demand for their services and products. The role of nuclear power in the United States and Europe has undergone a dramatic increase in importance, as a result of the disruption in supply and costs of fossil fuels for energy production. Until 1973, nuclear energy production had been growing at a slow, steady pace; in 1973, about 5 percent of the United States electric energy production was nuclear. Atomic Energy Commission (AEC) projections had indicated that nuclear plants would produce about 10 percent of U. S. electric energy by 1980 and about 50 percent by the year 2000. These projections now are considered conservative by the Federal Power Commission, and the nuclear fraction is

expected to reach 50 percent of United States total fully 10 years sooner, i. e. by 1990. In the next 16 years, it is expected that new nuclear plant construction will be about 500,000 megawatts, which will exceed the entire United States electric generating capacity in 1973 of about 430,000 megawatts.

The expectations for nuclear power in the United States are matched or exceeded in European countries. France has announced its intention of relying solely upon nuclear plants for new generation of electricity. In conjunction with this policy, the French national utility, Electricite de France, has placed a single order for 11 giant plants of the 1200-megawatt size, the largest order for electric generating equipment ever. Similar plans to "go nuclear" have been made in England, Scandanavia, Germany, and Italy.

In addition to the enormous market for nuclear plants, there has been a very rapid recognition by national planners of the importance of further development of nonfossil means of energy production, with particular emphasis on second- or third-generation nuclear plants. Research programs in advanced reactor concepts, including thermonuclear reactors, have been accelerated. In the United States, the AEC, electric utilities, foundations, and reactor vendors themselves all are increasing their budgets for research. The impact of this increased interest already has been felt in the Department's research activities and will be discussed below.

The worldwide increase in the importance of nuclear energy is reflected in the admissions statistics for the Department. The total number of applications for graduate admission for the past four academic years has been: for 1971-72, 87; 1972-73, 85; 1973-74, 102; and 1974-75, 130. It is evident that student interest is increasing, and it is likely to continue to do so in the foreseeable future. Graduate enrollment in the Department has shown a corresponding increase over the same period: for 1971-72, 117; 1972-73, 113; 1973-74, 122; and 1974-75, 125.

However, enrollment has been limited by available financial aid resources, rather than the number of available applicants. For the past two academic years, aid for new students has been limited to the equivalent of 12 full-time assistantships. As a result, many well-qualified and deserving students are unable to attend M.I.T. In spite of this dearth of support, enrollment in the Department is increasing. This reflects the interest and determination of students to pursue graduate studies in nuclear engineering at M.I.T. In the past academic year, a total of 46 graduate degrees in nuclear engineering were granted, including 33 Masters of Science, five Nuclear Engineer, and eight doctoral degrees.

The Department has been fortunate in receiving fellowship support from the General Electric Foundation, Babcock and Wilcox Company, and Northeast Utilities. In addition, the Boston Edison Company has agreed to begin a cooperative program in the 1974-75 academic year; the first student already has been selected. Furthermore, the AEC is continuing its traineeship program with six trainees. It is the hope of the Department that the increasing fortunes of the nuclear industry will stimulate additional fellowship support for deserving students.

Next year the level of graduate student support will be higher, due to increased research volume in the Department. The Electric Power Research Institute (EPRI) has awarded the Department a sizable research project on reactor safety. This is the first EPRI-Institute contract, and it is indicative of the recognized strength of the Department of Nuclear Engineering. Another important forthcoming project in the Department is a fusion technology program which is to be sponsored by the AEC. The Department also has attracted new projects from the United States Army, the National Science Foundation, the M.I.T. Energy Laboratory, and others. As a result of these successful efforts in obtaining research support, the total research volume administered by the Department is expected to increase from \$680,000

for fiscal year 1974 to over \$1.3 million for fiscal year 1975. In addition, research support amounting to approximately \$280,000 is supervised by Department faculty, but administered by various interdepartmental laboratories at the Institute.

The academic program in the Department has continued to evolve and expand. The growing interest in energy production and utilization has been reflected in the number of undergraduate students at M. I. T. seeking some knowledge of the nuclear engineering profession. In response to this demand, the Department has increased its undergraduate subject offerings during the past academic year. Professor Irving Kaplan introduced a new subject, 22.02 Physics of Nuclear Energy, which was aimed at providing students with a technical understanding of nuclear means of energy production. Professors Sidney Yip and Sow-Hsin Chen introduced 22.04 Radiation Effects and Uses, which explored the nature of radiation, its interactions with matter, and its applications. Professor David J. Rose introduced 22.08J Energy, which was of interest to both graduate and undergraduate students and discussed energy problems ranging from resources, technology, and production to the analysis of various existing and proposed energy strategies.

Although the Department of Nuclear Engineering does not offer an undergraduate degree, there are many undergraduates who have some interest in the field. Some of these pursue a five-year program leading to joint Bachelor of Science-Master of Science degrees. At present, the Department has joint five-year programs with the Departments of Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, and Physics. In the past academic year, there were five students in these programs. A total of three Masters of Science in nuclear engineering were awarded simultaneously with bachelor's degrees. This year the Department expects to have seven students in the program.

In order to plan better for the expansion of subjects in the undergraduate area, and to offer appropriate guidance to undergraduate students, Professor Michael J. Driscoll has agreed to serve in the new Departmental post of Undergraduate Program Coordinator.

The Department added a new graduate subject this year, 22.38 Current Developments in Nuclear Energy, which Professor Edward A. Mason offered in the fall term. The subject was limited to advanced graduate students and covered current topics of specific interest in the field. The Master of Science programs in the Department were reviewed in great detail, and several changes were made in the content of specific subjects. Most of the modifications will be introduced in the next academic year. The area of greatest change will be in fusion, where the curriculum has been revised greatly, and several new subjects on controlled fusion power will be offered next fall, as well as a new advanced subject on plasma diagnostics and transport phenomena.

The Department had a very active Independent Activities Period (I. A. P.) program, which ranged from a philosophical colloquium on paradoxes to a mini-subject on the legal aspects of nuclear reactor licensing. Altogether, the Department offered eight activities in which a total of approximately 150 students participated. The single most popular event was a two-week review of structural mechanics in reactor technology, which was taught by Dr. Thomas Jaegar of the Technical University of Berlin. In addition to offering the mini-subject, Dr. Jaegar helped in the curriculum planning and development for a new interdepartmental subject on structural mechanics in nuclear technology. This subject will be introduced in the fall of 1974 as a cooperative venture of the Department of Nuclear Engineering and the Departments of Civil Engineering, Mechanical Engineering, Metallurgy and Materials Science, Ocean Engineering, and Aeronautics and Astronautics.

Members of the Departmental faculty have been very active in teaching special summer programs. Professor Norman C. Rasmussen has continued to offer a well-attended program on nuclear power reactor safety. Professor Arden L. Bement has joined Professor

Rasmussen's program, with a particular emphasis on fast reactor safety. Professors Chen and Yip taught a summer program on neutron and light scattering. The lecture notes from this program were compiled into a manuscript entitled "Spectroscopy in Biology and Chemistry -- Neutron, X-ray, Laser," edited by Professors Chen and Yip. Professor Gordon L. Brownell directed a summer program on the physical aspects of nuclear medicine. Professor Rose, with the cooperation of Professor Michael W. Golay, presented a program on Energy -- A Unified View. Professors Manson Benedict, Kent F. Hansen, and Edward A. Mason presented a program on nuclear fuel and power management. All of the above programs have been attended well, and represent the continuing activities of the Department.

The M. I. T. Research Reactor was shut down for modifications on May 24, 1974. It achieved initial criticality in July, 1958, and has been running continuously since that time. Over 250,000 megawatt-hours of energy have been produced in the 16 years since the reactor start-up. The facility has been useful in the training of over 450 students. More than 900 thesis papers and reports have been published since its initial conception. Approximately 43 different M. I. T. faculty members have participated in research at the Reactor.

The redesign will include a new core which will increase the radiation intensities available. As a result, it is expected that the facility will be an even more versatile tool in the future than it has been in the past. The modifications of the Reactor are expected to be completed before the end of 1974, and the Reactor should be back on line in early 1975. The modification and redesign of the reactor are under the direction of Professor David D. Lanning, with the cooperation of Professor James W. Gosnell. The operation of the Reactor is under the direction of Lincoln Clark, Jr., director of the facility.

Research in the Department has been carried on at a high level of activity during the past academic year. Professors Allan F. Henry and Hansen have continued their work sponsored by the AEC on numerical methods for the analysis of reactor transients. Professor Henry also has directed work, sponsored by the Combustion Engineering Company, on light-water reactor theory. Professor Driscoll continues to lead an AEC sponsored project on fast-reactor blanket analysis and experimentation. Professors Benedict and Mason have been directing research on the nuclear fuel cycle, particularly on the economics, planning, and analysis of fuel management methods. The work has been sponsored by the Commonwealth Edison Company and the American Electric Power Company. Professors Yip and Chen have directed a program of experimental studies on the neutron scattering of hydrogen bonded solids, with the sponsorship of the National Science Foundation. In addition, Professor Yip has begun further studies of the molecular dynamics of solids and chemically reacting systems.

Professor Bement has been working on nuclear materials research, including deformation and fracture behavior of zirconium alloys, as well as critical materials problems for advanced high-temperature gas cooled reactors. Professor Golay has been working on a series of problems related to the engineering effects of nuclear power, and including such topics as cooling tower drift modeling and elimination, coupled thermal-electrical systems, and thermal-hydraulic modeling. Professor Neil E. Todreas continued his research on reactor thermal analysis in the areas of coolant energy mixing in rod bundles, numerical simulation of convective heat transfer, thermal design of fusion reactor systems, and the treatment of uncertainties in reactor thermal analysis. The work is supported by the AEC and by the General Atomic Company. Professor Elias Gyftopoulos continued work on quantum thermodynamics in collaboration with Senior Lecturer George Hatsopoulos of the Department of Mechanical Engineering. Much of the work was used in developing a new approach to the teaching of the basic engineering principles subject in the Department. Professor Gyftopoulos and his students also have been working on the application of Markovian theory to reliability and availability analysis. Professor Kaplan has continued his research in the area of the history of atomic theory and the general subject of history and technology. Professor Kaplan also has been a member of the undergraduate experimental education program, Concourse.

The increased interest in thermonuclear power has been reflected in the research activities of Professors Lawrence M. Lidsky and Peter A. Politzer regarding plasma experimentation and diagnostics. Professor Lidsky also has continued to serve as a member of the advisory committee to the ALCATOR experiment. Professors Deiter J. Sigmar and Thomas H. Dupree have continued their work in the area of plasma theory and dynamics.

Members of the faculty have received several honors in the past academic year. Professor Benedict was awarded the John Fritz medal and certificate for 1975. This is the highest honor the organized engineering professions can bestow for "notable scientific or industrial achievement." Professor Henry was awarded the Outstanding Teacher Award by the American Nuclear Society student chapter at M. I. T. Professor Chen was promoted to the rank of full professor.

The faculty members of the Department have been very active in service to the Institute and to the nation. Professor Gyftopoulos served as chairman of the M. I. T. faculty for the past academic year, and will continue to serve in the forthcoming year. Professor Henry has been a member of the Committee on Educational Policy and the Department's representative to the Committee on Graduate School Policy. Professors Bement, Rose, and Golay have served on various advisory committees to the Energy Laboratory. Professor Golay also has been a member of the I. A. P. Policy Committee.

Professor Mason was elected vice-chairman of the AEC Advisory Committee on Reactor Safeguards. Professor Henry continues to serve on the AEC Advisory Committee on Reactor Physics. Professor Rasmussen has continued his work as director of a special study on light-water reactor safety. The study, which is nearing completion, is aimed at providing an analysis of the probabilities of reactor accidents and their consequences. Professor Rasmussen has become recognized worldwide as a leading authority on reactor safety as a result of this work. Professor Bement served as a member of an International Atomic Energy Agency (IAEA) advisory committee to the Mexican Institute of Nuclear Energy. Professor Rose served as cochairman of an international workshop on fusion reactor design. Professors Mason and Hansen serve as members of the Board of Directors of the American Nuclear Society. Professors Yip and Chen were invited by the National Science Council and the National Tsing Hua University of the Republic of China to visit Taiwan and to assist local planning on nuclear energy programs.

During the past academic year, the Department was fortunate to have Professor Jack Scarborough as a visiting professor. Professor Scarborough contributed much to the work in nuclear economics and offered general advice on the Department's programs in management, fuel cycle analysis, and power economics. Professors Brownell and Lidsky were on sabbatical leave for part of the 1973-74 academic year. Professor Brownell continued his research in nuclear medicine and related topics, while Professor Lidsky worked on problems of plasma chemistry and fusion technology.

The Department was fortunate to obtain the services of Professor Peter A. Politzer as Assistant Professor of Nuclear Engineering. Professor Politzer is working closely with Professor Lidsky and other members of the fusion area in experimental plasma physics and fusion technology. In addition, Professor Dieter J. Sigmar accepted a joint appointment with the Department of Nuclear Engineering and the Department of Aeronautics and Astronautics. Professor Sigmar is a specialist in plasma theory and greatly strengthens the Department's academic program in this area. Professor Lothar Wolfe of the Technical University of Berlin has joined the Department for approximately one year as a visiting professor. Professor Wolfe will assist the Department in the fission reactor engineering area, and has agreed to help teach one of the introductory subjects in reactor engineering. John L. Cochrane was promoted from assistant to the director of the M. I. T. Reactor to the

post of administrative officer of the Department.

EDWARD A. MASON

Department of Ocean Engineering

The Department has completed this, its eightieth year, with strength and vitality. It continues its dedication to the broader aspects of ocean engineering, including marine resources, offshore platforms, ocean measurement systems, and the like, as well as to naval architecture and marine engineering.

Academic Highlights

Student enrollment in the Department reached an all-time high of 197 this past year, exceeding the previous year's enrollment by 13 percent. The Department is pleased with this growth, and especially pleased that the undergraduate body continues its relatively sizable increases (19 percent). It is expected that enrollment will remain constant, if not grow slightly, in the next academic year.

The Department's total enrollment now places it fifth in size in the School of Engineering. On the basis of graduate enrollment, the Department of Ocean Engineering ranks fourth in the School of Engineering and seventh in the Institute.

The Department's Cooperative Work-Study Program (Course XIII-C) has passed its pilot test successfully, and efforts are proceeding for a scale-up in operations. It is estimated that two or three companies and five students will be participating by this time next year. It is felt that there will be still more companies and as many as 10 students involved in the following year. This element of the academic program is attractive for several reasons, not the least of which is the opportunity it affords students to gain hands-on experience.

Other student opportunities for hands-on experience have been provided. The subject 13.90 Ocean Engineering Laboratory is one example; students design field tests, create instruments and gear, execute field programs, evaluate the results, and write a critical report. Another example is the Great M. I. T. Boat Race; students build hull models, measure resistance in the towing tank, normalize results to "race rules," and declare a winner based on minimum power. Other examples abound: students use a sextant aboard a ship in 13.S06 Art and Science of Navigation; students operate sonar gear at sea in 13.85 Fundamentals of Underwater Acoustics Applications; and students visit a shipyard in 13.64J Water, Air, and Interface Vehicles. Most importantly, the Department's laboratories (and a large number of other laboratories to which it has access) are a focus for student related research and education, as well as for advanced research. The Department strongly believes that hands-on experience should illuminate the concepts central to the student's program, and in this light such an experience can be quite rewarding and stimulating. While some students do not elect to take hands-on subjects as much as they should, most do, and the Department has been encouraged to continue this mode of education.

It is important that an academic program be relevant to society, as well as challenging to its students. Many faculty members are connected closely with industry through consulting. Also, many are connected with national and worldwide trends through relevant task groups or committees. This process enhances the Department's ability to center the academic program on meaningful career objectives. All feedback available to the Department, including records kept by the Career Planning and Placement Office and the Alumni Association, indicates a favorable job situation for its graduates. More directly, job opportunities flowing into Department headquarters exceed the available candidates in number. These opportunities

cover the spectrum of naval architecture, marine engineering, and other aspects of ocean engineering such as offshore platform engineering.

The Department has elected to focus on two of its existing courses for possible restructuring and improvement. Course XIII-A, Naval Construction and Engineering, long has been the best of its kind in the world and a cornerstone of the Department. Enrollment in this Course has decreased somewhat in recent years, and sponsors of the United States Navy students have questioned the disappearance of classified subjects. Course XIII-B, Shipping and Shipbuilding Management, is recognized as an important area, but student interest has been low. A review and planning process for each has begun. It is hoped that some elements of the Department's plans will be ready for implementation at the beginning of the next academic year.

A fundamental posture of today -- and at least for the next several years -- is one that must combine academic excellence with fiscal economy. This is true for this Department and for the entire School of Engineering. One can detect an increasing need to mitigate financial stringencies via fundamental questioning of the role of each department. Correspondingly, an increasing willingness to plan and execute common programs and to share human and physical resources also has become evident. Thus, the Department will become more involved with School-wide planning for the future. While somewhat of a change in style, the Department already has taken many important steps in this direction, and it should have little difficulty adapting to this fundamental and far-reaching change.

Research

The Department's funded research program now has a volume well above \$1 million. This past year, it consisted of about 50 separate projects, of which approximately 60 percent were new and 40 percent extensions of previous work.

The ship model towing tank increased its activities during the past year in all categories: demonstrations, student theses, sponsored research, and commercial testing. Rather extensive renovations were made to the tank's electrical system, for reasons of safety and convenience. The facilities were made available to students at the University of New Hampshire and to the U. S. Coast Guard Academy (for a short time and with reimbursement), and the tank and staff aided the Boston Museum of Science (gratis) in developing some of their display material.

Sponsored research programs using the variable pressure water tunnel have maintained the increased level of the previous year. While the total number of students using the facility decreased from 148 to 113, actual student use in hours increased substantially. This is a result of a trend toward increasing numbers of individual special projects and theses, and a reduced number of formal class laboratory sessions. To accommodate all users, a considerable amount of evening and weekend use of the tunnel has been necessary.

There has been substantial progress in the construction of the Department's precision free-surface flume for oil pollution studies. The design requirements and constraints on this flume are different from those on any other that has been built; an extensive research program was necessary before construction could begin. This included the design, construction, and testing of two alternative one-quarter scale flow models, one of which was found to be satisfactory. The design work for the full-size flume has been completed, and construction has begun. The Department expects to have the flume in operation by the start of the fall term, ready to serve its important research efforts in oil pollution control.

The Marine Data Systems Laboratory was established in 1973 to improve the Department's capabilities in ocean instrumentation. The Laboratory provides basic electronic test and

design equipment, working space, and a modest stock of specialized gear to support research. In addition, the Laboratory facilities are used for projects of the Ocean Engineering Laboratory that entail instrumentation and their mechanical constructs. Current projects in the Marine Data Systems Laboratory include the design and construction of an active, neutrally buoyant float for near-surface current tracking. This instrument and its associated sonar tracking system recently have been tested in the open ocean south of Nantucket Island. Other work includes development of a Doppler scattering speedometer and the design and construction of a robot submarine for underwater sensing.

Initial plans for the Department's Design Laboratory were formulated in 1971, and major new proposals for support were made in 1972. Work in support of education development for naval architecture and ocean engineering centered in the Design Laboratory has been funded by the National Science Foundation, and is to commence in July, 1974. This will be done in collaboration with the University of Michigan and the Webb Institute of Naval Architecture. Several other efforts centered on the Design Laboratory have been funded, or soon will be. These are: offshore platform design (Sea Grant); surface effect ship design (Naval Ship Research and Development Center); and procedures for evaluating water, air, and interface vehicle designs (Advanced Research Projects Agency).

Faculty

The Department has increased its faculty with the addition of Professors Wesley L. Harris and Judith T. Kildow. Professors Arthur B. Baggeroer of the Department of Electrical Engineering and J. Daniel Nyhart of the Sloan School of Management now hold joint appointments with the Department.

Professor Kevin J. O'Toole has succeeded Professor William R. Porter this year as Professor of Naval Architecture and chairman of Course XIII-A. Also, Professor Clark Graham relieved Professor Warren C. Dietz as Associate Professor of Marine Engineering. Both continue to enhance the strong tradition of U. S. Navy involvement with the faculty of the Department and with the substance of educational programs at M. I. T.

Effective July 1, 1974, Professor Chryssostomos Chryssostomidis has been promoted from assistant to associate professor, and Professors Norman Jones and Jerome H. Milgram will assume the rank of associate professor with tenure. The Department is pleased with these changes and extends to each congratulations and best wishes.

Professors Ernst G. Frankel and J. Nicholas Newman have been on sabbatical during the past academic year. For the academic year 1974-75, sabbatical leaves have been approved for: 1) Professor Norman Jones, who will be in residence at the University of Manchester from January through June, 1975; 2) Professor Koichi Masubuchi, who will be in residence at the University of Tokyo for the spring term of 1975; and 3) Professor Jerome H. Milgram, who will spend the entire academic year at Harvard University.

The Department was fortunate in having three visiting faculty and staff members: Visiting Professors Joseph Gabriel Debanne, of the University of Ottawa, and William Moore, of the United States Merchant Marine Academy, and Visiting Engineer Yoshitsugu Toshioka, of Ishikawajima-Harima Heavy Industries, in Tokyo, Japan.

Honors and Activities

Professor A. Douglas Carmichael published Ocean Engineering Power Systems in the spring of 1974 as part of the M. I. T. Sea Grant Series of texts. Professors Ernst G. Frankel and Henry S. Marcus coauthored Ocean Transportation, which was published by the M. I. T. Press. Professor Marcus was also the author of Planning Ship Replacement in the Containerization Era, published by Lexington Books.

Professor Ira Dyer was appointed chairman of the Sea Floor Engineering Committee of the National Academy of Engineering. Professor Justin E. Kerwin served as a member of the Society of Naval Architects and Marine Engineers (SNAME) Technical and Research Panel H-13 Sailing Yachts. Professor Judith T. Kildow was a member of the Governor of Massachusetts' Task Force on Coastal Zone Management and also served on the Editorial Board of the Coastal Zone Management Journal. Professor Alaa Mansour was appointed to the Sea Floor Engineering Committee of the National Academy of Engineering, and to Advisory Group II of the Ship Research Committee of the National Academy of Sciences. Professor Henry S. Marcus served as a member of the Advisory Committee for United States Ocean Shipping Technology Forecast and Assessment of the Maritime Administration. Professor Koichi Masubuchi was appointed a member of Committee III, Fabrication Factors Affecting Structural Capability, of the International Ship Structures Congress, and also a member of the Committee on Underwater Electrical Safety Practices of the National Academy of Engineering. Professor Masubuchi was one of five educators in the United States selected as a recipient of the Adams Memorial Membership Award by the American Welding Society.

Other Initiatives

Professional Summer Program The Professional Summer Program is made up of professional subjects organized and developed by M. I. T. and the Charles Stark Draper Laboratory. The subjects are intended for officer and civilian personnel working in systems design and analysis within technologies important to the United States services. The Program has been developed in part to meet the needs of the Navy graduate students in M. I. T. 's Department of Ocean Engineering, and in part to provide other qualified students with an opportunity to study and discuss technical issues important to the armed services. Lecturers in the Program are selected to present conceptual frameworks, up-to-date information, and perspectives for the future. They come from a variety of technical homes, including the armed services organizations, industry, and academia.

The 1973 Professional Summer Program consisted of three subject offerings and a two-day workshop. The 1974 Program will include seven subjects and a three-day workshop.

Tenth Naval Hydrodynamics Symposium M. I. T. was host this past year to the Tenth Naval Hydrodynamics Symposium. This internationally recognized symposium has been held biennially since 1956, alternately in this country and abroad. This year the symposium was sponsored by the United States Coast Guard and by M. I. T., in addition to the traditional sponsorship of the United States Navy Office of Naval Research. In keeping with the U. S. Coast Guard sponsorship, the dual theme of the symposium was: Hydrodynamic Problems Associated with Safety at Sea, and Fundamental Problems in Naval Hydrodynamics.

The technical program included 20 papers from abroad -- six from England, four from the Netherlands, three from Australia, two from Japan, one from Denmark, one from Germany, one from Israel, one from Norway, and one from Sweden -- and 17 papers from the United States. Five of the 37 papers represented the work of eight authors from M. I. T. Approximately 250 people attended. The program included a visit to the Woods Hole Oceanographic Institution and to M. I. T. research facilities.

1976 International Ship Structures Congress At the 1973 Meeting of the International Ship Structures Congress in Hamburg, the United States was designated formally as the host country for the 1976 Congress, with Professor J. Harvey Evans as chairman. The Congress will be held at M. I. T. Professor Alaa Mansour has been appointed secretary, and Professor Norman Jones has been appointed secretary for publications.

IRA DYER

Center for Advanced Engineering Study

As in the past, the main thrust of the Center for Advanced Engineering Study (C. A. E. S.) during the academic year 1973-74 was the provision of continuing technical education for mid-career men and women in industry, government, and other academic institutions. In addition, the Center continued to fill its Institute-wide responsibilities for television production and equipment rental services throughout the year.

Changes in Center administration during the year included the appointment of Evelyn T. Christiansen as assistant to the director and Linda E. Ward as administrative assistant. In these new positions, Ms. Christiansen became responsible to the director for personnel and budget policies, and Ms. Ward took over the detailed administration of C. A. E. S. space, finances, and personnel.

On-Campus Programs

Throughout 1973-74, the Center's two major on-campus programs -- the Advanced Study Program and the Education for Public Management (E. P. M.) Program -- continued to provide experienced men and women with the opportunity to spend one or more academic terms at M. I. T. while pursuing studies tailored to their individual needs and organizational objectives. These and all other C. A. E. S. on-campus programs were under the supervision of Dr. Paul E. Brown, Assistant Director of C. A. E. S.

During the academic year, there were 36 fellows in the Advanced Study and E. P. M. programs, coming from United States and foreign industries and governments. Their ages ranged from 26 to 55 years, with a median age of 40. Their educational backgrounds included not only various branches of engineering, but also business, education, mathematics, physical science, and psychology.

The foreign participants this past academic year came from ten different countries: Belgium, Bolivia, France, India, Iraq, Iran, Israel, Japan, New Guinea, and Poland. It is interesting to note that over the past several years, foreign participation in the C. A. E. S. on-campus programs has been increasing, while United States industrial participation has declined. This past year, in fact, there were more fellows from Japanese industry than from US industry. The causes of these trends are undetermined and are under study.

In addition to the foregoing programs, two new programs are under way: an Advanced Study Program in Air Transportation (in conjunction with the Department of Aeronautics and Astronautics), and an Advanced Study Program in International Nutrition Planning (in conjunction with the Department of Nutrition and Food Science and the Center for International Studies). This year, the air transportation program had its first fellow, and applicants have been accepted for the international nutrition planning program for the coming academic year.

Other activities closely related to the various C. A. E. S. on-campus programs included consulting on technical education for a number of foreign agencies. Among these were the Iranian Imperial Organization for Social Services, the Arya-Mehr University of Science and Technology (Iran), the Industrial Management Institute of Industrial Development and Renovation Organization of Iran, and several Japanese industrial organizations.

Self-study Programs

During the academic year 1973-74, the videotaping of a lecture series for ten new self-study subjects was completed under the direction of John T. Fitch, Manager of Self-study

Development for C. A. E. S. The new subjects were: 1) Colloid and Surface Chemistry, offered by Visiting Professor J. Theodoor G. Overbeek of the Department of Chemical Engineering; 2) Friction, Wear, and Lubrication, taught by Professor Ernest Rabinowicz of the Department of Mechanical Engineering; 3) Modern Control Theory, a five-part subject taught by Professor Michael Athans of the Department of Electrical Engineering; 4) Economics, a two-part subject offered by Professor Robert Pindyck of the Sloan School of Management; and 5) Artificial Intelligence, offered by Professor Patrick Winston of the Department of Electrical Engineering.

In addition, videotaping of two other lecture series was begun during the past academic year and should be completed during the coming academic year. These series are entitled Digital Signal Processing, by Professor Alan Oppenheim of the Department of Electrical Engineering, and Mechanics of Polymer Processing, by Visiting Professor J. R. A. Pearson of the Department of Chemical Engineering.

The number of organizations using C. A. E. S. self-study subjects increased from 31 during the academic year 1972-73 to 54 during 1973-74, while the number of students using that material increased from 1,550 during 1972-73 to 2,089 during 1973-74. Included among new users this year were Southern Methodist University, the University of Texas at Dallas, and Trinity University. The distribution of these materials was under the direction of Arthur J. Collias, Manager of Self-study Subject Distribution for C. A. E. S.

Continuing Education Research and Development

Evaluation In order to understand better the issues and problems arising in the distribution and use of self-study materials developed by the Center, an evaluation group was formed this year, and several detailed studies were undertaken. Professor Judah Schwartz of the School of Engineering and Eunice Moo of the Education Development Center, Inc. conducted a field study of two users: one was a large industrial corporation, and the other a government laboratory. At each location, four groups of people were interviewed: members of management (usually officials of training or education divisions); students presently taking the self-study subjects; supervisors of those students; and students who had dropped out of the courses. The data from these interviews is under study, and a preliminary report has been written. In addition, a study was made by Research Associate Charles P. Friedman (of the Department of Physics) of the use by M. I. T. students of four experimental videotapes on computer languages.

Finally, Research Associate Carroll G. Bowen and Administrative Officer Arthur Collias of the Center participated, with representatives of Colorado State University, Southern Methodist University, and Stanford University, in the planning of a National Science Foundation funded problem assessment study on the revitalization of education for engineers at mid-career, to be conducted during the coming academic year.

Educational Technology The studies of the potentials of CATV (community antenna television) in the educational program of M. I. T. led to the joint submission of a proposal to the Sloan Foundation in February, 1974, by Professor Wilbur B. Davenport, Jr., Director of C. A. E. S., Research Associate Bowen, and Professor Ithiel de Sola Pool of the Department of Political Science. The proposal covered: the development of educational material using visual media by several of the Schools at M. I. T.; evaluation of the material developed; installation of a backbone CATV system on the M. I. T. campus to distribute it; and the development of some new equipment needed to improve its generation and distribution over such a CATV system.

A second educational technology effort begun this past year was an attempt to use the MULTICS interactive computer system as a vehicle for developing a large book of problems

to be available to students for self-assessment in their studies. The protocols of students' interactions with the system would be available to faculty to help them assess the subject under study. A trial version of this self-assessment/subject-assessment instrument will be available during the summer of 1974 for use by students in the C.A.E.S. Calculus Revisited subject. This work is being done by Professor Schwartz and Research Associate Friedman.

Video Services

Facilities Two Ampex AVR-1 two-inch, quadruplex, videotape recorders were added to the C.A.E.S. central television facilities during the 1973-74 academic year, as was an RCA TK-44B color TV camera. The installation of this new equipment and the maintenance of all C.A.E.S. TV equipment was performed under the direction of Chief Engineer Charles D. Paton.

Two new TV studios also were completed during this academic year. One of these new studios is a small but complete color-TV studio to be used as an auxiliary, reducing the workload on the Center's main color-TV studio. A second new studio was fitted out with easy-to-use black-and-white TV equipment to provide an experimental facility for use by faculty and students in their explorations of the use of the TV medium. As an adjunct to the experimental studio, an experimental editing facility also was completed. The installation of these facilities was under the direction of Jerome H. Adler, Manager of C.A.E.S. Video Operations, and Chief Engineer Paton.

Services The major operations of the C.A.E.S. Video Services throughout the 1973-74 academic year were the videotapings of the self-study lecture series mentioned above, and the duplication of the videotapes required for the distribution of C.A.E.S. self-study subjects.

Other services provided included the rental of TV equipment to various members of the M.I.T. community, the videotaping of a number of special programs (including a special report to the M.I.T. Faculty Council by the Provost, Professor Walter A. Rosenblith, and two short skits by the Women's Forum), and the provision of a closed-circuit TV facility for the 1974 M.I.T. commencement. These various services were provided under the direction of Jerome H. Adler, Manager of Video Operations, and Mr. Fitch.

Film Unit In order to extend the visual recording capabilities of C.A.E.S. beyond its own studios, a film unit was established during the 1973-74 academic year. This unit can produce and edit 16-mm sound, color films for the self-study development program and for special projects. One of the latter, now under production, is a cinema-verité film entitled Women in Engineering, sponsored in part by the School of Engineering. The film unit is operated by Christine Dall, Head, and Niti Salloway, Production Assistant, under the general supervision of Mr. Fitch.

Special Operations

Under the supervision of James B. Roberts of the Center's staff, the C.A.E.S. (in conjunction with the Office for Information Technology of Harvard University) has endeavored to continue to provide some of the services formerly provided by the University Information Technology Corporation (UNITEL), which was sponsored jointly by Harvard and M.I.T. These efforts have provided information, assistance, and encouragement to a wide variety of actual and would-be video users throughout the M.I.T. and Harvard communities. Thus, for example, Mr. Roberts and Lecturer Edwin Diamond of the Department of Political Science worked with members of M.I.T.V. (an M.I.T. student television group) in the

production of their programs, using both portable TV cameras and the C. A. E. S. experimental studio.

WILBUR B. DAVENPORT

Center for Policy Alternatives

The second year of the Center for Policy Alternatives has been one of rapid growth in research volume and personnel, of increasing interaction with the educational and research activities of M. I. T.'s departments, centers, and laboratories, and of continuing service to the Institute as a whole.

Among the Center's primary functions are: the identification of major socio-technical issues facing society; the assessment of the consequences of present policies and practices; and the development and appraisal of alternative actions which will respond effectively to society's needs. The Center studies and investigates substantive issues in a wide spectrum of pressing societal problems in government, industry, and education, particularly those in which technology and engineering could play significant roles. A clear indication of the need for, and the place of, this kind of research at M. I. T. is the increase in the sponsored research volume administered by the Center, from \$300,000 in fiscal year 1973 to over \$1.3 million in fiscal year 1974. This significant increase in sponsored research activity during the past year is largely the result of the developmental research activities that were initiated by the Center in its first year of operation and funded by the Institute.

An important milestone in the Center's development as an integral part of the Institute occurred in February, 1974, when the Alfred P. Sloan Foundation awarded a two-year grant (with the probability of a three-year renewal) to the School of Engineering for ongoing research and analysis by the Center of important socio-technical problems. In the past two years, the Institute has funded the Center's research and development activities at decreasing levels. With the advent of Sloan Foundation support for the Center's ongoing research, Institute support should be at the level required only for continuing developmental efforts and for providing long-term continuity in Center activities. During the coming years, Sloan Foundation funds will support faculty, student, and Center research activities aimed at identifying and examining pivotal policy issues in the following areas: science, technology, and public policy; natural resources, recycling, and substitution; the delivery of municipal, health, and educational services; communications policy; and manufacturing, the nature of work, and public policy. Some exploratory research and program development activities in several of these areas are already under way.

In carrying out its sponsored and ongoing research programs, the Center serves as a focal point for many 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 this capacity, the Center's performance during the past year has been very successful. The number of faculty members supported in part by Center projects increased from seven in fiscal year 1973 to 16 in fiscal year 1974, with a corresponding increase in student support from 11 to 32 graduate students. Because the Center has no formal teaching program, the faculty and students it supports are drawn from M. I. T.'s departments, and these increases reflect, in part, the growing impact of the Center on the educational and research programs of the Institute.

Personnel

Paralleling the growth in research volume and in faculty and student support, the Center's professional research staff increased by six people, and at academic year's end included

four senior research associates, six research associates, two postdoctoral fellows, and one research fellow. Dr. K. Nagaraja Rao, formerly with the Ford Foundation's Office for Latin America and the Caribbean, was appointed senior research associate in May, 1974, joining Senior Research Associates Robert T. Lund, Joel Yellin, and Nicholas A. Ashford, and Research Associate Marvin A. Sirbu, Jr., as one of the Center's professional staff. Dr. Rao concurrently will hold an appointment as senior lecturer in the Division for Study and Research in Education during the academic year 1974-75. Mr. Lund also was appointed as lecturer in the Department of Mechanical Engineering, and taught a subject in that department during the second term of the academic year 1973-74. Dr. Yellin was appointed jointly with the Department of Political Science during this past academic year, and on July 1, 1974, will become an associate professor in the School of Humanities and Social Science.

Dr. Jean-Claude Derian, who came to the Center as a research fellow from the Commissariat a l'Energie Atomique, Centre d'Etudes Nucleaires de Saclay, assumed the rank of research associate in April, 1974, and will return to France in September, 1974. Research Associate Dudley W. Coillet was formerly with the Alfred P. Sloan School of Management and the Department of Political Science, and Research Associate Hani K. Findakly came to the Center from the Department of Civil Engineering. Research Associate Lois H. Godiksen was formerly at the University of Wyoming, and Research Associate Nake M. Kamrany came to the Center from the Department of Economics at the University of Southern California. Research Associates Findakly and Godiksen came to the Center specifically to work on the Sahel-Sudano project.

Robert Treitel of the International Institute of Applied Systems Analysis in Austria joined the Center as a research fellow for one year. Dr. Baruch Raz, of Tel-Aviv University, and Dr. Sam Pasternack, formerly with the Department of Transportation, were appointed postdoctoral fellows. Andre Staropoli, a research fellow and an active participant in several of the Center's projects, returned to his position as head of the Bureau of Information and Public in the General Delegation for Scientific and Technical Research of the French government in February, 1974.

Research

Research activities undertaken by the Center during the past academic year are not necessarily areas where policy analysis will have the maximum leverage, nor are they necessarily society's most pressing issues. Rather, they are important issue areas where the Center's initial efforts can have an immediate impact, where sponsored funding is available, and where current C. P. A. staff and M. I. T. faculty and students have expertise and active interests.

The Technology Policy Program is now an established program area, with three sponsored projects as well as continuing developmental research. This international research effort seeks to examine national policies for supporting technology in industrial nations, and then to formulate alternative policies for each nation. The Center is establishing this Program through bilateral agreements independently arranged with several nations.

Two of several anticipated bilateral agreements were funded this past year. Professor J. Herbert Hollomon, Director of the Center, and Research Associate Sirbu continued to direct a 20-month project, funded by the General Delegation for Scientific and Technical Research of the French government, which focused on French policy instruments and practices and aimed at supporting effective technology utilization in French industry. Professor Harvey Sapolsky of the Department of Political Science and three graduate students participated in the project. Research Associate Sirbu and the graduate students spent several months in France carrying out specific research tasks as a part of this project. The presence of

Mr. Staropoli and Research Associate Derian at the Center during the past year was an integral part of the French bilateral agreement. This was the Center's first project to be sponsored by a foreign government, and hopefully it will serve as a model for future efforts of this type.

The second bilateral agreement is being supported by the State of Sao Paulo in Brazil, and is just beginning as the fiscal year comes to a close. Funded for two years, the Sao Paulo project is directed by Dr. Rao; it provides for the exchange of professional staff between the Center and the Sao Paulo state government, and for research by M. I. T. faculty and graduate students in Brazil.

Professor Hollomon and Professor Thomas J. Allen of the Sloan School of Management continued to direct the 16-month National Science Foundation (NSF) project, begun late in June, 1973. An interim report describing some of the policy instruments influencing technological change in France, Japan, the Netherlands, the United Kingdom, and West Germany, and a preliminary bibliography of over 300 documents dealing with technology policy have been submitted to the NSF. The Center's final report, which will summarize the effectiveness of various policy instruments in influencing technological change in the five countries, is scheduled for publication in the fall of 1974. This project has provided support for six graduate students during the year, and involved Drs. Ashford, Sirbu, Coillet, Derian, and Yellin of the Center, and Professor Sapolsky and Lecturer John Zysman of the Department of Political Science. Dr. Jean-Jacques Salomon participated with project staff in October, 1973, during his appointment as visiting scholar at the Center for International Studies. Dr. Alexander Houtzeel of the Organization for Applied Industrial Research in the Netherlands was a project participant throughout the year.

The Sahel-Sudano project is administered by the Center and funded by a one-year \$1 million contract from the Agency for International Development (AID). This effort will describe the impacts of various economic development strategies on the countries in the sub-Sahara zone of Africa in terms of population, standard of living, health, education, and social traditions. The project is directed by Professor William Seifert of the Department of Civil Engineering, and includes Professors John B. Stanbury and F. James Levinson of the Department of Nutrition and Food Science; Professors David C. Major, Robert D. Logcher, Fred Moavenzadeh, and Paul O. Roberts of the Department of Civil Engineering; Drs. Kamrany, Godiksen, Findakly, and Rao of the Center; and ten graduate students. An interim report has been published by the Center, and the final report is scheduled for completion in the fall of 1974.

The second program to become an established area of continuing research and policy analysis is the Manufacturing, Work, and Public Policy Program, which focuses on understanding the contributions which new manufacturing technologies can make to industrial societies. It is concerned not only with identifying the opportunities for new technologies in industry, but also with understanding the relationship between technology and the manufacturing and production processes, and the relationship of those processes to the character of work.

A major project in this Program has been completed with the Center's publication in June, 1974, of "The Productivity of Servicing Consumer Durable Products." This project was the Center's first funded project, and its final report, which already has received widespread coverage by both domestic and foreign presses, is the first formally published by the Center. The project was supported by an NSF grant as a joint undertaking between the Center and the Charles Stark Draper Laboratory, Inc., and was directed by Senior Research Associate Lund of the Center and George W. Mayo of the Draper Laboratory. Project participants included Professor George C. Newton of the Department of Electrical Engineering, Professor Y. S. Chang of the College of Business Administration of Boston University, seven research staff members of the Draper Laboratory, seven graduate students, and four undergraduates. The cooperation and direct assistance of many individuals within manufacturing corporations,

service organizations, consumer activities, and both Federal and local government agencies was an integral part of the two-year effort. The Center intends to incorporate this cooperative spirit and direct assistance by industry into its future projects in the Manufacturing, Work, and Public Policy Program.

The second component of this Program has been the continuing development of a multi-year effort to examine computer managed parts manufacturing systems. Mr. Lund, Professor Nathan H. Cook of the Department of Mechanical Engineering, and Keith Glick of the Charles Stark Draper Laboratory are coordinating this joint project of the School of Engineering, Draper Laboratory, industry, and government. One part of this developmental effort was the national conference on Manufacturing Technology and Productivity held at M. I. T. during December, 1973. Jointly sponsored by the Center, the Department of Mechanical Engineering, the Center for Advanced Engineering Study, the Industrial Liaison and M. I. T. Associates Offices, and the Draper Laboratory, the two days of presentations and seminars attracted more than 90 individuals from government, industry, education, and foreign countries.

Part of this developmental effort was a three-day workshop and briefing sponsored by the Center and chaired by Mr. Lund. Twenty international experts summarized the current state of the art of computer managed manufacturing in each advanced industrial nation. Representatives of the U. S. Departments of Defense and Commerce, the NSF, the Office of Technology Assessment, and the General Accounting Office (GAO) were briefed on the final day. As a result of the conferences and workshops and the Center's continuing development efforts, funding is expected during the coming year.

Mr. Lund was involved actively during the past year with Professor Nam P. Suh of the Department of Mechanical Engineering in the M. I. T. -industry polymer processing program. The research program is sponsored jointly by the NSF's Experimental Research and Development Incentives Program, the Institute, and private industry; it is designed to establish a research effort in polymer processing at M. I. T. The program will evaluate whether Federal cost-sharing in establishing such research programs at universities is an effective means of stimulating research in industry.

A fourth component of the Manufacturing, Work, and Public Policy Program is Dr. Ashford's research on occupational health and safety and related issues. Dr. Ashford has completed a nine-month project for the Ford Foundation and submitted the final report, "Occupational Health and Safety in the United States: A Report to the Ford Foundation." The publication of this report as a book by the Foundation is scheduled for the fall of 1974. One result of this research is a one-year sponsored project to examine the impact of government regulation on the use and distribution of chemicals, which Dr. Ashford will direct during 1974-75.

All of the Center's Energy Policy Program activities are undertaken with the encouragement and cooperation of the new M. I. T. Energy Laboratory. This continuing cooperative spirit will broaden and strengthen Center studies with the Energy Laboratory's technical competence, and will provide the Energy Laboratory with a policy oriented resource upon which to draw, particularly on issues of regulation and research and development policy.

One exploratory project in this Program, funded by the School of Engineering, focuses on examining energy production, distribution, and consumption patterns and the public and private policies that influence these patterns. An updated economic analysis of breeder reactors in the United States has been completed by Dr. Derian of the Center and Dr. Irvin C. Bupp of the Harvard Business School, and is scheduled for publication in Technology Review. Two graduate students also carried out several studies as part of this informally funded developmental project.

The second activity, an eight-month project funded by the Ford Foundation's Energy Policy Project, focused on the existing institutional arrangements between government and industry which support, organize, and implement the nation's multiple research and development programs. Although the final report has been submitted to the sponsor and is scheduled for publication as a book in the fall of 1974, some of the project's findings already have been reflected in the planning of the Federal Energy Office. Participants included Professor Hollomon, Drs. Derian and Sirbu of the Center, Professors Judith T. Kildow and Joseph B. Lassiter of the Department of Ocean Engineering, Professor David C. White of the Energy Laboratory, Professor David C. Rose of the Department of Nuclear Engineering, and two graduate students.

The Center's focus on Land and Water Resources Policy issues during the past year has revolved around the Coastal Zone Policy project. Supported by the National Oceanographic and Atmospheric Administration, the one-year program is envisaged as the beginning of a continuing relationship with the Office of Coastal Zone Management, and is directed by Professors Kildow and Hollomon. The economic primer section of the final report has been completed by Professor John W. Devanney of the Department of Ocean Engineering, and is being reviewed. Other participants included Professors Michael S. Baram of the Department of Civil Engineering and Lassiter, and three graduate students.

Another project nearing completion is the Telecommunication Policy project, funded by the NSF. Focusing on the development of specific research proposals for critical issues in telecommunications policy, the project is directed by Professor Ithiel de Sola Pool of the Department of Political Science and Research Associate Carroll G. Bowen of the Center for Advanced Engineering Study. It also involved Professors Robert Crandall of the Department of Economics and Harvey Sapolsky of the Department of Political Science, Lecturer John Ward of the Electronic Systems Laboratory, and five graduate students.

Educational Activities

As part of the School of Engineering, the Center has a continuing interest and concern in public and private policies which influence the education and career development of engineers in the United States and throughout the world. This concern is reflected in part by Professor Hollomon's chairing, during the summer of 1973, the Task Force on Engineering Education, which examined future scenarios for engineering education programs. Participants included nine faculty members from the School of Engineering, three M. I. T. alumni from industry, and representatives of three other engineering schools. The final task force report, "An Engineering Education Report: System Response to a Changing World," was completed in September, 1973, and has been distributed to a number of engineering schools. Funding has been secured for the publication of a summary report in the fall of 1974.

Among the major inputs to the engineering education study were the eight papers published by the Center as part of a modest NSF grant to examine professional manpower markets. Carried out by Professors Richard B. Freeman of Harvard University and Eric Toder of Tufts University, and several graduate students, this series of studies examined the supply-demand relationships of the markets for engineers, lawyers, physicists, teachers, and new college entrants from an economic viewpoint. Similar studies are continuing at the Center, and research on professional manpower markets and the impact of education and government policy on these markets is becoming an established and ongoing activity of the Center. As in the past, the findings of this research will benefit not only the School of Engineering and the Institute in planning their educational programs, but also industry and government.

The Center's direct participation in the instructional dimension of the School's educational program was established formally in the second term of 1973-74, when Mr. Lund

introduced 2.863 The Manufacturing Environment. Mr. Lund will teach this subject again during the first term of 1974-75, and along with Professor David Hoult of the Department of Mechanical Engineering, will offer another newly designed subject, 2.96 Management in Engineering, during the second term of 1974-75.

J. HERBERT HOLLOMON

Center for Transportation Studies

During the past academic year, the Center for Transportation Studies established its headquarters in Building 5. Professor Paul O. Roberts continued in his second year as director of the Center. The six-person steering committee, also continuing in its second year, was composed of: Professor Ernst G. Frankel of the Department of Ocean Engineering; Professor Ralph G. Gakenheimer of the Department of Urban Studies and Planning, representing the School of Architecture and Planning; Professor Herbert H. Richardson, Head of the Department of Mechanical Engineering; Professor Robert W. Simpson of the Department of Aeronautics and Astronautics; Professor William C. Wheaton of the Department of Economics, representing the School of Humanities and Social Science; and Professor Zenon S. Zannetos of the Sloan School of Management.

On November 1, 1973, the Center hired Louise Carella as its new administrative assistant to the director. Two researchers from other institutions in the Boston area -- Dr. Frank C. Colcord, Jr., of Tufts University, and Dr. D. Daryl Wyckoff of the Harvard Business School, also have received appointments as research affiliates. The research affiliate appointment recognizes the cooperative relationship of the research program of the Center and the home institution of the affiliate. Dr. Colcord previously held this position at the Urban Systems Laboratory. As a political scientist and head of department at Tufts, he will be a valued asset to the Center as well as to the Institute. Dr. Wyckoff currently holds a position at the Harvard Business School. His association with the Center strengthens its ties with the business community.

Current Programs

Brochure The Center for Transportation Studies had designed and printed a one-page poster brochure which briefly describes the opportunities for transportation studies at M. I. T. These were mailed to universities and interested parties throughout the United States and Canada. At the bottom of the brochure, there were tear-off cards for those interested in finding out more about the Center. To date, the Center has received 235 returns on this card, which constitutes responses from two-thirds of the United States, plus inquiries from Malaysia, South America, and Canada. Packets of material describing the programs available in the various departments and financial assistance and application forms were returned to those sending requests for more information.

Newsletter Two editions of the Center's newsletter have appeared so far. Rebecca Muller, secretary in the Center, researched and wrote the newsletter. Articles on the work of the Center and items of interest concerning its faculty were included. The articles also served as a source of material for Tech Talk and Technology Review.

Publications There are now two publications in the Center's new report series. The titles are: "Education for Transportation Systems Analysis," by Professor Roberts; and "Stations, System Performance, and Scheduling in Personal Rapid Transit Networks," by Research Associate Marvin A. Sirbu, Jr., of the Center for Policy Alternatives.

Work is under way on the creation of a Transportation Publications Service. Room space in Building 7 was acquired in order to centralize transportation publications. Individuals and research groups throughout the Institute indicating interest in transportation will be invited to participate by donating to the Center distribution copies of any transportation related reports they wish to have included on the Center's publication list. The list then will be compiled, printed, and mailed to universities and interested parties throughout the United States. All requests for publications then will be met with a predetermined charge for each publication ordered.

Luncheon/Seminar Series A weekly luncheon/seminar series was given by the Center this past academic year. The program consisted of an informal buffet luncheon at noon every Friday. This was followed by a talk from an invited speaker on some timely or innovative issue. It concluded with a brief question-and-answer period. Among the speakers were: William K. Smith, vice-president of General Mills Inc., whose talk was entitled "A Shipper's View on How to Save the U.S. Railroad System"; Dr. Paul Banner, vice-president of marketing for the Southern Railway Corporation, who delivered "The Impact of Energy Costs on Rail-Trucking Competition"; Professor Daniel Roos of the Department of Civil Engineering, who presented "Innovations in Urban Transportation -- Lessons from Dial-A-Bus"; Dr. Clell G. Harrall, from the World Bank, who delivered "Labor Substitution in Highway Construction for Less-Developed Countries"; and Dr. Jack Doolittle, chairman of the Board of Directors of the Massachusetts Bay Transportation Authority (MBTA), whose talk was entitled "The MBTA: Problems and Prospects."

Requests for Proposals Service A Request for Proposal Information Service has been organized. A list of approximately 40 people with various transportation related interests has been compiled. The Commerce Business Daily is reviewed each day by the Center's administrative assistant, who identifies potential research projects which could be done by people at the Institute. She then writes or calls for the proposal, and when it is received, informs the interested parties. At this point they take the initiative. A meeting is held, a project supervisor designated, and the proposal is written and submitted.

Research Proposals Six proposals were channeled through the Center this past academic year. Their total dollar value was \$700,000. To date, there has been only one negative response. This brings the total dollar volume to \$600,000, either funded or still outstanding. The Center is continuing with the National Science Foundation's Research Applied to National Needs (RANN) project entitled Basic Transportation Research Studies. This project includes participation from the Departments of Aeronautics and Astronautics, Ocean Engineering, Urban Studies and Planning, and Civil Engineering. The conclusion of the study and final report should be ready early in the fall of 1974.

Undergraduate Research Opportunities Program (U. R. O. P.) The Center participated in the Undergraduate Research Opportunities Program during the spring term. Richard Okine, an undergraduate student from Ghana, was supported through the Center by the U. R. O. P. office for his project on world food movements. His project was approved for continuation, and he is now being supported jointly by the Center and by U. R. O. P. The results from this work should prove interesting.

Academic Program

Several new transportation related subjects were added this past academic year. The new core transportation subject, entitled 2.120J, 1.290J Introduction to Transportation Technology, was given jointly by Professors Herbert H. Richardson and David G. Wilson of the Department of Mechanical Engineering and Professor Daniel Roos of the Department of Civil Engineering.

A seminar entitled 1.961 Topics in Commodity Transportation was taught jointly by Professor Paul O. Roberts and Senior Lecturer James Sloss of the Department of Civil Engineering, with Professor Karen Polenske of the Department of Urban Studies and Planning.

A subject given jointly with the Sloan School of Management, the Department of Ocean Engineering, and the Harvard Graduate School of Business, entitled 13.69 International Shipping, presented a new dimension in transportation. Professor Henry Marcus represented the Center in the presentation of this subject.

Summer Session Offerings During the summer of 1974 there will be a subject entitled Shipping Management: Some Aspects of Strategic Planning for Tanker and Bulk Carrier Operations, given by the Sloan School of Management. The subject will be presented by Professors Zenon S. Zannetos and Peter Lorange of the Sloan School of Management, Professor Morris Adelman of the Department of Economics, and Professors John W. Devanney and Henry Marcus of the Department of Ocean Engineering.

Also on the agenda for the summer is a subject which has been given for a number of years, Analysis and Design of Transportation Systems. Those participating are Professors Ernst G. Frankel of the Department of Ocean Engineering, Robert W. Simpson of the Department of Aeronautics and Astronautics, and Moshe Ben-Akiva, Marvin L. Manheim, Wayne M. Pecknold, and Paul O. Roberts, all of the Department of Civil Engineering.

Development Plan

A long-range plan for the Center has been prepared and submitted to Dean of Engineering Alfred H. Keil by Professor Roberts, who worked closely with Joseph Carr of the Development Office and the Center's steering committee. The plan, which proposes the establishment of a \$1.0 million development fund to support four new areas of basic research, curriculum development, and the creation of a transportation information center, will be presented to the Engineering Council and the administration for approval.

Other Programs

Plans are under way for a transportation research directory, which will be similar to the directory for the Industrial Liaison Office. Plans for the M. I. T. Press series on transportation are complete. Professor Roberts has been working with Frank Satlow of the M. I. T. Press to get this program started. Professor Marvin Manheim of the Department of Civil Engineering has been selected as the series editor. It is felt that this program will be invaluable to the Institute community, as there is currently a largely unmet need for the publication of transport material in the United States and abroad.

PAUL O. ROBERTS

School of Humanities and Social Science

This year has been an important one for the School of Humanities and Social Science, the start of a period of reconstruction after the turmoil of the late 1960s and early 1970s. A number of new directions have emerged, and much of the groundwork has been laid for plans and projects that will reach fruition over the next few years.

In recent years, the School has had an essentially fragmented character. Its six departments have coexisted uneasily, with little communication and even less sense of common purpose. There have been many reasons for this, not the least of which is their physical separation. Scattered in diverse locations, members of the faculty have found it difficult to identify, let alone to nourish, whatever common interests they may have. Efforts to stimulate cooperative ventures sometimes have taken on the character of negotiations between foreign powers, sympathetic on principle, yet a trifle suspicious of one another's intentions and always conscious of a cultural gap. In considerable measure, this gap has resulted from the inevitable differences of style and purpose between departments that are concerned essentially with graduate education and those that are predominantly undergraduate in orientation. The Department of Humanities, at one extreme, has no graduate program, while the Department of Psychology, at the other, offers no undergraduate degree; the Department of Foreign Literatures and Linguistics is split in half, with an exclusively undergraduate foreign language program and an exclusively graduate linguistics program. The Departments of Economics, Political Science, and Philosophy operate at both levels, but have tended to base their professional identities more on research and on the strength of their graduate programs than on undergraduate teaching.

A primary concern of the past year has been finding ways to bring the various departments closer together and to create a greater sense of shared purpose. The School Council, composed of the dean and associate dean, the department heads, and the dean's representative to the Committee on Educational Policy, has become an important instrument for communication among the various parts of the School. Meeting regularly, it has become a forum for discussion of all matters of common concern and for the review of departmental recommendations for promotion and tenure.

Revision of the Institute requirement in the humanities and social sciences was a matter that consumed a major portion of the time of the School Council this year, and of many other faculty members as well. This was a sensitive issue for the School, as changes in curriculum requirements are bound to be. For something like a quarter of a century, there had existed a freshman and sophomore core program in the humanities with a limited list of available subjects taught, for the most part, by faculty members from the Department of Humanities. With the passage of time this core program, grounded originally in post-World War II concepts of general education centering on the history of Western civilization, lost its coherence and much of its rationale. For one thing, the student body had become a good deal more diverse in terms of quality and content of secondary school education. Some students were arriving at M. I. T. already well grounded in the humanities; others were presenting clearly inadequate backgrounds. This diversity of need and interest, coupled with a considerably lowered student tolerance for curricula offering little freedom of choice, had led to growing student dissatisfaction with the offerings available outside the sciences and engineering in the first two years of study. Such student concerns were

matched by internal pressures resulting from the enormous growth over the last decade or so in the range of the Institute's capabilities in the social sciences and the arts, fields represented only marginally in offerings available to freshmen and sophomores under the old requirement.

After extensive debate, first within the School and then among the faculty as a whole in a series of well-attended faculty meetings in the spring of 1974, a new form of the Institute requirement was approved. One major change is reflected in the new title of the requirement: it is now officially an Institute Requirement in the Humanities, Arts, and Social Sciences, with formal recognition given to the legitimate and important place of fields and disciplines beyond those traditionally subsumed under the "humanities" label. A second important change is the abolition of the freshman and sophomore core program: incoming freshmen no longer will be required to select their first-year humanities subjects before they arrive at the Institute, and they will be given, from the first term onward, a far wider range of subjects from which to choose. One thing remains unchanged, however. All undergraduates will continue to take at least eight subjects in the humanities, arts, and social sciences in the course of their undergraduate careers, preferably at the rate of one a term. The overall object of the requirement is to expose students to ways of thought and modes of expression not commonly encountered in science and engineering subjects; to provide a place in the curriculum not specifically assigned to professional training, through which students may enrich their personal lives; and to introduce students to the broader social context in which they will spend their lives after leaving M. I. T.

The new requirement contains two main features: a distribution component requiring students at some point in their undergraduate careers to take at least three subjects in three separate fields from a selected list of humanistically oriented "distribution subjects," and a concentration component requiring students to take at least three or four subjects in a given field in order to achieve some degree of depth. Fifteen fields of concentration, some of which are taught within the School of Architecture and Planning, have been approved thus far by the faculty. The remainder of the eight-subject requirement, over and above concentration and distribution, may be fulfilled from a wide range of elective subjects, including several from other Schools.

The most important aspects of the new requirement -- including particularly approval of distribution subjects and of new fields of concentration -- are to be administered by a faculty committee which will include members from all the Schools at the Institute. This seems a significant step, as it denotes a formal assumption of responsibility by the faculty as a whole for the content and administration of the requirement. Previously, the requirement had been administered by the Department of Humanities, in logical recognition of its central responsibility for planning and teaching this part of the curriculum. Members of that Department, and of other departments in the School, will continue to play a leading role in the new committee, but the participation of interested faculty members from other Schools, and the committee's responsibility to make regular reports to the faculty as a whole, should insure a more broadly based and continuing concern with the requirement and with the curriculum on which it rests.

It should be added that many in the School of Humanities and Social Science are by no means committed irrevocably to the idea that an Institute requirement of this sort is inevitable. In fact, it would be healthier if a climate could be created in which the importance of the humanities, arts, and social sciences were so obvious to the great majority of students that formal requirements were not needed. However, before abolition or major reductions of the requirement can be considered seriously, several conditions must be satisfied. First, the quality of the offerings in the humanities, arts, and social sciences must be made more uniformly excellent, so that they can compete on their merits, without benefit of a compulsory structure, for the time and attention of students. This is a goal to which all the depart-

ments of the School are giving higher priority, though it must be acknowledged that the incentive for curriculum reform and innovation is sometimes difficult to maintain in the face of student inertia or preference for the least demanding alternative. The second condition is that a gradual but significant change must take place in the general climate of the Institute which will encourage a greater recognition of the inherent value of these fields of study for M. I. T. undergraduates. There remain many implicit and explicit biases in the system that need to be recognized and, if possible, overcome. For example, it is still the case (though exceptions are being permitted with increasing frequency) that subjects in the humanities, arts, and social sciences normally receive only nine units of credit, whereas science and engineering subjects receive 12. This must be changed, along with other residues of earlier times and attitudes, if the Institute hopes to persuade undergraduates that it genuinely values the nonscientific and nonengineering components of their education.

One factor which has inhibited the greater integration of the humanities and social sciences into the intellectual life of the Institute has been the relative isolation of the faculty of this School. It is vitally important that connections with the other Schools be strengthened, and considerable energy was invested in this direction during the past year. More effective links have been forged with the School of Architecture and Planning, both through cooperative ventures in economics and political science with the Department of Urban Studies and Planning, and through collaboration between faculty members representing various fields of the creative arts in the Departments of Humanities and Architecture. The Council for the Arts, which increasingly has become involved in the curricular and extracurricular life of the Institute, has played a particularly useful role in encouraging interaction among faculty members in the creative and performing arts.

Particular attention has been given to laying the groundwork for more effective interaction with the School of Engineering. In recent years, engineers have become more clearly aware that their professional concerns have social, political, and economic dimensions that must be given more explicit consideration. Humanists and social scientists, by the same token, have begun to acknowledge more explicitly the need to develop better ways of studying the influence of science and engineering on society and culture. As a result, the traditional barriers between the engineering professions and the social sciences and humanities have been lowered, and potential new areas for cooperation have opened up.

The School of Humanities and Social Science has a particular responsibility to develop those areas of study which lie in the intersection of disciplines, and to offer encouragement to faculty members who wish to move freely between the two cultures. A first step has been taken with the creation of the Technology Studies Program, thanks largely to the initiative of Professor Nathan Sivin, whose report follows this one. It is worth drawing attention to the innovative administrative context within which the educational and research activities of the Program will be conducted. The Program will be responsible directly to the dean of the School, rather than reporting through a department, and the faculty members being appointed to the Program are being given School rather than exclusively departmental appointments. The new director of the Program, Professor Louis L. Bucciarelli, Jr., is an aeronautical engineer by training; he has been given a joint appointment in the School of Engineering and the School of Humanities and Social Science. By locating the Program at the School level, and by introducing in the person of its director an element of formal collaboration between the two Schools, this School hopes to reduce departmental parochialism to a minimum and to make the Technology Studies Program an effective instrument of the Institute's larger purposes.

One tangible result of this cooperation was the receipt this year, in response to a proposal prepared jointly by the Dean of Engineering and the Dean of Humanities and Social Science, of a \$400,000 grant from the Andrew W. Mellon Foundation to help establish a program for the study of the role of science and engineering in modern society and for the integration

of teaching and research in the humanities and engineering. One purpose of this grant will be to attract to the Institute a group of able young scholars, both postdoctoral fellows and junior faculty members, primarily concerned with the investigation of the nature of technological society. Some of these will be humanists and social scientists willing to commit some of their time to understanding the technologies whose social consequences they are seeking to explore. Others will be scientists and engineers prepared to enlarge their understanding of the social implications of their work and of the methods by which research on this problem can be accomplished.

The success of this overall effort, of course, will depend on the program's ability to attract teachers, students, and researchers capable of doing innovative work in largely uncharted territory. With the appointment of four new faculty members to the Technology Studies Program, in addition to Professor Bucciarelli, a good start has been made. A recruiting committee chaired by Professor Elting E. Morison this year identified and interviewed potential candidates for four additional senior faculty positions; three previously endowed chairs are being freed for the purpose, plus a new chair recently granted by the Mellon Foundation. The School's intention with these new appointments will be to shift the emphasis of the humanities at M. I. T. somewhat closer toward the particular concerns of the Institute, by locating men or women who have done distinguished work in history, literature, sociology, or political science, and who also have demonstrated an active concern for the meaning of science and engineering in the development of modern society. The School hopes by the end of the next academic year to announce the appointment of one or more such individuals.

HAROLD J. HANHAM

Table 1
Enrollment in Humanities, Languages, and
Social Science Undergraduate Subjects, 1973-74

<u>Freshman core program</u>		<u>Percent of 1416</u>
Foreign literatures and linguistics (Humanities in French)	33	2.3
Humanities	525	37.0
Philosophy	799	56.4
Political science	59	4.2
	<u>1416</u>	
<u>Sophomore core program</u>		<u>Percent of 1593</u>
Foreign literatures and linguistics (Humanities in French)	22	1.4
Humanities		
Anthropology	165	10.4
History	339	21.3
Literature	247	15.5
Music	460	28.9
Philosophy	242	15.2
Political science	118	7.4
	<u>1593</u>	
<u>Upperclass electives</u>		<u>Percent of 5956 (total upperclass)</u>
Humanities		
Anthropology	61	1.0
History	205	3.4
Literature	595	10.0
Music	418	7.0
Course XXI thesis	12	0.2
Writing	150	2.5
Interdisciplinary	446	7.5
Philosophy	190	3.2
Total humanities	2077	34.8
Social science		
Economics	1432	24.0
Economics thesis	27	0.5
Political science	469	7.9
Political science thesis	19	0.3
Psychology	1407	23.6
Total social science	3354	56.3
Foreign literatures and linguistics		
Elementary	246	4.1
Intermediate	100	1.7
Advanced	179	3.0
Total foreign literatures and linguistics	525	8.8
TOTAL ALL UPPERCLASS	<u>5956</u>	
TOTAL UNDERGRADUATE ENROLLMENT	<u>8965</u>	

This includes only subjects taught in the School of Humanities and Social Science. Additional subjects in the humanities and social sciences are taught in other Schools, most notably in the fields of management, urban studies, and the visual arts.

Statistics for 1973-74 in this chart were compiled from the end-of-term grade reports, rather than (as in previous years) from the five-week registrar's count.

Table 2
Majors in the School of Humanities and Social Science*

	Undergraduates			Graduates					Grand total		
	Social science	Humanities	Total	Social science	Humanities	Foreign literatures	Total				
1955-56 ¹	40	19	59	52	--	--	52	111			
1956-57	38	32	70	69	--	--	69	139			
1957-58	41	67	108	74	13	--	75	183			
1958-59 ²	46	75	121	81	13	--	82	203			
1959-60	38	64	102	105	23	--	107	209			
1960-61	35	93	128	114	--	--	114	242			
1961-62 ⁴	55	88	143	129	--	7	136	279			
1962-63 ⁵	65	85	150	145	--	22	167	317			
1963-64	71	87	158	165	4	31	200	358			
1964-65 ⁶	78	109	187	190	15	36	241	428			
	Economics	Political science	Humanities	Philosophy	Total	Economics	Political science	Psychology	Philosophy	Linguistics	Total
1965-66	50	60	114	--	224	111	63	23	24	34	255
1966-67	76	73	121	--	270	117	79	26	29	42	293
1967-68	81	76	148	--	305	114	80	27	27	31	279
1968-69	84	79	195	--	358	118	87	27	23	38	293
1969-70	68	85	200	--	353	117	82	41	31	41	312
1970-71	60	59	162	--	281	103	78	23	36	34	274
1971-72	63	38	124	13	238	104	70	29	29	40	272
1972-73	64	39	92	15	210	109	82	23	24	34	272
1973-74	118	65	134	19	336	222	169	51	41	64	547

*As registered in the second term of academic year 1955-56 to 1973-74 (omitting freshmen and undesignated sophomores).

¹Course XXI initiated.

²Graduate degree in political science initiated.

³Special program in teacher training.

⁴Graduate degree in linguistics initiated.

⁵Graduate degree in psychology initiated.

⁶Graduate degree in philosophy initiated, with small preregistration in 1963-64.

Table 3
Distribution of Registrants in Undergraduate Upperclass Electives by Schools, 1973-74

School	Economics	Political Science	Psychology	Subtotal in Social Sciences	History	Writing and Literature	Music	Anthropology	Interdisci- plinary	Philosophy	Subtotal in Humanities	Foreign Lit- eratures and Linguistics	Grand Total
Architecture	57	26	33	116	6	39	11	3	23	5	87	13	216
Engineering	526	79	472	1077	92	182	137	18	81	32	542	104	1723
Humanities	263	160	39	462	20	115	39	15	86	33	308	51	821
Management	82	26	44	152	4	17	4	--	21	2	48	12	212
Science	288	85	490	863	67	298	170	18	139	91	783	172	1818
Undesignated	216	93	329	638	16	94	57	7	96	27	297	173	1108
Total	1432	469	1407	3308*	205	745	418	61	446	190	2065*	525	5898*

*Does not include thesis students.

Statistics for 1973-74 were compiled from the end-of-term grade reports rather than (as in previous years) from the five-week registrar's count.

Technology Studies Program

The Technology Studies Program was conceived in the academic year 1972-73 in a series of informal Institute-wide meetings of faculty members to discuss how the humanities at M. I. T. might be related more directly to science and engineering. Formal planning began with the appointment of a Steering Committee with members from four of the Institute's Schools. The Committee was to be responsible for defining the goals of the Program, providing oversight for detailed planning, and assembling a staff. By the close of this academic year, these aims had been met. The Program was playing a regular part in deliberations on the future of the humanities at M. I. T. and on what the humanistic components of a science and engineering education should be. Educational priorities had been determined, and the shape of a curriculum defined as far as was fruitfully possible before the arrival of those who would do the teaching. A community of interest throughout the faculty grew perceptibly, and hitherto scattered teaching across the specious chasm between the "two cultures" began to involve greater cooperation. A series of faculty appointments were made which made it possible to move from the initial planning phase to the first phase of execution, although it will take another year to move much beyond the preliminaries.

By July 1, 1974, the Steering Committee had agreed upon the following priorities.

1. An undergraduate program, the major emphasis of which will be teaching science and engineering students those humanistic disciplines and viewpoints on individual experience and social relations which promise to be most useful in their future work. This program will offer opportunities for students to study at various levels of depth.
 - a. Professional seminars will be organized. The faculty of the Program will encourage, provide liaison for, and collaborate in professional seminars which will focus on upperclass subjects in the humanistic and social dimensions of the scientific and engineering professions. They will be offered on a voluntary basis by interested faculty members of the various departments, for credit in the department which offers them and with content defined by the faculty member responsible. A workshop to be sponsored by the Program will facilitate close cooperation among the instructors of professional seminars in the various departments as well as with the faculty of the Program, both in the planning and execution of these subjects. Because of its promise for reaching a significant portion of the student body with useful humanistic and social-science perspectives, the professional seminars program will be Technology Studies' first priority.
 - b. A series of general subjects will be offered for concentration in technology studies under the new Humanities, Arts, and Social Sciences Requirement. These subjects will coordinate and supplement the wide variety of electives now offered at M. I. T. which deal explicitly with issues of values as they touch on the work of scientists and engineers. Members of the Technology Studies Program, individually and in collaboration, will offer additional subjects planned to guide students to a coherent overview, and to develop their skill at moving from the in-depth study of cases to sound general insights. It is expected that these subjects will make considerable use of archival and oral-history materials.
 - c. Discussion has begun on a technology studies option in humanities and engineering (Course XXI-A) and humanities and science (Course XXI-B, Program 1). This will make it possible for a small number of students to work at considerable depth in the Technology Studies Program and to prepare for further study elsewhere. The number of such students will be kept small, and it is expected that each will acquire a sound disciplinary foundation in science or engineering.

2. A postdoctoral program. Postdoctoral training fellowships will make it possible to identify and bring to M. I. T. people who show exceptional potential for contributing to the humanistic studies of science and engineering. On one hand, the Technology Studies Program will provide facilities for people with sound training in a discipline which studies science or engineering (history of technology, philosophy of science, sociology of engineering, and so forth) who are ready to devote themselves to the study of issues in modern science or engineering which are too broad to fit within the confines of their professions. Scholars of this kind would become involved in collaborative research with M. I. T. scientists or engineers while at the same time studying their working environments. Scientists or engineers who show promise of important contributions to the humanistic investigation of their own professions, but who need time, a conducive environment, and professional guidance in order to succeed in what they have set out to do will also be welcome. A third sort of fellow would come to M. I. T. to use its wealth of documents and to study the development of recent science or technology and their social connections. Individuals in this program would be affiliated with members of the Technology Studies faculty and would take part in a regular colloquium. An application for initial funding already has been made, and planning for long-term funding will proceed in the next academic year.

3. Institute-wide activities. Throughout M. I. T. there are scientists, engineers, and others who are interested in a humanistic overview of the disciplines and developments which their research has helped to form. If their involvement is encouraged, there will be a very high level of participation in meeting the aims of the Program. Among activities undertaken in the past academic year or being planned are:

a. A headquarters for the Technology Studies Program in Building 20, which can serve as a center for contacts between scientists and engineers with humanistic interests.

b. A faculty seminar which provides an opportunity for Institute-wide faculty (as well as a number of students) to learn about and to discuss in depth recent advances in the humanistic study of twentieth-century science and technology and their social connections. Thirteen meetings of the Technology Studies Workshop took place in 1973-74, with attendance averaging between 15 and 50.

c. A colloquium in technology, society, and values in M. I. T. education. Representatives of subjects which pay explicit attention to values in the work of scientists and engineers described and evaluated their teaching for an Institute-wide audience, and led discussion of their accomplishments and problems.

d. A Technology Studies Bulletin, whose function is to circulate news, queries, and notes throughout M. I. T. Two issues were published during the past academic year. The first provided the entire faculty with a first report on plans and prospects for the Program. The second, mainly a directory of people interested in or working in humanistic studies of science or technology, was meant to encourage collaboration and contact between people with similar concerns.

In addition, the Steering Committee has continued to lay the foundations for activities essential to supplement the Technology Studies Program. M. I. T. is undertaking the formation of a research archive (not to be confused with the Institute Archives) which will gather complete collections of professional and personal papers of M. I. T. scientists and engineers, as well as the documents of laboratories, departments, and centers, and related collections useful in teaching or research. This archive, by storing, cataloging, and making accessible important documents, will make M. I. T.

an important center for the humanistic study of American technology over the last 100 years. Unlike other such collections, this archive will be planned from the start for active use in undergraduate education as well as advanced research.

A complementary activity will be teaching and research in oral history, a technique which supplements written sources for the study of change in science and engineering. Its disciplined use in conjunction with archival materials will make it possible for advanced undergraduates and postdoctoral fellows to study in depth not only the character of innovations but also the interplay between science, society, and individual consciousness. Development of both the archive and the oral history program will be furthered greatly by the appointment of Professor Charles Weiner, one of America's foremost practitioners of the oral history of science.

The most demanding activity of the Steering Committee during this past academic year has been assembling a faculty for the Program to take responsibility for its planning and execution. It has been possible, through a broad search inside and outside M. I. T., to bring together for next year a faculty of very considerable diversity, but one which at the same time is able to focus a variety of disciplinary tools on common problems and issues. Louis L. Bucciarelli Jr., formerly a member of the Department of Aeronautics and Astronautics, has been appointed director of the Technology Studies Program and Associate Professor of Engineering and Technology Studies. He is currently on leave of absence from M. I. T. to the Smithsonian Institute in Washington, D. C., where he is establishing a program on the history of technology. Joel Yellin, who has been at M. I. T. for two years as senior research associate in the Center for Policy Alternatives and lecturer in the Department of Political Science, has been appointed Associate Professor of Social Science to work with the Technology Studies Program. Kenneth Manning, who has just received his Doctor of Philosophy in the history of science from Harvard University, where he has been a teaching fellow since 1972, will join the Program as an Assistant Professor of the History of Science. Finally, Langdon Winner has been appointed Assistant Professor in the School of Humanities and Social Science; he has spent this past academic year as Visiting Professor of Political Science at the University of Leiden, the Netherlands, after receiving his Doctor of Philosophy in political science from the University of California at Berkeley.

NATHAN SIVIN

Department of Economics

The academic year 1973-74 was marked by a noticeable increase in the interdepartmental activities and capabilities of the Department, both in teaching and research. This is not a new trend. Movement in this direction has been evident for some time, first with the Sloan School of Management, then with the Departments of Political Science and Urban Studies and Planning, and finally with various Institute centers, laboratories, and more informal research groupings. There was considerable Departmental research involvement with the Energy Laboratory and the Center for Policy Alternatives this year. Next year, two joint tenure appointments will link teaching and research interests with the Departments of Nutrition and Food Science and of Civil Engineering. In other respects, the year was one of normal change and development -- in productive teaching, research, and public service.

Undergraduate Program

The Department continues to play a large role in the undergraduate humanities and social science program. This year more than 500 students enrolled in the first term of the introductory economics subject, 300 did so in the second term, and 300 students from out of course took one or more economics electives. These numbers are slightly above the average for the last several years.

The effect of this year's faculty vote to change the Institute Humanities and Social Science Requirement will be to treat all four undergraduate years as a unit. This change will make possible more concentration in a particular field, as well as more sampling of fields than currently is permitted. In view of these changes and also to satisfy the increasing demands of engineering and science fields for applied microeconomics, Professor Peter Temin is supervising a major reconsideration of the subjects 14.01 and 14.02, Economic Principles I and II, and is developing new teaching materials. The preliminary review indicates the pedagogic desirability of reversing the present macro-micro sequence, opening up some electives to students with only a microeconomics background, and developing more diversified applied microeconomics electives. The recent surfacing of economics problems with a major microeconomics aspect -- in transportation, housing, the urban economy, comparative international technologic change, pollution and congestion, health care, and energy and natural resources -- has created an active student interest in this aspect of economics, one that should be met.

The number of undergraduate economics majors remains at about the average of the last several years. The number of degrees awarded this academic year (26) was the same as last. The program has remained essentially the same, although greater flexibility has been permitted students in satisfying the senior research requirement, through the acceptance of 14.31 Econometrics or appropriate experience under the Undergraduate Research Opportunities Program. Economics majors have a growing interest in professional graduate schools -- law, business, and medicine -- common to other undergraduates.

Graduate Program

Despite the continuing tightness of financial aid for graduate students, the number of applications for admission rose substantially to well over 300. Nevertheless, the Department has held the size of the entering class to approximately 30 students. Foreign students represent one-third of this entering class, virtually equal to the average proportion of the previous five years. The numbers of both women and black students are up, the former to 22 percent -- the highest percentage in a long time -- and the latter to nearly 13 percent, a percentage exceeded only in 1971.

The Department's entering graduate students are heavily dependent on outside sources for financial aid. This year, for example, the single largest source will be National Science Foundation (NSF) fellowships; the Department's entering students have garnered over one-third of the total national awards. Although M. I. T. fellowship support for the coming year is only half as large as this, it is an important and flexible component of student aid. The Department was particularly gratified that its graduate alumni responded to an appeal for support sufficient to establish a Graduate Economics Alumni Fellowship, awarded for the first time this year.

A noticeable change occurred in the placement of graduates with Doctors of Philosophy. Heretofore, approximately 85 percent of the Department's students took university teaching positions, and 15 percent accepted research positions in government agencies, private research organizations, or business firms. These proportions had remained relatively constant despite the dramatic change in the job market in recent years. This year, however, the percentage of students accepting research positions rose sharply to just under one-half; most of these positions were in universities and government.

Research Activities

For several years, the largest research effort in the Department has been in urban economics. This year fewer faculty members were involved, as leaves of absence reduced the resident senior staff to Professors Robert F. Engle, Robert M. Solow, and William C. Wheaton. A large number of students continued to participate, however, and several working papers and journal articles were produced. The substantial support that had been provided

by the Ford Foundation for three years terminated last year. The largest single project -- the modeling of the Boston community -- was continued with NSF financing, under the general direction of Professors Engle, John R. Harris, and Jerome Rothenberg (the latter two of whom were on leave this year).

The largest group of faculty members is involved in research on energy problems. Many papers have been produced for journals and symposia. A major paper entitled "Energy Self-Sufficiency: An Economic Evaluation," published in Technology Review, was produced by the Policy Study Group of the Energy Laboratory. Departmental faculty involved in this Group are Professors Morris A. Adelman, Robert E. Hall, and Paul L. Joskow, plus graduate student Martin B. Zimmerman. Professor Jerry A. Hausman also was associated on this particular report. Professor Adelman has continued his studies of the oil industry. Professor Joskow's research has focused primarily on regulation, particularly public utilities and insurance, and also has broadened into other aspects of the energy problem.

Another looser grouping of interests is one based on the study of economic policy problems in an historical or developmental framework. Professor Evsey D. Domar has continued his studies of the comparative operations of socialist-capitalist economies; Professor Richard S. Eckaus published several papers and reports on the educational policies, financial markets, and income distributions of developing countries; Professor Charles R. Kindleberger is concerned with historical European commercial policies, and continues to make contributions in international finance; Professor Temin is studying business cycles of the last century; and Professor Martin L. Weitzman produced several papers on the theory of planning.

A large number of papers has emanated from the econometrics group, especially from Professor Engle on spectral analysis, and from Professor Hausman on simultaneous equation estimators.

Wide-ranging contributions in economic theory were made by Professors Paul A. Samuelson, Solow, Franklin M. Fisher, Hal R. Varian, and Hausman.

Research on stabilization and related monetary and incomes policies has been undertaken in depth by: Professor Stanley Fischer, who has focused on the efficacy of monetary and fiscal policies in coping with inflation; Professor Hall, who has studied labor markets, the Phillips curve, and income maintenance experiments; and Professor Franco Modigliani, who has completed the development of a quarterly model of the U. S. economy to test fiscal-monetary policies.

Attention should be drawn particularly to the rising level of interdisciplinary and interdepartmental research activity of the faculty. In urban economics, there is a natural relationship with the Department of Urban Studies and Planning. The substantial expansion of activities in the energy area has involved many faculty members with the Energy Laboratory and with the various departments associated with it. Professor Michael J. Piore has been collaborating with colleagues in the Departments of Urban Studies and Planning and of Political Science on a comparative study of dual labor markets in France and the U. S., financed under a Ford grant. Through the same Ford program, Professor Joskow was successful in receiving funds for a comparative study of nuclear power, in collaboration with Professors Joel Yellin of the Technology Studies Program and Henry Jacoby of the Sloan School. Professor Robert W. Crandall has cooperated with the Center for Policy Alternatives in its work on consumer durable goods and on communications, and has shared an undergraduate seminar on the recycling of materials with Professor Michael B. Bever of the Department of Metallurgy and Materials Science. Professor Eckaus participated in a new joint subject with Professors Fred Moavenzadeh of the Department of Civil Engineering and Nazli Choucri Field of the Department of Political Science on the transfer and adaptation

of technology to the less developed countries.

Personnel Changes

Distinguished visiting faculty members this year were Professors Anthony B. Atkinson of the University of Essex and Jurgen Franke of the Technical University of Berlin in the fall term, Lecturer William Poole of the Federal Reserve Bank of Boston in the spring, and Professor Anne Krueger of the University of Minnesota for the whole year. They partially replaced regular faculty members who were on leave, including Professors Jagdish Bhagwati, Peter A. Diamond, John R. Harris, and Jerome Rothenberg for the whole year, Professor Robert E. Hall in the fall, and Professor Peter E. Temin in the spring.

It is a pleasure to report the promotion to full professor of Professors Hall and Martin L. Weitzman, and that of Professor Robert F. Engle to associate professor. Two appointments that begin next year are of particular interest: Professor Ann F. Friedlaender will serve jointly with the Department of Civil Engineering, and Professor Lance J. Taylor jointly with the Department of Nutrition and Food Science. This brings the number of faculty members with appointments in another department to 11 out of 32.

Regretfully, the Department accepted the resignation of Professor Robert W. Crandall, after eight years with the Department. He will join the staff of the Center for Policy Alternatives and continue his research in communications.

Several members of the Department have received honors. Professor Franklin M. Fisher received the John Bates Clark Award, given every other year by the American Economic Association (AEA) to the outstanding economist under 40 years of age. Previous Department recipients were Professors Paul A. Samuelson and Robert M. Solow. Professor Hall was elected a Fellow of the Econometric Society. Professor Charles P. Kindleberger was appointed Distinguished Visiting Professor of the University of Edinburgh and was in residence there for one month. Professor Franco Modigliani was elected to the National Academy of Sciences, was nominated president-elect of the AEA, and was given an honorary doctorate by the Catholic University of Louvain, Belgium. Professor Solow gave the Ely Lecture at the AEA meetings. Professor Samuelson received an honorary degree from Gustavus Adolphus College.

E. CARY BROWN

Department of Foreign Literatures and Linguistics

During the year 1973-74 there was a conspicuous improvement in morale in the language and literature group. This psychological lift can be attributed reasonably to two factors: 1) the change in the Institute Humanities and Social Science Requirement, which was approved by the faculty in the second term; and 2) various measures taken during the year to regularize the status of instructors and lecturers in the Department. These factors, each in its own way, have had the effect of alleviating the feeling -- which had been acute at times -- that the Department and its members had been prevented from making their fullest and most appropriate contribution to the academic life of the Institute.

Under the Humanities and Social Science Requirement, which was in effect for several years, there were restrictions on the availability of Departmental subjects for its fulfillment which were felt to be discriminatory. Also, the monopolistic control over the requirement exercised by the Department of Humanities had been a source of resentment. The new Institute Requirement in the Humanities, Arts, and Social Sciences is considered to be a vast improve-

ment over the old requirement, both in general intellectual terms and in terms of the Department's participation. All Departmental subjects may be applied in one way or another to the new requirement, and foreign languages, as well as literature, is one of the designated fields of the program. Also, the new requirement provides for direct departmental control over the concentration component in each department's field or fields. Finally, the Department views with enthusiasm the establishment of a faculty committee, one of whose responsibilities will be to oversee the distribution component of the requirement. The Department is confident that the decisions of this committee will be judicious and fair with respect to its subjects.

Lecturers and instructors in the Department of Foreign Literatures and Linguistics are rather different from most other lecturers and instructors at the Institute. Rather than being auxiliary staff members who provide special expertise to round out departmental offerings or junior members on quasi-probationary appointments, as is the usual case, they are long-term, established teachers who form the core of the undergraduate language program, teaching the central subjects on which the rest of the Departmental program is based and some of the more specialized offerings. They are thus an essential part of the Departmental staff and are not still proving their abilities. In fact, the average length of service at M. I. T. of these staff members is approximately 11 years, the range being from four to 19 years. Up to and including the year under review, however, these teachers have been on year-to-year, or in some cases even term-to-term, appointments. The fraction of time employed in a given term also has varied, in some cases from one-third to full time, often with little advance notice. In addition to classroom teaching in various subjects, lecturers and instructors in the Department have charge of the content, planning, and organization of their subjects, and are listed officially as instructors in charge of their subjects, rather than working under the direction of a faculty member. They also serve as freshman, upperclass, and thesis advisers; they offer undergraduate seminars and Independent Activities Period (I. A. P.) projects, and so on. In short, lecturers and instructors in this Department routinely perform essentially the same academic functions as do faculty members, with the exception of scholarly research; yet they do not have faculty status and thus are not eligible to participate in faculty meetings or to serve on faculty committees. They also are excluded from certain financial benefits available to faculty members. It is a matter of considerable concern to these staff members that because of their lack of faculty status they are unable to make contributions to the discussions in faculty committees and meetings which, they feel, their long experience at the Institute places them in a favorable position to make. Moreover, the faculty deliberates on many issues of vital interest to this Department; in these deliberations, the voices of these staff members go unheard and the Department's vote is underrepresented. A case in point is the recent reform of the humanities program, which already has had considerable impact on this Department, in particular on subjects taught by lecturers and instructors.

Steps have been taken during the past academic year to relieve some of these difficulties. As indicated below, one instructor has been reappointed as an assistant professor, and the remaining five have been given full-time two-year "rolling" appointments (renewable every year for two additional years) as lecturers. Fruitful discussion has been initiated on the more delicate issue of fuller participation in faculty affairs, resolution of which may not be easy or prompt. In any event, the mere fact that the issues have been raised in a positive manner has been of tangible psychological benefit to the Department as a whole.

Research

The research conducted by the linguistics group this year continued to pursue essentially the same issues as in past years. The group's objective is to learn about the mental capacities of human beings by studying the structure of natural language and the uses to which it is put. As in the past, major emphasis (measured in man-hours) was placed on syntactic studies. Of the seven dissertations completed during the year, five were in the area of syntax and semantics.

Among the more noteworthy developments in other areas are studies of prosodic systems in various languages. These appear to lay the foundations for a new theory of tone and accent, which provides clarification of: 1) the nature of the tone rules in terrace-tone languages of the kind widely spoken in West Africa, 2) the reconstruction of the accentual system of Indo-European languages, and 3) other related questions.

Another topic that has begun to attract considerable interest once again is word formation. The character of the word formation component and its role in grammars were investigated in two dissertations which dovetailed with studies by other members of the group dealing with cyclical rule application in phonology.

Important insights into the nature of language often can be obtained by investigating the changes which languages undergo in the course of their evolution. Especially interesting results are emerging currently from historical investigations into the evolution of relative clauses in Australian and American Indian languages.

Studies situated on the borderline between linguistics and another field are continuing. Of particular interest are Professor Paul Kiparsky's contribution to the study of metrics, Dr. Judith Kornfeld's dissertation on psycholinguistics, and Professor Kenneth L. Hale's contributions to the design of teaching materials for elementary education in Navajo. Finally, note should be made of investigations which directly approach the theoretical foundations of linguistics, most conspicuously Professor John R. Ross's attempts to develop a nondiscrete logic to serve as a basis for a new linguistics, and Professor David M. Perlmutter's efforts (jointly with Dr. Paul M. Postal of International Business Machines) to replace transformational syntax by a syntax in which grammatical relations are the primitive entities.

The academic year 1973-74 saw the appearance of the first issues of a new journal, Diné Bizaad Nánl'iih, devoted to Navajo linguistics, under the editorship of graduate student Paul Platero.

In the foreign literatures group, also, research this year continued along familiar lines, through a spectrum ranging from the medieval French narrative lais, through Lenormand, Brecht, and Pasternak, to a new theory of comic universals in literature.

Faculty publication in both groups of the Department was substantial. Even when the listing is restricted to full-length books, an impressive record appears. Professor Noam Chomsky published For Reasons of State, and with Edward S. Herman, Counter-Revolutionary Violence: Bloodbaths in Fact and Propaganda. Professor Catherine V. Chvany, with Richard D. Brecht, edited Reading in Slavic Transformational Syntax. Professor Paul Kiparsky with Stephen R. Anderson edited A Festschrift for Morris Halle. Professor David M. Perlmutter with Janez Oresnik coauthored Razlaganje sintaktičnih posebnosti. Invariants and Variables of Boris Pasternak was published by Professor Krystyna Pomorska.

Staff Changes and Activities

Professor William F. Bottiglia, having stepped down as head of the Department last year, will transfer to the Sloan School of Management as Professor of Management in 1974-75. Professor Robert C. Channon has been promoted from instructor to Assistant Professor of Russian. Professor Catherine V. Chvany has been promoted from assistant professor to Associate Professor of Russian. Professor Margaret Z. Freeman has been promoted from lecturer to Associate Professor of Russian. After 42 years of service to the M. I. T. community in several different capacities, usually more than one at a time, Professor Freeman is retiring this year. She will continue to teach part-time next year, however, as professor emerita and senior lecturer.

Professor Morris Halle was elected president of the Linguistic Society of America, having served as vice president the preceding year. Professor Robert E. Jones was on sabbatical leave during the spring term. He studied various aspects of French literature and began an investigation of the nature of dramatic elements in operas and the plays from which their librettos are drawn.

Professor G. Hubert Matthews has resigned in order to teach and work on the development of bilingual and bicultural teaching materials for Indian children in Crow schools in Montana. Renata H. Briggs, Stella B. Greenfield, Claire C. Kramsch, Katherine T. O'Connor, and Martha M. Schecter have been promoted from instructor to lecturer. Professor David M. Perlmutter returned from leave after lecturing extensively in France and Japan. Professor Marcia G. Williams has been awarded an Old Dominion Fellowship for study of the French lais and related topics in medieval literature during the fall term of 1974.

JAMES W. HARRIS

Department of Humanities

The past year has been predominantly one of intensive discussion and planning concerning changes in three central dimensions of the Department's life -- the Institute humanities requirement, the curricula of the various sections and programs of the Department, and the organization of the Department itself. Although the impact of these planning efforts is not yet fully clear, and several important decisions are still to be made, the net effect over the next several years certainly will be to reshape the Department in many important ways.

The specific changes in the Institute Requirement in the Humanities, Arts, and Social Sciences have been described in Dean Hanham's report above. Many members of the faculty participated vigorously in the discussions within the Department that helped to formulate the proposal for a new requirement, as well as in the subsequent debate at Institute-wide faculty meetings. Opinion was divided sharply within the Department as to the merits of the proposal. Faculty members from the Literature Section were the most articulate opponents of certain features of the proposed new requirement. This was not surprising, since the Literature Section in recent years had accepted the lion's share of the responsibility for planning and staffing the Department's offerings in the core curriculum, especially for the freshman year; its members were committed deeply to the kind of general education program in the humanities symbolized by the old requirement. Largely through their efforts, the faculty was persuaded to modify the language of the requirement so as to insure that the three distribution subjects all undergraduates now must take will be "humanistic" in spirit and content. Debate over this issue surely will continue in the coming academic year, when the new committee organized to oversee the requirement must undertake to define, in the context of specific cases, just what does and does not constitute a "humanistic" subject.

Several years' experience with the new requirement will be needed to reveal its full impact on the Department. It does seem reasonable to predict an initial falling-off in enrollments, now that a larger number of subjects and fields of study in other departments will be available to undergraduates in meeting the terms of the requirement. While this is perhaps distressing in a context of interdepartmental rivalry, a decline in enrollments seems likely to have some distinctly favorable qualitative aspects. Many members of the Department believe that the quality of teaching and learning in freshman and sophomore subjects has suffered from the degree of compulsion inherent in the old system. Faculty too often were obliged to teach subjects not of their own design in fields outside the mainstream of their own interests, and students similarly too often ended up taking subjects because they seemed

to be the least onerous way of fulfilling a tedious requirement. It is hoped strongly that motivation and enthusiasm on both sides will improve markedly when a considerably greater variety of subjects becomes available. There is every reason to believe, moreover, that the Department faculty will rise to the challenge of a more competitive situation by designing and teaching subjects that can attract students on their intrinsic merits.

Introduction of the new requirement also has helped to stimulate the development of new teaching programs in the Department. The four sections into which the Department is principally organized do not represent adequately the intellectual interests and potential of the faculty, nor do they necessarily provide the best structure for the growth of new fields. The new requirement, with its provision for a number of fields of concentration in one of which each student must take a minimum of three or four subjects, provides a flexible organizational framework within which new fields of study can be developed. Under the new requirement, for instance, creative writing has become an independent field of study, a development which has encouraged a more fully articulated program of subject offerings and other activities. Another field with potential for development is that of drama; an outside evaluation was commissioned this year on the Institute's program in drama, both curricular and extracurricular, and there is hope that some substantial improvements can be made over the next few years in this generally understaffed and underbudgeted area.

The most noticeable tendency in curriculum planning, however, has been the effort to bring together faculty from different parts of the Department, and from other departments as well, in new interdisciplinary programs of study. Leadership in this effort was taken this year by Professor Arthur Kaledin, Director of Course XXI. Professor Kaledin played an indispensable coordinating role in the preparation of new programs in American studies, Russian studies, and crossroads in the Western tradition. (These activities are described more fully in his own report on Course XXI.) Professor Travis R. Merritt, who succeeds Professor Kaledin as director of Course XXI, will continue to foster such interdisciplinary programs. Particular attention will be devoted next year to the development of a coherent set of subject offerings in technology studies; this task will be facilitated greatly by the appointment of Professor Louis Bucciarelli of the School of Engineering not only as director of the Technology Studies Program, but also as co-director of Course XXI. It is hoped that over the next several years a far more effective collaboration than has been possible in the past between the humanities and the science and engineering segments of the Course XXI curriculum will be achieved.

It seems safe to predict, all in all, that the coming two or three years will see a more substantial revision of the Department's curriculum than has occurred in a long while. This will be inevitably a period of some confusion and uncertainty, as both students and faculty adjust to the conditions of the new requirement. Until new enrollment patterns manifest themselves, for instance, the faculty will have to be unusually flexible in distributing teaching assignments. The nature and composition of the Department's faculty over the longer run most likely will relate to the relative success of groups within the Department in putting together intellectually stimulating fare capable of attracting and maintaining student enthusiasm.

The organizational structure of the Department also has been under review this year. Whether or not the Department should continue to exist in its present form is a question that now must be faced squarely. The four existing Sections -- Anthropology/Archaeology, History, Literature, and Music -- vary greatly in their size, internal coherence, and mode of operation. Although the Department Policy Committee has met regularly during the year and has been helpful as a forum for discussing and resolving some issues, it would be too much to say that it has been an effective instrument of Departmental leadership or a successful device for integrating the various components of an extraordinarily diverse group of people. A positive step toward establishing more uniform policies and practices within

the Department was the creation this spring of a Personnel Committee, chaired by Professor Neal Hartley. Its prime responsibilities will be to gather information relevant to promotion, tenure, and contract renewal, and to review such personnel decisions made by the sections. It is by no means clear, however, that the interests of "the humanities" at M. I. T. can be served best by lumping together in a single Department programs with styles and needs as different as those now accommodated within the Department of Humanities. The alternative of creating several small separate departments is not feasible, however, for a variety of practical reasons. It may be that the answer lies in creating a new structure, perhaps a more loosely organized "Humanities Division," with its various component parts having greater autonomy than at present and reporting directly to the dean rather than through the traditional Departmental mechanism.

These issues, in any case, have not yet been resolved, and will be a major item on next year's agenda. Under the circumstances it has seemed best to suspend the search for a new permanent head of the Department. Dean Harold J. Hanham, who has served as acting head since coming to the Institute in April, 1973, is leaving that post to give full attention to his responsibilities as dean. Professor Bruce Mazlish, a long-time member of the Department and former head of the History Section, has agreed to serve as acting head for the coming year.

HAROLD J. HANHAM

Anthropology/Archeology Section

In 1973-74, the Anthropology/Archaeology Section continued along the lines initiated and developed during the preceding four years, achieving its initial goals with regard to staff and instituting some innovative changes in administration of the program and curriculum development.

Professor Martin Diskin participated in a session at the American Anthropological Association (AAA) meetings in New Orleans, reading a paper on markets and economic innovation in the Oaxaca Valley, Mexico. He continues his research in Mexican peasant society and looks forward to returning to the Oaxaca Valley for further research in the near future. He also has been engaged in research in anthropology and nutrition under a seed grant from the Rockefeller Foundation, administered through the Center for International Studies. He is currently working with two graduate students and an anthropologist with a medical degree, Sergej Bogojavlensky, who also is interested in nutrition and related matters.

Professor James Howe, in his first year at M. I. T., completed his doctoral dissertation entitled "Village Political Organization among the San Blas Cuna" for the University of Pennsylvania. He read a paper, coauthored with Joel Sherzer, entitled "Semantic Analysis of Sappi Turpa 'fruit' in San Blas" for a symposium on the ethnography of speaking at the AAA meeting in New Orleans. In the spring of 1974, he attended the meetings of the Southern Anthropological Society, at which he read a paper on land tenure and descent among the San Blas Cuna at a symposium on peoples and cultures of Central America. Professor Howe's future interests include returning to the San Blas Cuna and completing several articles in the areas of kinship, politics, and ritual from his previous field work with the Cuna.

Professor Jean Jackson read two papers at the New Orleans AAA meetings, one on Vaupés marriage patterns for a symposium on Amazonian marriage patterns. This paper currently is being revised for publication in the proceedings of the symposium. Another paper, entitled "Ethno-Linguistics: What the Bará Say about Vaupés Languages and Speech," also is being revised. In October, 1973, she attended a conference on formal methods in regional systems analysis, giving a paper on the Vaupés as a regional system that will be published in the proceedings of the conference. Professor Jackson currently is writing a review of the literature on the ethnography of northwestern South America and also is completing a paper for submission to a special issue of the American Ethnologist. It compares the

position of Bará women of the Vaupés to middle-class American women. This past fall, she offered an undergraduate seminar entitled The Anthropology of the Beavers of the Lower Charles, which was designed to allow students to study their own environment, and offered a subject during the Independent Activities Period on ethnography and women. She has been serving as director of the anthropology/archaeology program, following a decision to make that position an annually rotating rather than a permanent one; Professor Arthur Steinberg will become director on July 1, 1974.

Professor Steinberg, W. R. Kenan, Jr. Associate Professor of Archaeology, taught a new subject in collaboration with members of the Department of Metallurgy and Materials Science entitled Materials Processing, an Engineering and Historical Approach. Jointly with Professor Miranda Marvin of Wellesley College, he again taught Archaeological Theory and Method. At the University of Illinois International Symposium on the History and Philosophy of Technology, he read a paper, coauthored with Professor Heather Lechtman, titled "The History of Technology -- An Anthropological Point of View." It will be published in the proceedings of the conference. An outgrowth of that paper, entitled "Chinese and Greek Ceramics: Aspects of Technological Style," has been given at several meetings and lectures this year. Professor Steinberg also has continued with his studies of the ancient Cypriot copper industry through examination and analysis of slags collected on the island. He has continued to run the seminar on materials and archaeology held at M. I. T. each month.

Professor Lechtman was promoted to Associate Professor of Ancient Technology and Archaeology, jointly in the Departments of Humanities and of Metallurgy and Materials Science. In addition to her collaboration with Professor Steinberg, she has published several new papers on pre-Columbian metalworking, including "The Gilding of Metals in Pre-Columbian Peru." She followed up her laboratory studies with a year in Peru, where she investigated ancient mining and metalworking areas.

The Anthropology/Archaeology Section appointed a new colleague during the past academic year, Instructor Wilma Wetterstrom, who will begin in September, 1974. She is an archaeologist who is completing her Doctor of Philosophy at the University of Michigan, and who specializes in ethno-botany and nutrition studies. Her dissertation is concerned with analyzing the nutritional resources of the Arroyo Hondo site in New Mexico.

The Section was fortunate in having Professor Monni Adams as a visiting professor this past spring. She taught a subject during Professor Lechtman's absence entitled Aesthetic Anthropology: The Art of Black Africa. During the spring, she read papers at several conferences on African and Asian art and ritual.

The Anthropology/Archaeology Section began a guest speaker program this year which it hopes to continue. In addition to talks by several of the candidates for the position in archaeology, two invited speakers, Professor Carol B. Stack of Boston University and Professor John U. Ogbu of the University of California at Berkeley, gave lectures on racial discrimination. Their topics were "The Culture of Poverty Doesn't Exist: A Contemporary Critique," and "Race, I. Q., and Socioeconomic Status: A Critique of Jensen's Hypothesis about Black-White Inequality," respectively.

The Section has revised its subject offerings significantly for next year, a result of many discussions regarding its program and what it wishes to offer students who are concentrating or majoring in anthropology/archaeology. The introductory subject now is offered to freshmen, and three new mid-level subjects, on ethnography, anthropological theory and method, and archaeological theory and method, are offered to sophomores. The mid-level subjects will be team taught and will introduce new teaching methods and subject matter. It is hoped that these changes will fit the changing needs of students better and better utilize the Section's collective resources for teaching and counseling. With the addition of Instructor Wetterstrom, the Section is on a more solid footing, and attention now can be

turned to matters not directly connected to establishing a curriculum. The Anthropology/ Archaeology Section hopes thus to serve more fully its students and the M. I. T. community at large.

JEAN JACKSON

History Section

The History Section met weekly throughout most of the first term for the purpose of viewing course offerings and determining future needs. The meetings were noteworthy for the spirit of cooperation which prevailed. They were also productive: first, the subject offerings were reduced significantly in number and rearranged in new sequences. Second, it was agreed that the Section's immediate priorities lie in the areas of Chinese, Japanese, and Latin American historical studies. It also was felt that it would be desirable to augment the strength of the American history offerings.

The necessity for appointments in these fields was underscored by the fact that the Section has suffered marked attrition as a consequence of failure to provide replacements for those members who have retired or resigned to accept appointments elsewhere.

In addition to these much-needed appointments, the Section has had a problem which seems to have gone unnoticed. At least seven senior members of the Section divide their time between teaching history in the Department of Humanities and performing other teaching or administrative duties in the Department or elsewhere in the Institute.

During the past academic year, Professor Emeritus Robert S. Woodbury completed his post-retirement teaching in the Section, and Professor Lynwood S. Bryant retired. Both will be missed sorely, but Professor Bryant's loss is mitigated by his returning for the fall term as a lecturer.

Professor David Ralston, who spent the year teaching at the Naval War College, Newport, Rhode Island, will return to that institution for the coming year as well. Also absent during half or all of the forthcoming year will be Professors Arthur Kaledin, William Watson, and Lewis Wurgaft, who will be on leave.

During the year 1973-74, History Section members continued to take part in various scholarly activities including research and professional meetings. Indications are that these activities will continue in force during the coming academic year.

THOMAS H. D. MAHONEY

Literature Section

For most of the members of the literature faculty, the academic year 1973-74 has been a year of working and planning outside the Section more than inside of it, a response to a year of Department, School, and Institute discussion of the humanities requirement. Members of the Section also continued to teach in the M. I. T. experimental programs, Concourse and the Experimental Study Group (E.S.G.). In addition, a new program was launched, the Cambridge Humanities Seminar, by Professors Alvin C. Kibel and Eugene Goodheart.

New activities for next year, planned in whole or in part by members of the Literature Section, are Crossroads (a revised program of study in the Western tradition), an American studies program, and a separate and distinct writing and literature program. By the end of the academic year, the Section had returned to reworking its program of study for literature concentrators.

In the midst of such a great amount of curriculum planning, the Section's faculty continued to publish, perform, and be performed. Professor Patricia Cummings' well-received volume of poems, Afterwards, was published in the spring by Alice James Books. Professor Barry Spacks published and read his poetry widely, and "Seasons," a choral work for which Professor Floyd Barbour did the libretto, was performed at Regis College in the spring. Spring also saw the London production (at the Mermaid Theatre) of Professor Albert R. Gurney's Children and the New York publication of his novel, The Gospel According to Joe. Both were acclaimed widely by critics.

Professor Eugene Goodheart published a paper, "Utopia and the Irony of History," in Modern Occasions. Professor Peter Donaldson has had two of his manuscripts on Machiavellism accepted for publication in England. He also has been awarded a fellowship for younger humanists by the National Endowment for the Humanities.

WAYNE O'NEIL

Music Section

The Music Section altered the focus of much of its introductory curriculum this year with the addition of class instrumental and singing instruction. Besides enrolling for subjects which included sight singing, ear training, and wind playing, many students elected to sign up for seminars in vocal technique and ensemble playing. The Council for the Arts' and the Committee for Space Planning's funding of pianos and practice spaces this spring allowed for the addition of basic piano to the opportunities for beginning music students starting next fall. Hopefully the time will come when most music subjects will have a "laboratory" of "doing" music in conjunction with the theoretical and historical studies common to many university programs.

Student interest in performing groups remains strong. New organizations this year which received help from faculty members included the Chamber Music Society, the Gospel Choir, and the Schola Cantorum. The Concert Band celebrated its twenty-fifth anniversary under John Corley's direction with a gala May concert. The Orchestra continued its auspicious record under Professor David M. Epstein with glowing reviews in a spring tour to areas north of Boston into Canada, and a recording project under the auspices of the Council for the Arts. Large turnouts for choral singing necessitated the development of a new group which specialized in the Bach cantata and chamber vocal literature, under John Oliver's leadership. Brass, woodwind, and string chamber music became more a part of student and campus life, with many informal concerts in lobbies, libraries, and other free space in the Institute.

The Studio for experimental music received backing from Project MAC in its bid to develop a more musically flexible and efficient system for analysis and composition. Professor Barry L. Vercoe worked during the year with a number of M. I. T. and Boston area graduate student composers, culminating in the first concert of works from the Studio in May. Lecturer Adrian Houtsma extended his acoustical interests into a subject in instrument building, in collaboration with the Department of Architecture. July, 1974, will see the unveiling at an M. I. T. concert of a new design guitar, and plans are now under way for the design, production, and fabrication of other instruments.

The Section strengthened its program in traditional and folk music. Professor Donald Sur, a specialist in Far Eastern music, led a seminar in the instrumental and musical techniques of Persia, India, and Korea. He also sponsored a residency and concert by the Kathak Dancers. The addition of Professor Stephen Erdely, an ethnomusicologist with interest in American and European traditional and folk music, adds a more global and interdisciplinary dimension to the Section's subject offerings.

Concerts remain central to the teaching of music at M. I. T. . Outside groups visiting the Institute included the Contemporary Chamber Ensemble, performing works by Professor John Harbison and Schoenberg; the Philadelphia String Quartet, in works by Professor Epstein, Haydn, and Mendelssohn; harpist Nicanor Zabaleta, in traditional and contemporary works; and pianist Nina Milkina, in a Scarlatti and Haydn recital. Faculty concerts included a Brahms chamber music evening with Lecturer William Draper, a Beethoven birthday concert by Professor John Buttrick, and a series of concerts and lectures in Burton House organized by Professor and Mrs. Rufus E. Hallmark as part of a seminar including Professors Hallmark, Vercoe, Erdely, Sur, Marcus A. Thompson, Harbison, Buttrick, and Epstein. A series of noon-hour concerts in the chapel on Thursdays offered a variety of works for mixed chamber groups featuring local artists. A summer series of Tuesday evening concerts continued to be one of the few sources of good summer music in the area; large audiences attest to the growing interest in chamber music performance. .

The faculty has had an active year outside of M. I. T. Professors Epstein and Harbison received composition grants for major chamber works. Professors Buttrick, Epstein, and Thompson were on concert tours during part of the year. Professor Hallmark was tenor for the Camerata singers and at Emmanuel Church. Lecturer John Cook worked with the Guthrie Theatre in Minneapolis during part of the fall, and John Oliver continued his conducting duties with the Tanglewood and Boston Symphony choruses.

The faculty's strength in the various musical disciplines it represents, and its dedication to the need of M. I. T. to represent and celebrate the arts, has been responsible for the increasing numbers of M. I. T. students studying music. It is expected that this trend will continue as the Section searches for better ways to involve students at all levels in the process and meaning of music. The Music Section is appreciative of the support extended by the Council for the Arts and the administration during the past year.

JOHN BUTTRICK

Course XXI

This year saw the beginning of a major review of Course XXI, its various programs, its relationship to the semiautonomous sections of the Department of Humanities, and its place at M. I. T. This review is still in progress; its outcome is dependent, to a degree, on how questions about the future structure of the Department of Humanities, and indeed of the School, are resolved. Despite continuing uncertainty about what Course XXI will look like in the future, there is a strong conviction that it should serve as a sponsor and center for interdisciplinary programs that will draw on all the resources of M. I. T. ; above all, it should provide leadership in the difficult task of linking the humanities and sciences in carefully constructed undergraduate subjects and programs. In other words, the feeling that Course XXI's major function should be integrative -- that it should stand for the ideal of the unity of knowledge and against the fragmentation of learning -- gained strength during the year's deliberations. Much time and energy was given to the planning and development of several new interdisciplinary programs, some of which will be launched next year. Beginning in 1974-75, new programs in American studies, Russian studies, and writing and literature will be available as options to undergraduates in Course XXI. In whatever ways appropriate to them, these programs will attempt to link the study of science and technology with the humanities, arts, and social sciences.

Course XXI also plans to build a strong partnership with the new Technology Studies Program as a means of strengthening its Humanities and Engineering (XXI-A) and Humanities and Science (XXI-B, 1) programs. To this end, the director of Course XXI served on the Technology Studies Steering Committee during 1973-74. Beginning in 1974, the director of the Technology Studies Program, Professor Louis Bucciarelli, Jr. (jointly appointed in the School of Engineering and the School of Humanities and Social Science) will serve as

co-director of Course XXI with Professor Travis Merritt of the Department of Humanities. The possibility of forging a link between Course XXI and the Cambridge Humanities Seminar -- the M.I.T. based inter-university, interdisciplinary program of advanced study in the humanities for graduate students and advanced undergraduates enrolled at participating universities -- is also a promising prospect.

Discussions with a view to establishing new interdisciplinary programs in collaboration with the various social science departments, with the Department of Foreign Literatures and Linguistics, and with the film section of the Department of Architecture, also began in 1973-74, but remain in a preliminary stage. Finally, Course XXI also sponsored the discussions that led to the elaboration of the new Crossroads program, a sequence of six interdisciplinary subjects that will explore different eras in the evolution of Western civilization with the aim of achieving a deeper understanding of change and continuity in the Western tradition.

Until the future status of the disciplinary sections (Literature, History, Music, and Anthropology/Archaeology) is clarified, Course XXI retains overall responsibility for the various disciplinary programs offered under program XXI-B, 2.

The distressing decline in Course XXI enrollments that began in 1970-71 continued this past year and remains a matter of sharp concern, although it showed some signs of abatement. Seventy-two undergraduates were enrolled in the various Course XXI programs in the spring of 1974 (compared with spring term enrollments of 92 in 1973, 132 in 1972, and 185 in 1971). This drift from the humanities reflects a clear nationwide shift toward more practical and utilitarian fields; a growing preoccupation with technique and technical problems; an intensification of vocational concerns; and a growing willingness of students to specialize narrowly. All this is accompanied by a deepening apathy and even cynicism among the young with regard to the prospects for large-scale social change, and a return to privatism, narrow horizons, and modest ambitions that characterized the 1950s. In the 1960s, students were attracted to those disciplines and ways of thinking that promised more explicit deliberation on moral issues, social change, and values and society -- that promised the kind of broad understanding that the social turmoil in which society was engulfed seemed to require. The decided shift in the cultural, social, and political climate since that time has had a sharp impact on the hopes, ambitions, and interests of students.

Some local factors also lie behind the decline in humanities enrollments at M.I.T., among them the increasing diversification of the curriculum and the availability of excellent new programs and options for undergraduates throughout the Institute. Although this attrition has reduced somewhat the ranks of the Department of Humanities faculty and though some first-rate teachers have been lost, basically the same faculty and programs that proved attractive enough to undergraduates in 1970 to make the Department the fourth largest at M.I.T. (in terms of undergraduate majors) now have a considerably reduced clientele. Clearly the Department must rethink its curricula, and it has begun to do so. It also has raised again the question of how M.I.T. might attract more students interested in the humanities and social sciences without altering the Institute's basic character or purposes.

ARTHUR KALÉDIN

COURSE XXI ENROLLMENT, SPRING 1974

	<u>By Disciplines</u>							Subtotal	Total
	Anthropology/ Archaeology	History	Literature	Music	Philosophy	Social Inquiry	Major Departure		
XXI-A		1	4	6		1		12	
XXI-B,1			10	2	3	3		18	
XXI-B,2	4	2	30	3	1		2	42	72

	<u>By Classes</u>							Subtotal	Total
	Anthropology/ Archaeology	History	Literature	Music	Philosophy	Social Inquiry	Major Departure		
Seniors (41)									
XXI-A		1	4	3		1		9	
XXI-B,1			4	1	2	2		9	
XXI-B,2	1		17	2	1		2	23	41
Juniors (17)									
XXI-A				2				2	
XXI-B,1			3	1	1	1		6	
XXI-B,2	1	1	7					9	17
Sophomores (13)									
XXI-A				1				1	
XXI-B,1			3					3	
XXI-B,2	2	1	6	1				10	14

By Science or Engineering Field (XXI-A, XXI-B,1)

Electrical Engineering	9	Chemistry	1
Psychology	8	Civil Engineering	1
Biology	4	Life Sciences	1
Physics	3	Mathematics	1
Chemical Engineering	1	Mechanical Engineering	1

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 was organized by Professors Eugene Goodheart and Alvin Kibel of the Department of Humanities. A seminar of 14 faculty members from six universities representing seven disciplines was assembled. Operating with a grant from the National Endowment for the Humanities, the seminar met on a biweekly basis for three hours, with additional meetings for curricular planning and discussion. The seminar had two distinct but related tasks: 1) to identify and explore the most fruitful areas for interdisciplinary scholarship, and 2) to design subjects which will be taught by future members of the Seminar to classes of cross-registered students. It is hoped that subjects developed in this way -- i.e. out of the ongoing concerns of an active professional seminar -- will speak to each other more closely than is usual with interdisciplinary programs. At the end of three years, a regular program offering students a concentration in the humanities during the last year of undergraduate and the first two years of graduate work in an area of interdisciplinary scholarship to be determined periodically by its faculty membership, working through a central seminar, is envisioned. Such a program would be addressed to three problems, the first of which is of special concern to M. I. T.

1. How can a first-rate humanities program, extensive in range and depth, be mounted at an institute predominantly oriented toward science and technology?
2. How can universities share their intellectual resources so as to provide their students with the widest choice of educational opportunities without compromising academic quality?
3. How can serious, ongoing programs in interdisciplinary subjects develop a curriculum?

The mandate for the first year's Seminar was to determine, by trial and experiment, the common subject matter of the program for ensuing years. To this end, the Seminar began by proposing five topics for consideration under the general theme of the idea of the past as it plays a role in various cultural activities. The theme appeared to be particularly appropriate at a time when consciousness is dominated excessively by the contemporary and the new, with a consequent loss of historical perspective. The topics were: 1) the role of the university in people's conception of learning; 2) the relation between originality and tradition in the arts and sciences; 3) the relations between high culture, i.e., intellectual and artistic activity, and general culture; 4) the idea of progress in the arts and the sciences; and 5) the idea of the avant-garde in the arts and in politics.

Each meeting was occupied by discussion of a paper of publishable quality on one of these topics. The paper, accompanied by a manageable bibliography, was circulated two weeks in advance of each meeting, and discussion would begin with a brief statement by a respondent selected from the group and the author's reply. The seminar has produced a body of professionally acceptable work, of which several papers -- including those of the co-directors -- have been accepted subsequently for publication.

As a result of these discussions, the Seminar has agreed to focus next year upon a subject matter capable of sharper formulation than the idea of the past, one that seems logically suggested by the tenor of the year's discussions. The Seminar proposes to examine moments in cultural history when the validity or relevance of tradition, or the very idea of tradition, become problematical. Those moments at which an aspect of the cultural inheritance becomes difficult to acquire, and this difficulty becomes the focus of argument, will provide a core

topic. Culture always identifies its relevant past; at certain moments, however, novel, often contested ways are devised to overcome a newly felt estrangement which subsequently become paradigms for continuity. An attempt will be made to study several such moments in historical perspective.

The following discussions already are planned and assigned to participants: St. Paul and the Judaic tradition; Augustine at the end of classical culture; Montaigne as the heir of two incompatible spiritual and cultural traditions (class antiquity and Christianity); higher criticism in relation to Christianity; Nietzsche as the philosopher par excellence of the problematic past, the experience of nihilism, the need for transvaluation of values; modernism as a paradoxical synthesis of the need for tradition (i. e. tradition itself, tradition as an abstract value, and the passion for novelty); and Cezanne and tradition.

In the course of this past year's work, the Seminar has secured endorsements from appropriate administrators at Brandeis University and Wellesley College and has initiated talks to the same end with Boston University. In addition, several subjects emerging out of the Seminar discussions have been listed in the Wellesley and Brandeis catalogues for next year, and the apparatus for cross-registration has been set up in a preliminary fashion.

ALVIN KIBEL

Department of Philosophy

Teaching

Approximately three-fourths of the Department's teaching time goes into the teaching of undergraduate subjects, and the bulk of this time is spent in freshman and sophomore "core" subjects. In past years, Departmental representation in subjects designed for satisfaction of the freshman requirement in humanities and social sciences was limited to 24.01-02 Contemporary Moral Issues. Although pleased with the success of that subject, it was the Department's judgment that a diversity of offerings would relieve certain staffing problems and would present freshmen with a less one-sided view of Departmental interests. Accordingly, two new subjects were introduced in the 1973-74 academic year: 24.03-04 Logic, Language, and Science; and 24.05-06 Science and Philosophy. The former was intended as an introduction to the principles of critical thinking and rational inquiry, especially as these are exemplified in scientific thought; the latter was designed as an examination, both historical and systematic, of the ways in which scientific and philosophical problems interact. Freshmen responded to the diversification of offerings by enrolling in the two new subjects in unexpectedly high numbers. Enrollment figures for the three freshman subjects were as follows:

<u>Fall Term</u>	<u>Spring Term</u>
24.01 66	24.02 61
24.03 241	24.04 227
24.05 112	24.06 92

Heavy enrollment in the two new subjects doubtless can be attributed to their special appeal to prospective students of science and engineering.

The graduate program continues to suffer from lack of adequate funding. The number and quality of applicants remain high, but it has become increasingly difficult to compete for the best students with public institutions and with those private institutions that have unusually large resources for the support of graduate students in philosophy. In fact, the Department is approaching a situation in which enrollment is below the minimum required for a successful program. Enrollment in the graduate program from its inception is as follows:

1963-64	4	1967-68	25	1971-72	27
1964-65	17	1968-69	21	1972-73	22
1965-66	23	1969-70	25	1973-74	21
1966-67	27	1970-71	34	1974-75	18 (estimated)

Without additional funding, the decline in enrollment that began in 1971-72 undoubtedly will continue.

Research

The year 1973-74 was a productive one in terms of publication and research. The long-standing collaborative effort of Professors Jerry A. Fodor, Merrill G. Garrett of the Department of Psychology, and Thomas G. Bever of the Department of Psychology at Columbia University saw fruit in the publication of their Psychology of Language. The book promises to be the standard work in its field for many years to come.

Professor George S. Boolos, jointly with Professor Richard C. Jeffrey of the Department of Philosophy at Princeton University, published Computability and Logic. Designed as a text at the intermediate level, the book incorporates much original material and is noteworthy for its successful combination of rigor with clarity.

Members of the Department published articles on a wide variety of topics, including semantics (Professor Jerrold J. Katz), Beethoven's "Fidelio" (Professor Irving Singer), preferential hiring (Professor Judith J. Thomson), definability in formal systems (Professor Boolos), Aristotelian essentialism (Professor Boruch A. Brody), the heritability of intelligence (Professor Ned J. Block), and utilitarianism (Professor Paul Horwich).

Special mention should be made of the publication of Professor Block's "Why Do Mirrors Reverse Right/Left But Not Up/Down?" Originally presented as a lecture during the January Independent Activities Period (1973 and 1974), it appeared in a recent issue of The Journal of Philosophy.

Personnel

Professor John C. Graves will leave M. I. T. at the end of this academic year. James Kostman, who will receive his Doctor of Philosophy from Stanford University, will join the Department next year as assistant professor. A specialist in Plato and Aristotle, he will provide needed strength in the history of philosophy. Professor Katz was a member of the faculty of the Summer Linguistics Institute at the University of California at Santa Cruz. Professor Judith Thomson has been appointed to the Executive Committee of the Eastern Division of the American Philosophical Association. Professor Barbara Herman has been appointed to the Executive Committee of the Society for Philosophy and Public Affairs.

RICHARD L. CARTWRIGHT

Department of Political Science

The change in the leadership of the Department of Political Science at the end of the 1973-74 academic year, with Professor Myron Weiner succeeding Professor Eugene Skolnikoff as head, marks a new stage in the Department's development. It has a young and extremely active faculty with a high and growing international reputation for its quality of research and teaching, especially at the graduate level. However, it has reached rough maturity in size, and thus faces the problems of sustaining vitality without substantial growth or turnover. It also must come to grips with the traditional problem of its relationship to the undergraduate program at the Institute.

The Department has grown modestly in faculty size during Professor Skolnikoff's four-year tenure as head, as major emphasis has been placed on the development of American and urban fields, while policy-relevant competence has been emphasized. In a period of retrenchment at other universities, the Department has chosen instead to increase the size of its graduate student body and to broaden its interests. It has been possible to choose the very best of both faculty and students, so that the quality of the graduate program, already rated one of the leaders in the country in the last national evaluation several years ago, is now significantly higher.

The increased number of students in the program has brought about some minor difficulties in student-faculty interaction, but these should be easy to resolve. Extended discussions were held with students to design new advisory and other mechanisms to meet the altered needs. Placement of the Department's graduates, though more difficult than in the past, has been more successful than the experience of major departments in other universities. A swing away from academic to government and private research positions has become evident. This transition matches the Department's strengths. In fact, the demand for its graduates in positions outside universities probably will exceed the number of the Department's students interested in such careers for quite a few years. However, the Department is considering the possibility of inaugurating master's programs and special cross-departmental doctoral programs as a means of more effectively using its educational capabilities while helping to meet an important need for policy analysts. As one step in this direction, the Department is cooperating with the School of Engineering in a new master's program for the training of engineers for systems analysis positions.

The most serious problem for the Department's graduate program, which looms very large in the immediate future, is the substantial decline in the availability of fellowship funds. Some of the slack has been taken up by increases in research assistantships, but not enough to offset the overall decline in student support; the problem is especially severe for entering students, who usually cannot be assigned to research assistantships. The major blow will hit next year when a special Ford Foundation fellowship program is terminated. The Department is exploring new sources of funds, but the outlook is not encouraging.

A different kind of problem arises from the relatively young average age of the faculty, coupled with the likelihood of very limited future growth. Almost ten years must pass before there will be an appreciable number of retirements, which makes it particularly difficult to respond quickly to changing student or disciplinary interests, or to meet new interests within M. I. T. that call for the involvement of political science faculty. The unexpected departure of two faculty members this year provides some flexibility, but turnover traditionally has been very low.

The increased interest in greater interaction with other parts of M. I. T. is especially important, and has been receiving considerable attention within the Department. The development of new, related programs in the Institute, such as the Technology Studies Program in the School of Humanities and Social Science and the prospect of joint appointments with other departments, should help to meet that important need. However, the growing recognition in the School of Engineering of the need for political science inputs in their own programs will continue to present requirements that never can be satisfied fully by the Department of Political Science alone. The relative sizes of the School of Engineering and this Department militate against simple solutions. Most likely, a relatively new pattern of social science appointments in the School of Engineering will have to be expanded, creating significant difficulties of quality control over appointments and specific subjects. These difficulties can be met, but will take close collaboration between the social science departments and the School of Engineering.

In contrast with the quality and momentum of the graduate program, the Department's efforts at the undergraduate level have not yet had the hoped-for impact. The Department has continued such special efforts begun in the past several years as new undergraduate subjects, special lectures and seminars, and other means of bringing its offerings to the attention of undergraduates. The American politics faculty of the Department, in particular, has innovated substantially in reaching out to undergraduates. The result of these efforts has been an excellent and unusual political science program, but not the desired response from undergraduates. The ability and interest of those who do become engaged is very high, but the numbers are small relative to the quality of the program and the potential of the Department. Even more extensive efforts will be made in the coming academic year, with more publicity about the Department, special meetings, visits to living groups, campus lecture series, and other activities. The apparent cyclical nature of student interest in the study of politics (a phenomenon common to most American universities today) is disturbing, and may be exaggerated during the next year or two by the change in the humanities requirement at M. I. T. This phenomenon is particularly unfortunate, for the quality of the program in this Department and the favorable student-faculty ratios give undergraduates an opportunity equalled at few universities.

It is in fact likely that the major causes of this situation are more structural than substantively related to the study of politics. One major problem is the skewed nature of the interests of many applicants to M. I. T., who still believe and are often told that M. I. T. is only concerned with science and engineering. This problem of the specialized interests of most applicants to M. I. T. may be so basic that little can be done. However, discussions have begun with the Office of Admissions on the attempt to get better information out to high schools and alumni about the Department's program, and new brochures are being prepared for this purpose. If these efforts are unsuccessful, there may have to be a fundamental rethinking in the next few years of what the undergraduate role of the Department should be, and how best to use the talents and energies of the Department of Political Science faculty in undergraduate education.

Research activities in the Department continue to grow, especially in areas interacting with other parts of the Institute, such as communications policy, energy, migration, and regulation. Additional possibilities in these directions are promising. Funding problems exist most often in the more traditional fields such as international relations, for government and private funding sources remain relatively disinterested. The emphasis of both foundations and government continues to be focused excessively on policy issues with short-term payoff. This is useful for raising funds for policy oriented research, but hurts the equally essential long-range research.

Professor Eugene B. Skolnikoff will continue as director of the Center for International Studies, having held that post simultaneously with the Department headship for the past two

and one-half years. The post of executive officer of the Department, held most successfully by Professor Harvey Sapolsky in the 1973-74 year, will not be filled next year, in recognition of the return of a full-time Department head.

Two current members of the faculty are leaving at the end of this academic year, plus a third who has been on leave for the past two years. Professor Frederick W. Frey, who has been with the Department since 1960, has resigned to accept an important professorship at the University of Pennsylvania. His long and constructive participation was a major factor in building the Department in its earlier days and in continuing its commitment to quality teaching and research. Professor Francine Rabinovitz, who came to M. I. T. this past year on a joint appointment with the Department of Urban Studies and Planning, has had to return to California for personal reasons. She will be missed sorely, for she had become an integral part of the program of both Departments, as well as an important link between them. Professor Alan Altshuler, who had been on leave for two years as Secretary of Transportation and Construction in the Commonwealth of Massachusetts, elected to remain in that post and therefore has resigned from the Institute. It is hoped that eventually he will be able to return.

Two new faculty members will join the Department. Professor Ted Greenwood, who received his doctorate from the Department in 1973, returns to teach in the defense studies and science and public policy fields, and to strengthen the Department's capabilities generally in the area of technology and politics. For the first several years, he will devote one-half of his time to the Harvard University research program on science and international affairs. Professor Christopher Arterton joins the Department for one year in the American politics area, filling in for Professor Walter Burnham, who will be on leave. Professor Arterton also received his Doctor of Philosophy from the Department, and has been on the faculty at Wellesley College.

The scholarly production of the faculty continues at a high level, with some 75 articles published, 19 books written or edited, plus numerous reviews, lectures, television appearances, and similar activities. A large proportion of the faculty serves on editorial boards or professional journals. Professor Walter Burnham was awarded Guggenheim and Fulbright-Hays Fellowships; Professor Harold Isaacs was elected to the American Academy of Arts and Sciences; Professor Rabinovitz was elected to the Council of the American Political Science Association; Professor Lucian Pye was selected as Phi Beta Kappa Lecturer and as Philips Visiting Scholar at Haverford College; and Professor Skolnikoff was elected a Councillor of the American Academy of Arts and Sciences.

EUGENE B. SKOLNIKOFF

Department of Psychology

The year under review, 1973-74, brought the Department of Psychology to the threshold of its second decade. Such a time affords an occasion to look back over the first ten years and to look ahead. From its beginning in the summer of 1964, the Department has been deliberately unorthodox in its composition and program. The small faculty assembled over the first few years included from the outset not only experimental psychologists, but neuro-anatomists and neurophysiologists, students of linguistics and students of mathematical biophysics. Such an unusual mixture, one might have thought, soon would have led to progressive compartmentalization, with individual faculty members drifting into separate niches; instead, throughout these ten years, the interdisciplinary character of the Department has remained intact, without losing any unity of purpose.

This unity stems from the Department's continuing commitment to a scientific program. Its work revolves around three interrelated themes, covering aspects of: 1) relations between brain and behavior; 2) studies of perception and perceptual-motor coordination; and 3) inquiries into cognition and its early development, with particular emphasis on psycholinguistics. Such a threefold structure, which has defined the research and teaching within the Department, does include much that other, more traditional psychology departments would have left out. By the same token, however, there is also a good deal that this Department has elected to pass by. It is felt that the gain has been in the cohesion of the program, in spite of its obvious diversity.

If one prescription for a successful university department is that it should give the impression of productive chaos, then the Department of Psychology certainly follows that prescription. Discoveries come with increasing frequency, often where least expected, and open new areas for additional work. External signs of recognition likewise are coming to the Department with increasing frequency; even though three members of the Department's faculty (of only 12) have been elected to the National Academy of Sciences, their teaching and research show no signs of slowing down.

In fact, if there are hazards immediately ahead, they derive from the pace at which the Department is moving and from the legitimate demands made upon it by students and the rest of the Institute. There simply are not enough faculty members in the Department to cover the many activities in other sectors of the Institute that lay claim to their time. Equally serious is the fact that there are not quite enough people in the Department for it to do justice to the extent to which its undergraduate teaching has grown. Clearly, the role of the Department in the general pattern of the Institute's undergraduate curriculum will have to be redefined. This will require additional facilities and funds.

In the past year, the Departmental faculty consisted of 12 regular full-time members and two more shared with other departments. This exceedingly small faculty taught 1,407 undergraduates in 17 different subjects, and 207 graduate students in another 20 subjects. In addition, this unit carried 23 different research projects, supervised the work of 26 doctoral candidates, and acted as hosts to nearly two dozen postdoctoral fellows or visiting investigators from the U. S. and abroad. All this speaks to the extent of individual overcommitment and the need for more staff.

In the past year, the bulk of the undergraduate enrollment again was in the introductory subject (9.00 Psychology and Brain Science), and in a new offering (formerly 9.60 Personality Structure and Development, now provisionally called Conflicting Images of Man). Both subjects together (9.00 in the fall and spring terms, and 9.60 in the spring term) attracted 993 students. For next year, this part of the introductory curriculum will be restructured. For the first time, 9.00, taught by the Department's head, will be offered only in the fall term, to be followed in the spring term by the modified 9.60, which will function as the second half of the introductory subject. In this way, humanity "in nature" and humanity "in culture" will be presented, and the peculiar location of this field at the intersection of the natural sciences with social science and humanities will be underscored.

This reshaping of the introductory offerings should provide, at the same time, a new framework for a special part of the graduate program: the effort to teach how to teach. As in the past, the introductory undergraduate subjects will be taught by the Department's head on Thursday nights, in two-hour sessions, with an additional weekly hour taught by the second-year graduate students as section leaders. Next year, evening lectures and demonstrations, as well as selected section meetings, will be videotaped for repeated review in a continuing seminar on the teaching process.

With this emphasis on the teaching of teaching, it is ironic that the Department has acquired over the past year an evident gap in the teaching of "learning." This gap developed inevitably as the result of a progressive shift in the research interests of one faculty member who originally had been typecast as the main representative of this topic. Evidently, such shifts in personal commitment are both natural and desirable, but they can have grave consequences in a group as small as this one. It seems imperative that the Department be able to add at least one junior faculty member primarily devoted to the study of learning, who will provide undergraduate and graduate instruction in that field. A further need is for a new appointment in the closely related field of ethology.

All in all, during the past year the Department has pressed against the outermost limits of its resources, both in terms of what was expected, particularly of the senior staff, and in what could be provided through outside funds. Without some increase in both staff and external resources, the Department will run the immediate risk of losing momentum, and of reverting to much more traditional patterns of operation than was ever intended.

This review and preview would be incomplete if it were not mentioned how much the unit again profited in the past year from the flux of visitors, and particularly from those who came to share more formally in teaching. In 1973-74, there were three senior visiting faculty members. In the fall term, for two weeks, Professor Jack Cowan of the University of Chicago gave a seminar series on the modeling of neural networks and related issues in mathematical biophysics. Throughout the spring term, Professor Alvin Liberman of Yale University and Storrs, Connecticut taught the major psycholinguistics seminar instead of Professor Merrill Garrett, who was away on a Fulbright Exchange Appointment in Australia. Professor Liberman also participated in the supervision of graduate students concerned with the analysis of speech production, speech perception, and the principles of first-language learning. The third to arrive was the long-awaited exchange professor from the University of Moscow, Eugene N. Sokolov, who had been slated to teach the Department's learning subject. Owing to his late arrival (through no fault of his own), the Department had to arrange instead a series of weekly seminars on his work, which dealt with orienting reflexes and habituation on all levels, from intact man to single units in the nervous systems of invertebrates. These lectures attracted a large audience, both from within and outside the Institute.

Other visitors included Special Research Associate Dr. Francois Vital-Durand from the University of Lyon, who worked for the entire year in Professor Alan Hein's laboratory. He devoted himself primarily to problems of "plasticity" in the early cortical and visual development of kittens. Besides Dr. Vital-Durand, the Department last year acted as host to Dr. Michele Brouchon-Viton of the University of Aix-Marseille, and, for a shorter time, to Professors Francois Michel (University of Lyon) and Michel Imbert (Paris, College de France). In turn, four members of the Department of Psychology were guests of the French National Center of Scientific Research at an international meeting on programs of voluntary movement, held in Aix in the fall of 1973.

It is impossible, in this short report, to describe in detail this past year's research activities, or to cover the more recent signs of outside recognition afforded to individual members of the Department. Mention can be made, however, of the fact that work on neural circuitry was aided further by the invention of new forms of autoradiography and other kinds of applied neurochemistry (in the laboratories of Professor Walle J. H. Nauta and Research Associate Ann M. Lackner-Graybiel). Also, the evidence for (structural) plasticity of the brain in very young mammals was strengthened further by the work of Professors Richard M. Held, Alan Hein, Gerald E. Schneider, Peter H. Schiller, and others, as well as Professor Hans-Lukas Teuber's group, for observations on humans. New forms of computer assistance were obtained for mapping single units in the central nervous system of rodents, cats, and monkeys, as a result of the efforts of Professors Emilio

Bizzi, Stephan L. Chorover, Schiller, and others. Work in experimental psychology flourished with new discoveries about the perception of gravity (Professor Held); the acquisition of perceptual-motor coordination (Professors Held and Hein); and the mechanisms underlying discrimination of form, color, texture, and depth (Professor Whitman A. Richards). The work in psycholinguistics and developmental psychology likewise progressed, with the appearance of a long-awaited major book on the psychology of language by Professors Jerry A. Fodor and Merrill F. Garrett, and with vigorous experimentation on the perception and production of speech sounds, on the normal and abnormal development of recognition of faces by young children, and on their capacities to form concepts (Professors Susan Carey-Block and Mary C. Potter).

As in the past, the Department's colloquium program added to the more formal advanced instruction. There were 52 speakers throughout the year, 23 of whom came from abroad.

HANS-LUKAS TEUBER

Alfred P. Sloan School of Management

Teaching Programs

Undergraduate Program

The total number of students enrolled in the Sloan School's undergraduate program has varied between 140 and 150 for the past several academic years. Undergraduate enrollment remained at about this level during the 1973-74 academic year. While the special programs and management science options continue to attract the majority of students, the behavioral science option has a smaller but equally enthusiastic enrollment; the senior subjects in research methods and the research practicum, taught by Professor John E. Van Maanen, are very well received.

In February, 1974, a revisitation team of the American Assembly of Collegiate Schools of Business visited the School, following the usual periodic procedure of determining reaccreditation. Both the undergraduate and graduate programs received accreditation, and several of the team's observations concerning the Sloan School's coverage of the functional areas of marketing, production, and finance will be the basis of further discussion of curriculum changes in the coming academic year.

The School's participation in the Undergraduate Research Opportunities Program (U. R. O. P.) has increased substantially under the guidance of Professor Stuart E. Madnick. Also, the number of students paid for their research participation is larger now than the number of participants working exclusively for academic credit.

This year the School was able to provide some additional faculty counseling for undergraduates, and arrangements have been made to improve the ratio of faculty counselors to students.

Senior Lecturer Stanley M. Jacks and Esther Merrill served as chairman and program coordinator of the undergraduate program, and will continue to serve in these capacities during 1974-75. Senior Lecturer Jacks, Ms. Merrill, and the Undergraduate Program Committee members and counselors deserve commendation for the attention devoted to an ongoing review of the undergraduate program and for their efforts to give serious individual counseling to its participants, despite many other calls on their professional time.

Master's Program

The successful second year of operation of the accelerated program confirms the decision of a year ago to make the 12-month program a permanent part of the School's curriculum. It is felt that a group of 30 to 35 is the optimal size for a class in this type of program. The School is considering running two sections if the review of the recruitment process entailed here suggests that the number of strong applications can be increased sufficiently to permit this change.

The size of the entering class in the two-year master's program continues to be held at approximately 100. One notable change in the composition of the class which entered in September, 1973, was an increase in the number of women enrolling (about double that of the previous year). Further efforts to attract women have resulted in an increase of 43 percent in the number of applications from women. The School expects that about 25 percent of the students entering in September, 1974, will be women; this is double the 1973 figure. Furthermore, the School has admitted a small number of students with child-care problems to a program of part-time study toward the master's degree.

The data below presents a profile of the Class of 1974 (including students who entered the two-year program in September, 1973, and the accelerated program in June, 1974).

<u>Accelerated Program</u>		<u>Two-Year Program</u>	
<u>Personal Characteristics</u>			
Sex:		Sex:	
Male 31	Female 4	Male 100	Female 14
Age:		Age:	
Median 27	Range 22-34	Median 23	Range 19-38
Marital Status:		Marital Status:	
Married 25	Single 10	Married 35	Single 79
Full-time Work Experience:	35	Full-time Work Experience:	53
<u>Academic Characteristics</u>			
ATGSB Median:	619	ATGSB Median:	630
Undergraduate Grade Point Average		Undergraduate Grade Point Average	
Median:	4.2	Median:	4.2
Geographic Distribution:		Geographic Distribution:	
10 states		22 states	
6 foreign countries		9 foreign countries	

A preliminary placement report for the Class of 1974 shows an increase of about 4.5 percent in average starting salary, to approximately \$17,750. A slight decrease in the percentage of graduates accepting jobs in business or consulting services was offset by an increase in the percentage entering nonprofit organizations, while those in other areas remained relatively constant.

The number of minority students accepting admission has leveled off at about seven percent, although admission has been offered to a larger number each year. Exceptionally high costs (M. I. T. tuition plus living expenses in this area) are probably responsible, at least in part, for their failure to accept admission. The reputed difficulty of the program may discourage others.

To many students, an appealing feature of the program is its great flexibility. Previous equivalent preparation may permit a student to shorten the time required for the master's degree from two years to one and one-half, or even, occasionally, to just one year.

Professor Thomas M. Hill, Program Committee Chairman, and Miriam Sherburne, the program coordinator, and their staff have given continued care to the smooth functioning of the master's degree program. During the coming year, renewed attention will be directed toward the program's curricular core in an effort to define better its applicability to both specialist and general student interests.

Special attention also has been given to the development of a public systems concentration option for students interested in preparing for professional managerial positions in city, state, and national governments, nonprofit companies, and public organizations. This will be discussed further during the coming academic year.

Many students are anxious to take the lead in helping to find solutions to health care, pollution, population, transportation, welfare, and energy problems. To help prepare these students, a subject base, from which further specialized work may be pursued, has been developed. Illustrative of the subjects designed for this core are the following: Public Systems Fiscal Management; 15.314 Organization Theory; Management Science in Public Systems; and 15.826 Marketing Issues in Public Systems.

With this base, plus the additional core subjects in economics, quantitative methods, information systems, and organizational development, students have moved in different directions to design programs fitting their special interests. Finally, ongoing faculty research and active student participation in many of these studies and projects have helped to prepare students for careers in public systems and policy programs. Active research projects have included work in: energy policy planning; urban revival policy; statistical aspects of pollution; design of health innovation; science and technology policy in developing countries; narcotics in the community; form and timing of professional education; and several other major domains of policy for public systems.

The increasing significance of these challenges to management is reflected in the fact that about 20 percent of the jobs reported by members of the Class of 1974 are in nonprofit organizations.

Doctoral Program

The purpose of the Sloan School's doctoral program is to prepare students for careers in either teaching or research, or for nonacademic positions requiring advanced research and analytical capabilities. The demand for graduates of the program continues to be strong, with most graduates accepting positions either with universities or with research organizations. This year graduates went to Boston University, American Management Systems, the International Institute of Management in Berlin, Steinberg's Ltd., the University of Quebec in Montreal, the First National City Bank, and the Provident National Bank.

The program continues to attract a large number of excellent applicants from the United States and abroad. Twenty students entered in September, 1973. Of these, ten are foreign, three are women, and two are minority students. The entering students' areas of intended specialization were: management science -- 7; finance -- 5; organization studies -- 4; system dynamics -- 3; industrial relations -- 1.

Policy and requirements for the doctoral program are set by the Doctoral Program Committee, composed of a program coordinator, eight Sloan School faculty members, and three students. This year the Committee made several evolutionary changes in program design. The purpose of these changes was to allow students to devote more of their first year of study to their major field of interest and to research. A new major field qualifying examination will be given at the end of the first year. One or more of the qualifying examinations previously given in the first year now may be delayed until the second year. The Doctoral

Program Committee feels that these changes will lead not only to a better education for Sloan School doctoral students, but also will reduce the time required to complete the degree.

Professor Stewart C. Myers continued as chairman of the Program Committee and Kathryn S. Scott as its coordinator.

Alfred P. Sloan Fellows Program

The 36th class of Alfred P. Sloan Fellows received the degree of Master of Science in Management on May 31, 1974.

The class consisted of 50 members -- the second largest class since the Program began in 1931 -- and they represented the richest variety of backgrounds of any class in the Program's history. A brief profile of this class compared with the previous year's class follows:

	<u>1972-73</u>	<u>1973-74</u>
Industry (US)	30	26
Industry (foreign)	5	13
Total	<u>35</u>	<u>39</u>
Government (US)	7	7
Government (foreign)	2	2
Total	<u>9</u>	<u>9</u>
Medical management	1	1
Church management	1	1
Research institute	1	0
Military	1	0
TOTAL CLASS	<u>48</u>	<u>50</u>

The class of 1974 included 19 organizations that were represented for the first time in the Program: Alcan Jamaica Limited (Jamaica); Archdiocese of Detroit (US); Australian International Services (Australia); Bangkok Bank Limited (Thailand); the Canada Systems Group (Canada); Columbia Fabricators, Inc. (US); Editora de Guias L. T. B., S. A. (Brazil); Embassy of France (France); General Electric Corporation (US); the Gillette Company (Braun A. G.) (Germany); the Hartford Special Machinery Group (US); Ministere de l'Aménagement du Territoire (France); the Mitsubishi Bank, Limited (Japan); Mitsubishi Corporation (Japan); S & D Feldberg Erben Heirs (Germany); Thrige-Nakskov Machine Works (Denmark); the Tokai Bank Limited (Japan); Top Properties Limited (South Africa); and Yuen-Sun Textile Mill (Republic of China).

The Program also welcomed back five organizations that had been absent for a year or two: Ford Motor Company, Chrysler Corporation, Continental Oil Company, Sun Oil Company, and Continental Oil Company of Canada.

The Sloan Fellows Program continues as the archetype of executive development programs around the world, and the School is proud of its continued successes. Peter P. Gil, Associate Dean for Teaching Programs, continues to give, with his staff, important direction to the Program's administration.

M.I.T. Program for Senior Executives

The 35th and 36th Programs were offered in 1973-74. Demand has increased strongly from US industry and the Federal government, as well as from countries throughout the world. The wide variety of national backgrounds represented in the Program is impressive. In keeping with the international character of the Program, its curriculum offers an increasing number of topics and seminars of interest to multinational executives.

A self-study program for each of the participants recently has been established. Each senior executive is invited to pursue an area of special interest while at the Sloan School, often with the tutorial or consultative assistance of a faculty member.

Professor Michael S. Scott-Morton, the chairman of the Program's faculty committee, continued major reviews of its content, with an eye toward more effective coordination of its parts. Alan F. White, an M. I. T. alumnus (Sloan fellow, class of 1970-71), became the director of the Program in August, 1973, and has brought to it dedicated and imaginative leadership.

The age range of senior executives in both the fall 1973 and the spring 1974 programs continued to be 40-50 years. The average participant was in the mid-40s. Typically, 10 to 12 foreign senior executives are enrolled in classes whose number generally ranges between 26 and 28 participants.

M.I.T. Program for Urban Executives

The seventh M. I. T. Program for Urban Executives was held at Endicott House and the Sloan School from June 2 to June 28, 1974. Part of the teaching load was carried by faculty members from the Department of Urban Studies and Planning and the Department of Civil Engineering.

Twenty-six participants from 22 cities attended the Program. Those attending were deputy city managers, department heads, or other career managers. The demand for places in the Program continues to grow. One of the most encouraging signs is that cities represented in earlier programs continue to make nominations on a regular basis.

The Program continues to appreciate the support of the following organizations: the National League of Cities; the United States Conference of Mayors; the American Society for Public Administration; and the International City Managers Association. Mr. White is the program director for this effort, as well as for the Program for Senior Executives.

Greater Boston Executive Program

The 17th Greater Boston Executive Program was held from January 25 to May 3, 1974. In keeping with the decision to increase participant interaction, the number of participants was limited to 17. Among these were one woman and three minority group members. Nine organizations were represented in the program.

This 15-week, one-day-a-week program continues to receive very positive reception from the greater Boston area companies who have participated, as well as continued high marks from its alumni.

Summer Programs

During the Summer Session of 1973, the Sloan School offered eight special summer programs.

Professor Jay W. Forrester presented a two-week program, System Dynamics, Methodology, and Applications; Emphasis on Industrial, World, Urban, and National Issues. This program treated system structure, policies, information flow, and time delays, and showed how these create fluctuation, growth, decline, and equilibrium. Internal structure and dynamic behavior were emphasized. Morning lectures were followed by small group discussions in the afternoons. Assisting Professor Forrester were: Professor John F. Collins, Professor John Henize, Louis E. Alfeld, William Behrens, Research Associates Kenneth R. Britting and Alexander L. Pugh III, Walter W. Schroeder III, Instructor Richard Wright, and other members of the System Dynamics group.

New Horizons in the Management of Change and Organizational Development, led by Professor Edgar H. Schein and Senior Lecturer Richard Beckhard, was conducted again as a one-week "live-in" session at M. I. T.'s Endicott House. This program was designed for top executives (at the senior vice-president and president level) to discuss in depth some of the major issues in the management of human resources which will face corporation leaders in the next few years. Strategies for dealing with such issues also were explored.

Professors Stewart C. Myers and Gerald A. Pogue presented two one-week programs in finance. The first, Basic Concepts in Financial Management and Strategy, considered the questions of capital budgeting decisions, cost of capital, dividend policy, acquisition and merger decisions, and measurement of a firm's pension fund. The second, Models for Financial Management and Long-Range Financial Planning, was an intensive program intended for managers and analysts interested in the design and application of financial models. It dealt with proven models and new approaches which will find future use, and it gave participants experience in the use of time-shared computer based models.

Although either program could be taken separately, they were complementary, and a good number of participants did take both programs. Guest lecturers in these programs were Professor Scott-Morton of the Sloan School and Robert F. Calman, vice-president of International Utilities, Inc.

Mathematical Programming for Management Decisions, Theory and Applications was a two-week program under the direction of Professors Arnolde C. Hax, Thomas L. Magnanti, and Jeremy F. Shapiro. Topics included the simplex method of linear programming, nonlinear programming, network optimization, and integer programming. These were followed by an in-depth discussion of the analysis and synthesis of communications networks, including models of computer, telephone, highway, and airline networks. The program concluded with a case study of the problems of implementing a large-scale mathematical programming model for making production and scheduling decisions. Guest lectures were presented by Anthony F. Fiacco of George Washington University; William Orchard-Hays of Management Science Systems and the National Bureau of Economic Research; and Richard Van Slyke of the Network Analysis Corporation.

Management Science in Marketing; Decision Support Systems for the Marketing Manager again was offered under the direction of Professor Alvin J. Silk, assisted by Professors John D. C. Little, Glen L. Urban, Arnolde C. Hax, and Senior Lecturer Arnold E. Amstutz. The program was designed for marketing managers who wish to evaluate the applicability of marketing models in their companies, and who want to find out how such models are built and implemented; for product managers who want to explore the use of models for brand management; and for marketing researchers and management scientists who are interested in determining what is required to implement and to support model based information systems.

Research

Professor Edward B. Roberts offered the popular one-week program entitled The Dynamics of Health Service Systems for the second time. The program was aimed at responsible health care administrators, health system analysts, and university faculty members interested in pursuing new approaches to health problems. The problems assessed from the system dynamics perspective ranged from examination of health services at the level of the individual health care organization, to the analysis of health care problems at the overall community level, and to a concern about national policy for health service delivery. Assisting Professor Roberts were Professor Gilbert Levin of the Albert Einstein College of Medicine, Dr. Stanley B. Troup of the University of Rochester School of Medicine, Dr. James Potchen of Washington University Medical School, Senior Lecturer Leon S. White of the Sloan School, Research Associate Alexander L. Pugh III and Instructor Richard Wright of the Sloan School System Dynamics Group, Morton Ruderman of Medical Information Technology Inc., and Gary Hirsch of Pugh-Roberts Associates Inc.

Professor Roberts also directed the two-week program, Management of Research, Development, and Technology Based Innovation, which focuses on the underlying innovative process. The program aimed at enhancing the managerial skills and perspectives of its participants. Increased attention was given to the interrelationships among research and development and the other major organizational functions. Actively collaborating in the program were Professors Thomas J. Allen and George F. Farris of the Sloan School. Visiting lecturers included: Professor Paul Lawrence of the Harvard Business School; Dr. Marvin J. Cetron, president of Forecasting International Ltd.; and Dr. Alan L. Frohman of Pugh-Roberts Associates, Inc.

Once again, these special summer programs helped to provide much-needed attention to post-experience training for a wide variety of managers in both the private and public (or nonprofit) sectors of society.

Industrial Liaison Symposia

In October, 1973, Professor Charles A. Myers presented a symposium entitled Industrial Relations. This symposium drew on the findings of several recent studies undertaken by members of the School's Manpower and Labor Relations Group and on active participation in the programs reviewed for the symposium. Among these were: the implications of Puerto Rican labor migration; the American Telephone and Telegraph settlement with the Equal Employment Opportunity Commission; collective bargaining in 1973; increasing legalism in industrial relations; and the significance of recent Supreme Court decisions affecting industrial relations.

In May, 1974, Professor Edgar H. Schein conducted a symposium entitled Career Development: Managerial, Technical, Professional. This session reported on recent research done at Harvard University and M. I. T. on several samples of alumni and students. Topics covered included: early career issues, such as the congruence between cognitive style and type of career chosen; mid-career issues for engineers, scientists, and technical and general managers pertaining to the presence or absence of work involvement; conflict between family and career decisions; the process by which career attitudes and values are learned; and new developments in career counseling, including the use of assessment centers and career workshops to aid the integration of people into organizations.

Research

The underpinnings of the School's curricula rest in large part on the research undertaken by faculty, staff, and students. The School continues to produce research which is both disciplinary and multi-disciplinary in character; this section summarizes some of the major

efforts which are grouped at the School, along some rather general lines which do not always reflect the cross-functional character of the projects noted.

Human Factors in Management

The faculty in the School's Organization Studies Group and its Manpower and Labor Relations Group take as their primary research focus the human factors in management. Research in these groups often is based on a number of disciplines in the social and behavioral sciences -- psychology, sociology, economics, and so on.

Organization Studies

Several members of the faculty are attempting to understand the process of adult socialization and career development, with particular attention to the determinants of satisfaction with work and career, or, alternately, the sources of alienation from work and career.

Professors Ralph Katz and John Van Maanen are analyzing a survey of the attitudes of public sector employees, which is comprised of a large sample of responses from five different cities. Factors which correlate with job and career satisfaction will be reported at an international conference in York, England, in the summer of 1974. The data will be used to launch programs designed to improve the functioning of the city governments which provided the data. Professor Katz also is working on a project which examines the relationship between leadership style and intragroup conflict.

Using the research on job satisfaction and his continuing work on the socialization process of urban policemen, Professor Van Maanen is developing a more general theory of socialization.

Participant-observer studies, carried out by Professor Van Maanen and various students on religious groups, railroad work gangs, direct selling organizations, and other organizations, are providing case material for this general theory of occupational-organizational socialization. With Professor Edgar H. Schein, Professor Van Maanen is working on a paper on individual-organization matching to be contributed to a monograph, sponsored by the Department of Labor, under the editorship of Professor Richard Hackman of Yale University.

Professors Peter G. W. Keen and David A. Kolb are investigating the relationships between cognitive style and various career related variables. Professor Kolb continues his studies of the relationship among his learning model, the four modal cognitive types which it generates, and the process of career choice. Data on undergraduates, graduate business students, medical students, and working managers supports the theory that there are characteristic cognitive styles which accompany occupational choice.

Professor Keen, using a similar but different cognitive model, is concerned particularly with the relationship of cognitive style to the process of decision making. In particular, he is focusing on "management scientists," such as computer professionals, and is attempting to determine how their cognitive style and decision-making processes differ from other members of organizations. This research has important implications, for it raises the possibility that differences among various functional managers or specialists may be quite fundamental and may make it difficult for them to work comfortably with each other.

Professor Lotte Bailyn is continuing to analyze the basic M. I. T. alumni study data in an effort to discern the roots and correlates of work involvement of people with a high degree of technical education and background. Currently, she is working with Professor Schein on this study and writing a book on work involvement in technically based careers. In addition, Professor Bailyn is continuing her seminal work on the relationships among work, family, and self-involvement. By analyzing both survey and case materials, she gradually is developing a conceptual scheme for analyzing the competing and sometimes conflicting demands

of each of these areas of involvement throughout the career and life cycle. The results of this work have especially strong implications for women, but the general analysis applies to men as well.

Professor Schein is continuing to work with alumni data, especially a panel study of 44 Sloan School alumni of the early 1960s, in an effort to understand the longitudinal dynamics of career development and the interaction of values and careers. He completed a ten-year follow-up study of the panel, and currently is analyzing the data in terms of a set of career anchors which seem to explain much of the stability he found in the 44 cases. Senior Lecturer Peter P. Gil and Professor Schein also launched new career surveys of the alumni of the regular master's program, the Sloan Fellows Program, and the Program for Senior Executives. The purpose of these surveys is to obtain accurate career history information in order to unravel the dynamics of the managerial career, especially the development of general managers. The impact of the Sloan School on these careers also will be investigated.

Senior Lecturer Richard Beckhard is continuing his survey of mid-career crises in high-potential managers. Working primarily with cases uncovered through his extensive consulting activities, Senior Lecturer Beckhard is generating hypotheses concerning the reasons why an increasing number of these managers are turning down promotions and leaving organizations in which they have high career potential. Senior Lecturer Beckhard and Professor Schein are exploring the value implications of this data in relation to societal changes in values.

Professor Leo B. Moore is looking at the process of management development within several organizations, and is examining the factors which make this process more or less effective over a period of time.

Several of the studies related to career and adult socialization were reported in a very well attended symposium sponsored by M. I. T.'s Industrial Liaison Office in May, 1974. The symposium was organized and chaired by Professor Schein, and the papers presented will be collected and prepared for publication by Professor Van Maanen.

Another area of research within the Organization Studies Group is related to the improvement of health care delivery through the design and study of educational interventions, particularly at the management level. Senior Lecturer Beckhard and Professor Irwin M. Rubin, under the sponsorship of the Robert Wood Johnson Foundation, are engaged in a multipronged effort to develop team-building materials for health care teams, to test these materials in a field setting, 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 curriculum materials or educational strategies can be incorporated in medical school curricula and postgraduate training for health care personnel to improve their overall effectiveness.

Several projects have been launched in medical schools, schools of nursing, and in postgraduate training programs. Each is being treated as an experimental intervention, and careful evaluation studies of their effects are being carried out by Senior Lecturer Beckhard, Professor Rubin, and their team consisting of Research Associate Eric Herzog, Mark Plovnick, Ronald Fry, Nina Rosoff, and Eleanor Gaspard. This project has promise of becoming a major intervention in the critical area of health care. Several papers and a book describing the project are in preparation.

Though the research efforts of individual faculty members continue to be guided largely by the requirements of their own projects and the scientific issues they are addressing, there is a growing communality of both scientific and practical concerns evident in the group. In particular, there is a growing concern for the development of theory in the art of applying knowledge and translating scientific findings to the practical arena of management. Many

faculty members are engaged actively in planned change and organization development activities, and this applied or clinical focus of the group continues to be one of the main sources of its strength.

Manpower and Labor Relations

Research in this group continues to cover the fields of labor-management relations and public policy, law and labor law, international aspects of industrial relations, labor economics, manpower and manpower policies, and the management of human resources (personnel administration).

Professor D. Quinn Mills has completed a major portion of his continuing study of wage stabilization policy in the United States. He has submitted a book-length manuscript to the University of Chicago Press. It is a systematic examination of the experience with wage controls during World War II, the Korean War period, the wage-price guideposts of 1962-64, and Phases I and II of the Nixon administration, with some reference to the Construction Industry Stabilization Committee. Professor Mills also has been working on a study of price control policy in the United States as affected by industry characteristics. Another study, supported by the US Department of Labor through the Joint Center for Urban Studies, continues to review the application of computer technology to the construction industry labor market. Professor Mills is being assisted in this study by Research Associate Edward Markowitz. Finally, Professor Mills has been working with Professor Steven Rosefielde of the University of North Carolina on a comparative study of technological change in the Soviet and American construction industries.

The two-year research contract with the Manpower Administration of the US Department of Labor, Labor Market Information Systems and the Disadvantaged, was extended through September, 1974. This allowed some ongoing research, principally by graduate students under the guidance of various members of the staff, to be completed, and a final report to be written.

Professor James E. Annable has made an assessment of the role of labor market information in job opportunities and income, and is supervising further graduate student research in this area. Professor Michael J. Piore, with graduate student assistance, has examined the kinds of jobs taken in the Boston area by Puerto Rican migrants and has drawn some tentative conclusions about these patterns of labor market distribution. Two studies were completed under the general direction of Professor Charles A. Myers: Leonard Davidson's doctoral thesis, "The Process of Employing the Disadvantaged" (a longitudinal study of minority trainees in a large Boston area firm), and John Mikulsky's master's thesis, "The Implementation and Operation of Computerized Job Banks in Massachusetts."

Professor Piore, with several colleagues from the Departments of Political Science and of Urban Studies and Planning, continues his work on the common problems of developed industrial economies. The study focuses on a comparison of the labor market structure in the United States with various Western European countries. Areas of exploration have included the role of immigrant labor and racial and ethnic minorities, the relationship between the educational system and job structure, and wage and salary structures at the plant level and their relationship to national income distribution.

Visiting Professor Phyllis A. Wallace was the recipient of a National Science Foundation (NSF) grant from its Research Applied to National Needs (RANN) program. The purpose of the grant was to conduct three research workshops on equal employment opportunity and to develop a comprehensive research agenda. The grant permitted three such sessions to be held at the Sloan School during the academic year, and during the summer of 1974, the papers and proceedings from these workshops will be prepared for publication. Recommendations from the workshops have been distributed to a large number of scholars, public

officials, and representatives from the private sector. The National Science Foundation has requested a follow-up study to deal with the role of women in management. Professor Wallace has continued her research on how the implementation of affirmative action plans affect and alter personnel and industrial relations systems. Her manuscript on some perspectives on equal employment opportunity currently is being prepared for publication by the M. I. T. Press. Finally, Professor Wallace has continued her research on the employment status of black women, and is completing a monograph for the National Manpower Policy Task Force and for publication by the Johns Hopkins Press.

Professor Charles Myers has continued his general supervision of staff and graduate student research on the Manpower Administration research contract referred to earlier, and has completed a short policy report for the US Department of Labor. He also has continued his work on the final report of the inter-university study of human resources in economic development, entitled "Industrialism and Industrial Man Reconsidered: An Inter-university Study Over Two Decades." He is coauthor with Clark Kerr, John T. Dunlop, and Frederick H. Harbison of the final report in this major undertaking. In addition, Professor Myers has completed a paper assessing present and future manpower needs and trends in the nation, which will be published in the proceedings of the Employer Institute and Manpower Symposium held at Northeastern University in November, 1973.

Professor Douglass V. Brown continued his research on legalism in industrial relations in the United States, and contributed an essay, "The Future of the National Labor Relations Board," to the Industrial Relations Research Association's 25th anniversary volume, in which past presidents of the Association were invited to write short essays on suggested topics.

Professor Kenneth S. Mericle participated in the joint Sloan School and Center for International Studies international business project. His work involved a study of the role of multinational corporations in the Brazilian motor vehicle industry. Professor Mericle also continued his research on the Brazilian government's comprehensive wage policy, and is preparing a paper on the implications of the Brazilian experience for issues and policy in this field in the United States.

Senior Lecturer Stanley M. Jacks continues his work on the impact on labor relations practice of certain recent Supreme Court decisions with particular focus on the use of judicial equity powers to enjoin implementation of management decisions pending arbitration.

Economics and Finance

Analysis of the human factors in management is the first of three general disciplinary pillars on which the Sloan School's research and teaching programs build. The second such major area comprises work in the Economics and Finance Group.

Professor Sidney S. Alexander, head of this group, has continued his work on an extensive study of the normative foundations of public policy. His studies are directed toward the provision of a solid basis for making normative judgments in the social sciences, particularly in economics. He also has undertaken a study of the international oil market, in relation both to United States policy and to the economic and political development of the Middle East.

Professor Paul W. MacAvoy's major research activity consisted of finishing, and making available for general use, an econometric policy model of the natural gas industry for the National Science Foundation, under a Project RANN grant to the M. I. T. Energy Laboratory. This project is being undertaken with Professor Robert S. Pindyck and the following assis-

tants: M. G. Subrahmanyam and Krishna Challa, both Sloan School doctoral candidates; Ira K. Gershkoff, an undergraduate in the Department of Electrical Engineering; Philip N. Sussman and K. Lloyd, master's candidates at the Sloan School; Robert Brooks, a doctoral candidate at the Operations Research Center; and I. Perloff, a secretary at the Sloan School. The aim of the project is to provide the Federal government and industry with predictions on the effects of policy changes in natural gas regulations. A journal article on gas policies was published (Bell Journal of Economics and Management Science, April, 1973), and testimony given before three Senate committees in the winter of 1973-74. In the past year, the model has been expanded to include the supply of oil reserves, new exploratory activity in gas and oil, and equations to represent the demand for fuel oil (thereby permitting an analysis of the substitution between oil and natural gas). This work will continue to be an Energy Laboratory project next year, with Professor MacAvoy as its principal investigator. The final product should include a book on gas policy, and a manual on the model for the use of Federal agencies and private companies.

Professor Lester Thurow's research continued to focus on the distribution of income. He is in the process of completing a book entitled Income Distribution Economics, prepared under a Manpower Administration grant. His publications this past year include the following articles: "Zero Economic Growth and the Distribution of Income"; "Cash Versus In-Kind Transfers"; and "The Political Economy of Income Distribution Policies." He also completed an introductory textbook, The Economic Problem, in conjunction with Robert Heilbroner.

Professor Pindyck has worked with Professors MacAvoy, Gordon M. Kaufman, and Henry D. Jacoby on an interdepartmental project on energy resources and needs. Professor Pindyck's specific interests focus on studies of the economics of the energy system. He has examined dynamic demand-supply models for policy analysis, particularly in the natural gas industry, and with Professor MacAvoy has completed construction of a large econometric policy model of that industry. This model has been used to look at the effects of alternative regulatory policies on natural gas demand and supply. He has begun to construct consumer choice models for residential energy use. In addition, Professor Pindyck continues his research into the application of control theory to economic policy. The particular applications of the research on which Professor Pindyck worked during this academic year included optimal monetary control, monetary and fiscal policy in a decentralized framework, and application of optimal control techniques to large-scale econometric models. Professors Pindyck and Edwin Kuh recently have received an NSF grant to pursue these and related studies of optimal control applications to economic and management policy.

Professor Kuh was on leave of absence during the fall term. During the spring, he continued research on statistical aggregation theory. He is also a member of an interdepartmental research project on optimal control in economics, which includes Professor Michael Athans of the Department of Electrical Engineering and Professor Pindyck of the Sloan School. Professor Kuh continues as executive director of the National Bureau of Economic Research Center for Economics and Management Science, an activity devoted to basic research on new algorithmic and software techniques in statistical data analysis, econometrics, and mathematical programming.

Professor Franco Modigliani continued his research on a variety of topics: saving behavior and the life-cycle hypothesis; the optimal design of international payment systems; use of the capital asset pricing model in evaluating portfolio managers and regulating advisory fees; and the use of an econometric model to analyze current issues of monetary and fiscal policy. His publications range over these fields of interest, and also cover such topics as the relation of inflation to the term structure of interest rates, and the generalization of the Phillips curve for a developing country. He also has initiated a broad study of the possible use of index linked mortgage contracts and index linked deposits in the financing of residential con-

struction.

Professor Daniel M. Holland continued his research on the effects of taxation on business executives, and on the economics of property taxation. He undertook a preliminary study in the United Kingdom in the summer of 1973 to ascertain the feasibility and value of a major investigation in that country, similar to one undertaken in the United States some years earlier, on the effects of taxation on the work incentives of business executives.

In the field of property taxation he completed, with Professor Oliver Oldman of the Harvard Law School, a study evaluating the tax burden distributions attendant on full-value assessment for Boston. (While the city is not now on this basis, there is a real possibility that the courts may require it in the near future.) Also, he studied recent developments in land value taxation in Trinidad, Barbados, and Jamaica. With the Caribbean countries in the process of shifting from a tax based on real estate to one on land value alone, there is an unusual opportunity to observe the effects of switching to this new base, which, incidentally, is receiving more support in the United States.

Professor Stewart C. Myers continued work in the general area of asset valuation and corporate finance. He completed two studies in this area during the course of the year. One investigated the interactions of financing and investment decisions in a capital budgeting context, and the other presented a mathematical programming approach to financial planning. He continues to work on the real determinants of market risk measures and on financial aspects of the government regulation of business.

Professor Robert C. Merton has completed several studies dealing with the pricing of corporate debt (the risk structure of interest rates); rational option pricing and the mathematics of speculative prices; the efficiency of a competitive stock market; and economic growth in a stochastic environment. He has continued his research in the capital markets area, stressing inter-temporal equilibrium.

Visiting Professor Gail Pierson began work on a study of long-term trends in interest rates, dealing with the period since 1870 in the United States. In addition, she has continued to work on the question of the optimal size of the financial intermediary sector.

Professor Donald R. Lessard has been engaged in research in three related areas: international portfolio diversification, international financial management, and financial aspects of economic development. He has completed an empirical study of diversification potential based on aggregate stock market data, and presently is analyzing individual stock data to determine the strength of country and industry influences. Together with Professor Peter Lorange of the Management Science Group, he has completed a note integrating the international treasurers' and controllers' functions. He is preparing for publication a study of security yields and realized returns in the Andean region countries of South America. It will be published this summer, as a monograph, by the Organization of American States.

Working with Edward Fielding, a Sloan School doctoral candidate, Professor Lessard is studying US corporate attitudes toward a variety of local ownership options in the Andean region. This study, supported by the Center for International Studies, will provide background information for the determination of feasible financing/ownership strategies for developing countries.

In collaboration with Professors Modigliani, Holland, and Richard A. Cohn, Professor Lessard prepared a proposal for a study of alternative types of mortgages for the United States, with special emphasis on index linked mortgages. A preliminary phase of this study will be funded by HUD (the Department of Housing and Urban Development) during the summer of 1974.

Professor Cohn completed several papers during the year. His research dealt with the implications of life insurance policyholders' attitudes toward risk and their probability beliefs for efficient mutual life insurance company asset management; the differential impact of inflation and economic growth on the riskiness of the equity of individual firms; and the problem of integrating short-term asset and liability management into the theory of corporation finance.

Management Science

The Management Science Group is the third of the Sloan School's principal foci of teaching and research. The group is concerned broadly with models, measurements, and information systems, and their impact on managerial processes in a variety of settings. The research of the group can be divided roughly into context related research that deals with specific areas of management concern, and methodological research on tools and techniques that are relatively context free. Using this dichotomy, the application areas can be subdivided further into public and private sectors.

A chief concern in the public area has been energy and energy policy. This work has been interconnected heavily with other parts of the Sloan School and of M. I. T., particularly with the Energy Laboratory, where Professor Jacoby is a member of the Steering Committee. Professor Jacoby is also architect of an Energy Policy Study Group, and was chairman of the Governor's Emergency Energy Technical Advisory Committee for Massachusetts at the height of the energy crisis last year. In one important activity, Professors Jacoby and John J. Donovan and a group of students have been designing and implementing a New England Energy Information System. In other energy developments, Professor Gordon M. Kaufman has undertaken an extensive effort to model the process of oil and gas exploration. Also, Professor Jeremy F. Shapiro has started investigation into the development of mathematical programming models of energy systems, so as to be able better to evaluate US energy alternatives with medium-term planning horizons.

Health systems are being studied by two members of this group. Professor Glen L. Urban has started an effort in health maintenance organization. Recent Federal legislation requires employers to offer their employees options of this type, but as is often the case, very little is known about what attributes of the proposed services actually are desired by the intended customers, nor about what demands or costs will result if various alternatives are offered. Professor Urban is beginning research to try to answer some of these questions. He also continues his pioneering work in models for the management of family planning systems. His models already have been implemented in five domestic sites, and will be implemented in five more during the next year. Work is also under way to design appropriate systems for application in developing countries. In a somewhat different health direction, Professor John F. Rockart has developed a number of planning and control systems for the Lahey Clinic of Boston.

The identification and creation of technological aides for policy analysis in state governments has been the thrust of recent work by Professor John D. C. Little. During the summer and fall of 1973, a computer model for the evaluation and analysis of proposed Massachusetts programs in financial aid for college students was developed by Professor Little and students. During the spring of 1974, they worked with Deputy Commissioner for Fiscal Affairs Edward Moscovitch to bring into operation an on-line tracking system for the Commonwealth of Massachusetts budget.

As food prices continue to soar, the work of Senior Lecturer Gordon F. Bloom on productivity in the food industry takes on increasing importance. Senior Lecturer Bloom has been a leader in facilitating the application of new techniques to the food industry through workshops, colloquia, and writings. In addition, he has worked with Professor Samuel A. Goldblith of the

Department of Nutrition and Food Science on the marketability of squid, a potentially important source of protein from the ocean.

In the private sector, a variety of projects has been progressing, especially in the areas of marketing and in large-scale production and distribution systems. Professor Alvin J. Silk, along with Professor Urban, has been working with measurement techniques and supporting models to predict long-run market shares for new products without the necessity of the expensive and often unreliable step of test-marketing. In addition, Professor Urban has developed related techniques for a new product design and positioning, and Professor Silk has been studying the affective qualities of advertising and their relationship to customer response. Professor Gary L. Lilien has embarked on a major study of industrial advertising in which 10 - 15 cooperating companies will provide historical marketing data on a considerable number of industrial products. The study seeks first to determine how industrial advertising budgets presently are set, and second to provide some rationale for how budgets should be set.

Although management science techniques long have 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 Arnoldo C. 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; the latter feed back information to the former. In this effort, Professor Hax is working parallel to Professor William A. Martin, who seeks to add automatic programming ideas to the design of these systems so as to make them more readily adaptable to new managers and new operating conditions. In other activities, Professor Edward W. Davis has continued his studies of management science scheduling methods in the construction industry.

The ability to extend knowledge and to 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 paper on concepts and research issues in management control. He is being assisted in this by Professor Lorange. Professor Lorange also is studying formal planning systems, especially in the complex setting of multinational corporations. Professor Jerry D. Dermer has been doing research on managerial behavior in planning and control systems in a large retailing firm.

A major methodological thrust within the group is mathematical optimization. Many large-scale systems are potentially improvable by these techniques. A surge of theoretical developments in recent years has not yet been integrated well into practice, because of lack of adequate computational support and a few important stumbling blocks in the theory. Recent research by Management Science Group faculty has been directed at these issues. Professor Shapiro has been supervising the development of a modular system of mathematical programming packages at the National Bureau of Economic Research Installation in Cambridge. He also has focused research effort on certain outstanding issues in integer and mixed-integer programming. Professor Thomas L. Magnanti has been attacking certain problems in combinatorial theory and nonlinear programming, and has had a particular concern for optimization in large linear programming models. Professor Roy E. Marsten also has been concerned with large-scale optimization, and in particular has been making headway on a class of difficult, discrete, nonlinear allocation problems. Professor Hans H. Weber, a visitor from the Technical University of Berlin during the past year, has been contributing

in the area of dynamic programming.

Computer based information systems consume large quantities of resources in an industrial economy, and generate more than their share of concern and controversy. Professor Stuart E. Madnick has been directing a substantial project on security and information systems, laying out requirements and frameworks for analysis and decision in this delicate area. Professor Madnick also is engaged in research on advanced software design and on methods for automating the generation of information systems. Professor Scott-Morton has been studying the impact (or lack of it) of advanced decision support systems. Students working under his direction have been doing research on issues of systems implementation in specific settings.

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 has been working on the development of robust techniques and implementing them on easy-to-use computer systems. Recently he has worked with Professor Little in developing robust methods for calibrating nonlinear marketing models.

In a somewhat different direction, Professor Ralph L. Keeney has continued his work on multi-attribute utility functions and their incorporation into decision analysis. These techniques have seen application to a range of problems, from deciding on the amount of fire equipment to send on a call to the location of a new airport for Mexico City.

System Dynamics

System dynamics methods and applications have continued to be extended to a number of fields during the past year. The Rockefeller Brothers Fund is sponsoring a three-year research program directed by Professor Jay W. Forrester on the dynamics of social and economic change at the national level, which continues for its third year. The system dynamics model equations for a United States model presently are being formulated. Initially the emphasis will be on the factors underlying inflation -- shifts between sectors in population, prices, demand, and capital. An abbreviated foreign section will be included to deal with balance of payments.

The second major research activity in the System Dynamics Group focused on urban dynamics. During this past year, the group had continuing sponsorship from the Department of Housing and Urban Development for extending the earlier work in urban dynamics. Professor John F. Collins has been working with Professor Forrester in guiding and advising this project. Louis E. Alfeld and Walter W. Schroeder III, research associates with the urban dynamics subgroup, have extended the urban dynamics model to deal with urban management issues in Lowell, Massachusetts. Several graduate students continue to work in both the Rockefeller Brothers Fund project and the urban dynamics project.

Management of Science and Technology

Research here concerns itself primarily with the dynamics of generating technical innovation and with the processes which determine the circulation of technical information between organizations. Professor George F. Farris is continuing his work on the characteristics of the more-or-less innovative technical group, focusing especially on the roles which colleagues play with respect to each other and the role which the supervisor takes in such groups. This work is related to the larger project on the management of research and development, which has been carried on by Professor Thomas J. Allen since the untimely death of Professor Donald G. Marquis in the spring of 1973.

Research

Professor Allen is continuing his seminal work on the flow of technological information into and out of organizations. Where early research concentrated on the relationship between an organization and its environment, Professor Allen now is investigating communication patterns and information flows in an entire country (such as Ireland) in an effort to understand the relationships among universities, research and development laboratories, and industrial users of technical information. Professor Allen presently is working on a book which will bring together almost a decade of his research in this area.

Professor Edward B. Roberts continued to work on system dynamics problems related primarily to technology and health issues; he also did some empirical studies on new ventures. Professor Eric A. von Hippel's research this year has focused on the multi-party aspects of the industrial innovative process, as part of a larger study aimed at a better understanding of the industrial goods innovative process.

The joint M. I. T. - Harvard program on the management of technology, under the auspices of the Sarnoff endowments, continues to develop. Professor Richard Rosenbloom at the Harvard Business School and Professor Roberts offered a joint seminar in this area, which helped to define the scope of work to be done in the field.

Corporate Strategy

The demand for subjects in the general area of corporate strategy, policy, and strategic planning continued to grow during the academic year 1973-74. From an entrepreneurial activity of Professor Edward H. Bowman, the field has grown to the point where it now occupies the full attention of three faculty members, Professors Bowman, Mason Haire, and Zenon S. Zannetos.

The basic subject in this area is now a requirement for the Sloan Fellows Program, the Accelerated Graduate Program, and part of the Senior Executives Program. A decision by the Master's Program Committee that it be made a required part of the regular two-year master's program temporarily was shelved, because of inability to staff appropriately for the required number of sections.

During the year, the members of the Corporate Strategy Group devoted a considerable amount of effort to curriculum development. In addition to changes in the basic subject, two new subjects were offered in the form of experimental seminars. Professor Bowman offered a research seminar in corporate strategy, and Professor Zannetos a seminar entitled Some Issues in the Energy Industries.

The research of the members of the Corporate Strategy Group ranged through issues of corporate social responsibility (Professor Bowman), diversification (Professor Haire), and strategic planning and organization structures (Professor Zannetos). In addition, Professor Zannetos continues his work in the general area of oil economics, with particular emphasis on the economics of ocean transportation of oil by tankers.

International Management

Managing operations in an international context is still another important area of faculty research. A new research initiative was begun during the year in collaboration with the Center for International Studies, designed to examine the issue of workers' participation in management and ownership in Peru. In the spring of 1974, a conference was held at the Sloan School which brought together scholars who currently are engaged in research on this topic. Professor Richard D. Robinson is directing the Peruvian project.

Another joint project with the Center for International Studies involves an examination of some of the longer-run economic, political, and managerial ramifications of the multinationalization of business. The project is of an interdisciplinary nature; it involves individuals from the Departments of Political Science and Economics, as well as the Sloan School. Professor Robinson currently is directing a study of national restrictions on inflows of direct investment and technology in eight Latin American and five Asian countries. Professor Mericle is engaged in research on the impact of direct American investment in the Brazilian motor vehicle industry on employment transfers and on the development of human resources in Brazil.

The Sloan School, in conjunction with a consortium of graduate schools of business (Stanford, Indiana, and Harvard Universities), has extended an invitation to a delegation from the People's Republic of China to look at the process of management education and development within this country. If the Chinese accept this joint invitation to visit the US in the fall of 1974, it is hoped that this experience will lead to continuing communication and will provide insight into managerial development and practices within the People's Republic of China. In a very real sense, the enterprise would be the first step in an ongoing, two-way research project.

Sloan School faculty members and students will be working with the Center for Policy Alternatives on a two-year project sponsored by the Projecto Ciencia e Tecnologia in Sao Paulo, Brazil, for the purpose of examining alternative policies and programs for the support and promotion of industrial technology for economic growth and development in Sao Paulo.

Professor Lessard is conducting an ongoing study of the potential benefits of international diversification of stock market holdings. Professor Lorange has begun an exploratory project aimed at identifying how formal planning systems might be adapted for use by multinational corporations.

Health Systems Management

The Sloan School's report for 1972-73 summarized in some detail the ongoing research and related educational programs in health systems management. This survey illustrated the extensive focus of faculty interest in managerial issues affecting nonprofit institutions and organizations. Much of the work described last year is still in process, since almost all of the research efforts involved longer-term projects.

Professor Urban this year has initiated a new pilot study of the "marketing" issues in the development and growth of health maintenance organizations, which promises to open systematic review of an important set of questions concerning trade-offs in consumers' decisions on whether to use qualified health maintenance organizations, conventional health insurance coverage, and so on. In understanding consumer choice criteria better, providers of health care may be more able to design and develop desirable health care plans.

The other ongoing research in health systems management, conducted by Professor Rockart, Senior Lecturer Beckhard, and Lecturer Rubin has been described earlier in this report.

Programs aimed at the experienced health professional continue to receive enthusiastic praise and response. The special summer program in the dynamics of health service systems has been described above. The Sloan School's special one-week management advancement program, offered to deans of medical schools and their staff, has proceeded from its initial phase, which involved primary emphasis on a "deans'" program, to the second and third program phases, which focus on teams of deans, key department heads, and health delivery managers. The program is cosponsored by the Association of American

International Visitors

Medical Colleges, and many of the participants already have cited important management changes which have occurred in their institutions as a result of these programs.

The School continues to develop new curricula for other educational programs to be addressed explicitly to the professional managers of health care facilities and programs.

International Visitors

Dr. Aroon K. Basak, of the International Bank for Reconstruction and Development, Calcutta, India, visited the Sloan School during the spring term of 1974. During this time, he worked with Professors Robinson and Hill to help prepare a formal proposal on an international comparative study of the effectiveness of public sector enterprises as instruments of economic development. The proposal will be presented to the World Bank for review.

Dr. Zev Bonen, of the Ministry of Defense, Tel Aviv, Israel, was with the School for three months in the fall of 1973 as a guest of the Institute, with Professor Roberts acting as his host.

Dr. Stanislav Dubrovsky joined the School as a research fellow for four months during the spring term. Dr. Dubrovsky was sponsored by a program which encourages graduate student-young faculty exchanges between the USA and the USSR. Professor Little was his faculty advisor.

Gianni Granata of the Olivetti Corporation in Milan, Italy, joined the School as a guest from November, 1973, to March, 1974, under the supervision of Professors Donovan and Madnick. Mr. Granata worked on an information systems project during his stay.

Professor Tor Greness of the Centre for Informatikk in Oslo, Norway, visited with Professor Allen as a guest of the Institute during May - June, 1974. Dr. Spyros G. Makridakis, an assistant professor at INSEAD, Fontainebleau, France, was a visiting scholar for three months this spring. Professor Little worked with him on his research in the area of technological forecasting and operations.

Dr. Ignatius van Wyk Raubenheimer, Head of the Department of Industrial Psychology at the University of South Africa, was a visiting scholar at the Sloan School for the academic year 1973-74. Dr. Raubenheimer's research interests were addressed primarily to issues of organizational performance and productivity.

Professor Hans H. Weber of the Technical University of Berlin was a Visiting Professor of Management for the past year.

Staff Changes and Promotions

Professors Jeremy F. Shapiro and Alvin J. Silk both were granted tenure positions effective this year.

Assistant Professors Ralph L. Keeney, Robert C. Merton, and Roy E. Welsch advanced to the rank of associate professor, effective July 1, 1973.

Professor William F. Bottiglia, formerly Professor of Foreign Literatures and Humanities and head of that Department at M. I. T., joined the faculty of the Sloan School of Management this past year. He was on sabbatical leave for the fall term, but in the spring of 1974 joined the School full-time as a Professor of Foreign Literatures and Humanities and Professor of

Management.

Professor Wilbur G. Lewellen, of the Krannert Graduate School of Industrial Administration at Purdue University, was a visiting professor this past fall; he joined the faculty of the Economics and Finance Group.

Professor Harvey M. Wagner of Yale University joined the School as a visiting professor for the spring term of 1974, working with the Management Science Group faculty.

Professor John J. Donovan, formerly with the Department of Electrical Engineering, became an Associate Professor of Management Science in July, 1973. Professor Donovan will be associated closely with Professor Michael S. Scott-Morton in further developing computer applications in management decision systems.

Dr. Edward W. Davis, who was formerly with the Harvard Business School, was with the Sloan School for this past year as a visiting professor, working with Professor Little in the management science area.

Dr. Gail Pierson of the Department of Economics of Harvard University joined the Economics and Finance Group of the Sloan School during this year as a visiting professor.

Eight new assistant professors became members of the Sloan School teaching staff during the period covered by this report. Dr. Richard A. Cohn, from Stanford University, is now Assistant Professor of Finance. From the University of Pennsylvania, Dr. Ralph Katz came to the faculty of the Organizational Psychology and Management Group, as did Peter G. W. Keen from the Harvard Business School. Additions to the Management Science Group faculty include: Dr. Gary L. Lilien of the Columbia University School of Engineering and Applied Science; Dr. Peter Lorange, from the Harvard Business School; and Dr. Roy E. Marsten, from the University of California at Los Angeles. Professor Kenneth S. Mericle received his Doctor of Philosophy from the University of Wisconsin, and will teach in the area of manpower and labor relations. Professor Eric A. von Hippel, who had been a management consultant for McKinsey and Company in New York, will work with Professor Edward B. Roberts in the field of management of technology.

Dr. Jørgen Randers, who had been a research associate with the System Dynamics Group of the Sloan School, became an assistant professor for the fall term.

Dr. Stewart D. Hodges of the London Business School was a Visiting Assistant Professor of Finance during the year, and Dr. Donald R. Lessard from the Amos Tuck School at Dartmouth College was also a visiting professor. Dr. Lessard taught 15.434 Advanced Financial Administration in the fall and 15.436 International Managerial Finance during the spring term.

The School was happy to welcome back Professor Emeritus Everett E. Hagen, who joined it this past year as a senior lecturer, teaching in both the Sloan School and the Department of Political Science.

Dr. George O. Gardner III of the Arthur D. Little Company was a part-time lecturer with the Management Science Group for the fall term of 1973, and Dr. George H. Harris of the same firm replaced him in the spring of 1974. Dr. Judith A. Lachman, who received her Doctor of Philosophy in Economics at Michigan State University, was an instructor with the Economics and Finance Group for the academic year 1973-74.

Visiting scholars during the past academic year included Dr. John K. Major, Professor of Physics and dean of the Graduate School of Arts and Sciences of New York University;

Staff Changes and Promotions

Dr. Leonard J. Parsons, associate professor at the Claremont Graduate School, Claremont, California; and Dr. Norman S. Sterns, Associate Professor of Medicine, Tufts University School of Medicine.

Dr. John H. Murphy, senior engineer with the Bettis Atomic Power Laboratory of Westinghouse Electric Corporation, visited with the System Dynamics Group as a postdoctoral fellow during the academic year.

New appointments to the administrative staff of the Sloan School include Leslie M. Clift, who became assistant to the dean in September, 1973, and Alan F. White, who left the University of Hawaii (where he had been a special assistant to the president) to become the Associate Director for Executive Programs in the Sloan School.

Professor Jay Galbraith has accepted a position at the Wharton School, and Professor Murat Sertel has decided to continue as senior research fellow at the International Institute of Management in Berlin.

Professor Edward H. Bowman returned from his year at the European Institute for Advanced Studies in Management in Brussels, Belgium, where he was a visiting professor.

Professor Myron S. Scholes was on leave for the academic year as a visiting professor at the University of Chicago Graduate School of Business. Professors Jeremy F. Shapiro and Roy E. Welsch were on half-time leave of absence to participate in a research project at the National Bureau of Economic Research Computer Research Center.

WILLIAM F. POUNDS

School of Science

This was a year of intense activity for the School of Science. Students took their academic work seriously and thought more about their future careers. They found the job market had improved, and, as usual, M. I. T. premedical students were very successful in gaining admission to medical schools. The faculty improved and extended educational programs and worked harder to raise the funds required to support their research.

The number of undergraduates in the School of Science was about the same as in the previous academic year, 1,173, compared with 1,199 in 1972-73 and 1,105 in 1971-72. The increase in the number of undergraduates in biology has leveled off (369 students, compared with 363 the preceding year). Approximately 38 of these students are enrolled in Course VII-2, which is operated by the Department of Nutrition and Food Science. After several years of decline, the number of undergraduates in physics increased from 263 during the 1972-73 academic year to 276 this year.

Course XXV, the Interdisciplinary Science Program, continued to provide individual curricula for undergraduates with approved programs in interdisciplinary sciences containing a solid science core. Eight students received their Bachelors of Science in this Course this past year. Professor Louis N. Howard served as faculty counselor; the Course XXV Committee was drawn from the departments of the School of Science, plus Professor Gerald E. Schneider of the Department of Psychology. The Course XXV Committee has begun work on an interdisciplinary master's program to be proposed in the fall.

This year there were seven science subjects, other than subjects fulfilling Institute Requirements, that had enrollments over 20 percent of the maximum possible steady-state undergraduate enrollment (about 1,000). They were: 5.31 Introduction to Chemical Experimentation (25 percent); 5.42 Organic Chemistry (33 percent); 7.05 General Biochemistry (36 percent); 8.03 Physics III (46 percent); 8.04 Principles of Quantum Physics I (22 percent); 18.03 Differential Equations (83 percent); and 18.075 Advanced Calculus for Engineers (44 percent).

The participation of undergraduate students in the Undergraduate Research Opportunities Program (U. R. O. P.) in the School of Science was up a little this year, and this Program continues to offer an opportunity for undergraduates to become involved in research at any stage in their education.

The number of graduate students in the School of Science was 934, compared with 938 in academic year 1972-73 and 899 in 1971-72. The stability of the number of graduate students reflects the consistency of the support of sponsored research in the School. The Office of Sponsored Programs has reported the volume of sponsored research in the School of Science as \$16.6 million in fiscal year 1972, \$18.1 million in fiscal year 1973, and \$18.5 million in fiscal year 1974. In addition, there are two new laboratories this year, the Center for Cancer Research and the Cell Culture Facility, which are not included in these figures.

This year there have been several new developments in the area of astronomy. On January 18, 1974, the computer control of the pointing and data acquisition of the 36-inch telescope at the Wallace Observatory was turned on. Another indication of growing interest in astronomy is that M. I. T., the University of Michigan, and Dartmouth College have signed an agreement

to move Michigan's 1.3-meter optical telescope to Kitt Peak and to collaborate in its use, especially to make optical identifications of X-ray emitters detected by the forthcoming Small Astronomical Satellite No. C (SAS-C). In addition, preliminary plans for the construction of a new type of large telescope have been developed under the auspices of the steering committee for the Astrophysics Program, chaired by Professor Bernard F. Burke.

Thanks to a gift from George R. Wallace, Jr., a Geophysical Observatory is being constructed on the same hill as the George R. Wallace, Jr., Astrophysical Observatory. The new facility, under the supervision of Professor Frank Press, involves an underground vault for seismometers which will be mounted on a baserock surface.

Unfortunately, the Institute is losing Professor Norman A. Phillips at the end of this academic year to the National Meteorological Service in Washington, D. C., where he will be principal scientist. Professor Phillips came to the Institute in 1956 as a research associate and has been on the faculty since 1957. He was appointed head of the Department of Meteorology in 1970. The new head of the Department of Meteorology is Professor Jule G. Charney, Alfred P. Sloan Professor of Meteorology. During the year there were discussions to develop greater cooperation and coordination between the Departments of Earth and Planetary Sciences and of Meteorology; Professors Press, Charney, and Phillips developed a plan for this collaboration.

The School lost Professor Alberto P. Calderon to the University of Chicago, and Professor Steven Weinberg to Harvard University.

The School of Science lost four faculty members through retirement. These include Professor Victor P. Starr of the Department of Meteorology, who is a recognized authority on the circulation of planetary atmospheres. Professor George E. Valley, Jr., of the Department of Physics, served as associate director of Lincoln Laboratory and in 1969 founded the Experimental Study Group for M. I. T. freshmen and sophomores. Professor George P. Wadsworth has contributed significantly to Norbert Wiener's classic theory on generalized harmonic analysis, and has provided a basis for understanding seismic exploration. Institute Professor Victor F. Weisskopf is an international leader in theoretical physics, was head of the Department of Physics from 1966 to 1973, and also served as director-general of the European Center for Nuclear Research (CERN) in Geneva, Switzerland.

This year there have been several additions to the senior faculty of the School from outside M. I. T. Professor Herman M. Chernoff is joining the Department of Mathematics to develop a group in statistics, and Professor Peter H. Stone is joining the faculty of the Department of Meteorology. Professor Mac V. Edds, Jr., of the University of Massachusetts has been appointed Professor of Nutrition and Food Science and executive director of the Neurosciences Research Program.

During the year Professor Hartley Rogers, Jr., became associate provost, Professor Press became director of the M. I. T. office for the joint M. I. T. -WHOI (Woods Hole Oceanographic Institution) graduate degree program in oceanography, and Professor John G. King became associate director of the Research Laboratory of Electronics. Samuel A. Goldblith, Underwood-Prescott Professor of Food Science, will become director of the Industrial Liaison Office in September, 1974, and Professor Marcus Karel will become deputy head of the Department of Nutrition and Food Science.

Members of the School of Science received many honors from outside the Institute and from within the Institute community. Professor Weisskopf has been honored this year with selection (by a faculty committee) as the James R. Killian, Jr., Award Lecturer in 1973-74.

Professor King was named the Francis Friedman Professor of Physics, and Professor Alexander Rich was named William Thompson Sedgwick Professor of Biophysics. Professor Seymour Papert was appointed the first Cecil and Ida Green Professor of Education in the Division for Study and Research in Education. Five faculty members in the School of Science were elected to the National Academy of Sciences: Professor David Baltimore (Department of Biology); Professor Ali Javan (Department of Physics); Professor Hamish N. Munro (Department of Nutrition and Food Science); Professor Irwin I. Shapiro (Department of Earth and Planetary Sciences); and Professor John S. Waugh (Department of Chemistry).

ROBERT A. ALBERTY

Department of Biology

During the academic year, 361 undergraduate students concentrated in the life sciences, and 146 were awarded the Bachelor of Science in this field; the previous year's figures were 387 and 126, respectively. Between July 1, 1973, and June 30, 1974, 15 Doctors of Philosophy and six Masters of Science were awarded in biology. There were 110 graduate students during the past year.

Approximately 32 undergraduate students participated in research programs during the regular academic year. During the summer of 1973, the Department again obtained funds from the National Science Foundation (NSF) for the support of approximately 20 undergraduate students. This very successful program has been under the direction of Professor Harvey F. Lodish.

Research

The research by members of the Department's faculty, research associates, research fellows, and graduate students is described in a publication entitled "Research Summaries." It is available in Departmental headquarters.

Of particular interest is the Department's greater involvement in the study of eukaryotic organism and of development. A number of its faculty members have extended their research interest from the study of molecular biology and genetics in bacteria to a study of these problems in yeast (Professors David Botstein and Boris Magasanik) or slime molds (Professors Charles E. Holt and Lodish). Research on genetics and development in *Drosophila* is being carried out by Professors Linda M. Hall and Mary Lou Pardue, and on development in amphibia by Professors Lisa A. Steiner and Pardue. Over the last two years, Departmental facilities have been adapted for the work on these organisms.

Research activity in the Center for Cancer Research will increase the Department's role in the study of tumor viruses by Professor David Baltimore and his colleagues, and the study on the surface components of normal and tumor cells of animals by Professor Phillips W. Robbins. A new departure will be research on tumor immunology by Professors Herman N. Eisen and Paul D. Gottlieb.

Personnel

Phillip A. Sharp has been appointed Associate Professor of Biology. This is a joint appointment with the new Center for Cancer Research; he will assume the position on July 1, 1974. Professor Sharp received his Doctor of Philosophy in 1969 from the University of Illinois, and is presently a staff member of the Cold Spring Harbor Laboratory. He has been awarded a Faculty Research Award by the American Cancer Society. The grant covers a stipend and

institutional allowance for a five-year period.

Three other new appointments also have been made in the Department, jointly with the Center for Cancer Research. Raymond M. Baker will become Assistant Professor of Genetics in September, 1974. Professor Baker received his Doctor of Philosophy from the University of California at Berkeley. He is currently lecturer at the Department of Medical Biophysics, University of Toronto.

Richard O. Hynes will join the Department as Assistant Professor of Biology in January, 1975. Professor Hynes received his Doctor of Philosophy from M.I.T. in 1971. He is presently a research fellow at the Imperial Cancer Research Fund Laboratories in London, England. David Housman also will join the Department in January, 1975, as Assistant Professor of Biology. Professor Housman received his Doctor of Philosophy from Brandeis University in 1971, and is presently assistant professor at the Department of Medical Biophysics, University of Toronto.

Tenure was awarded to Professor Steiner effective July 1, 1974, and to Professor Paul R. Schimmel effective July 1, 1975. Professors Jonathan A. King and Joel A. Huberman have been promoted to Associate Professor of Biology, effective July 1, 1974.

Professor Alexander Rich, whose research has helped to elucidate the structure of genetic materials, has been appointed William Thomas Sedgwick Professor of Biophysics, effective July 1, 1974.

The Department regrets that after one year of service, Professor Luther S. Williams has left to return to his former position as associate professor at the Department of Biology at Purdue University.

BORIS MAGASANIK

Department of Chemistry

Fifty-three undergraduates were awarded the Bachelor of Science in chemistry this year. Almost all of the graduates either will be attending graduate school in chemistry, medicine, or related areas, or have been employed by industry. The Master of Science was awarded to 5 candidates. A total of 48 doctoral degrees were awarded. To date, 1,384 doctoral degrees and 342 master's degrees have been awarded by the Department.

Personnel

Professor Thomas W. Cole, Jr. of Atlanta University was a visiting professor in the Department this year. He has been involved with the undergraduate teaching program in addition to carrying out research in Professor Glenn A. Berchtold's laboratories.

Edward J. Curtis, a technical assistant in the Integrated Chemistry Laboratory, retired after 49 years at M. I. T., 46 of which were in the Department of Chemistry.

Professors Alan Davison and James L. Kinsey were promoted to the rank of full professor. Dr. James L. Gole joined the staff as assistant professor. Professor Stephen G. Kukolich left to accept a position at the University of Arizona at Tucson. The Department was saddened by the death of Professor George Scatchard on December 10, 1973.

Professor John S. Waugh was appointed the Arthur Amos Noyes Professor of Chemistry. He also was elected to the National Academy of Sciences. Professor Waugh gave a series of

lectures at Columbia University as the Falk-Plaut Lecturer for the 1973-74 academic year.

Professor Ralf A. Steudel of the Technical University of Berlin also was a visiting professor in the Department. Other visiting faculty and scientists were: Eric Block of the University of Missouri, St. Louis; Evan B. Carew of the University of Michigan; David F. Eggers, Jr. of the University of Washington; John E. McMurry of the University of California at Santa Cruz; Harvey A. Gould of Clark University; Rudolf Lenk of the University of Grenoble; Earle K. Ralph of Memorial University of Newfoundland; Vernon Reinhold of the University of Vermont; and John R. Lombardi of Harvard University.

The Department was privileged to sponsor a series of lectures provided by the Arthur D. Little and Karl Pfister Visiting Professorships. There were two A. D. Little Visiting Professors: J. H. van der Waals, of the Kamerlingh Onnes Laboratorium de Rijksuniversiteit in Leiden, the Netherlands, who gave a series of three lectures entitled "Electron Resonance of Photo Excited Molecules in Zero Field"; and Professor Fred Basolo of Northwestern University, who gave three lectures entitled "Coordinated Nitrene Intermediates in Reactions of Azido Metal Complexes," "Synthetic Oxygen Carriers," and "Mechanism of Substitution Reactions of Metal Carbonyls." Professor Jerome A. Berson of Yale University presented three lectures on cycloadditions, cycloreversions, and thermal rearrangements as a Karl Pfister Visiting Professor.

Curriculum

The options for entering undergraduate students in chemistry subjects are as follows: 5. 41 Introduction to Structure, Bonding, and Mechanism; 5. 60 Chemical Equilibrium; 3. 091 Introduction to Solid-state Chemistry; and 7. 01 General Biology.

The new subject in biochemistry, 5. 50 Enzymatic Reaction Mechanisms, taught by Professor Christopher T. Walsh on an experimental basis in 1973-74, has become a regular offering and will be taught each spring term.

Professor Richard H. Holm has developed a new subject in bio-inorganic chemistry which will be taught for the first time in the coming academic year.

Research

Research in the Department of Chemistry is carried out by members of the faculty, post-doctoral fellows and associates, and graduate and undergraduate students. Research throughout the academic year continued at an active pace, in a large variety of fields, within chemistry and associated disciplines. The following is a description of a few representative research programs which are in progress in the Department's laboratories.

In 1970, Professor Jack E. Baldwin's research group began a synthetic study of an iron complex which would bind oxygen reversibly in a manner similar to hemoglobin. Having identified two influences -- dielectric constant in the vicinity of the oxygen, and steric hindrance to a bimolecular redox reaction -- as important in the maintenance of a reversible binding, they undertook to synthesize suitable "cleft" containing molecules. The first success was in a system which bound oxygen (1:1) reversibly at -50° centigrade. More recently, a cagelike structure which is a closer molecular analogue of hemoglobin was synthesized. This substance, as its iron (II) complex, reversibly binds oxygen at 25° centigrade over many cycles. Professor Baldwin's intention is to bind such a species, by a covalent bond, to a solubilizing substrate, such as a polyglucose (dextran). Such a copolymer should be compatible with plasma and have oxygen-carrying properties.

In concert with Professor Baldwin's synthesis of chirally labeled valine and its incorporation into penicillin, he has undertaken the direct chemical conversion of peptides to penicillin. In this work he has formulated a new biosynthetic theory for the formation of penicillins, and is in the process of testing this theory in vitro.

Professor Davison's research group is continuing work in the following areas:

1. Studies with chiral transition metal complexes are of two types: a) use of chiral complexes in asymmetric synthesis; and b) examining the stereochemical course of organometallic reactions at the metal center.
2. A number of transition metal complexes of small boranes bonded to metal have been synthesized, and new modes of bonding of boranes to metals have been achieved.
3. The use of dihydrofulvalene to synthesize metal fulvalene complexes is continuing. These complexes undergo reversible redox reactions and lead to novel mixed valence systems.
4. The synthesis of cysteinyl-containing oligopeptides has led to their use to construct model systems for the active sites of nonheme iron-sulfur proteins.

Professor John M. Deutch and his group have concentrated their research efforts during the past academic year in two areas. The first area is concerned with the structure and dynamic properties of complex fluids, in particular dipolar liquids. Since dipole-dipole forces, such as those present between water molecules, are of long range, one finds behavior in this important class of fluids not encountered in simple atomic fluids. The Deutch group has found it possible to elucidate the consequences of these long-range forces for the two-particle orientation dependent distribution function and for the thermodynamics of these systems. In addition, considerable progress has been made on quantitative determination of properties such as the dielectric constant and the free energy of model polar fluids.

Recently the group has turned its attention to dynamic phenomena in polar fluids. It has been possible to resolve a long-standing controversy over the appropriate molecular expression for the frequency dependent dielectric constant of polar fluids. In general, it has been shown that the fluctuation expressions for the dielectric constant depend on sample shape and surroundings (because of the long-range nature of the dipolar forces). The controversy has its origin in a misunderstanding on this point. Future work will be directed toward obtaining an alternative theoretical expression that does not have the undesirable feature of geometry dependence. In addition, this latter work will permit an investigation of other transport coefficients. In an amusing and pleasant coincidence, it has proven possible to exploit some of the results on hard sphere polar fluids to interpret data on roton interactions in liquid helium.

The second area where the Deutch group has been particularly active involves the consequences of the hydrodynamic interaction that exists between colloidal particles in solution. The hydrodynamic interaction results in a dependence of the relative diffusion coefficient on separation, with the diffusion coefficient decreasing as the separation is reduced. The physical origin of this effect is that the particles must push solvent out of the way as they approach each other, and for an incompressible fluid this becomes more difficult as the particles come closer together. The consequences of this effect can be insignificant or quite large. For example, the theoretically predicted rate for diffusion controlled reactions is decreased by approximately 50 percent. The predicted intensity patterns in chemically induced dynamic nuclear polarization are changed by factors ranging from 0.3 to 2.0. On the other hand, there is essentially no observed effect on the quasi-elastic light-scattering spectrum from a colloidal solution.

Future work of the group will focus on dynamic phenomena in dipolar fluids, surface phenomena (in collaboration with Professor George M. Whitesides of this Department), and fundamental problems in polymer theory.

Professor Gole's research group is concerned primarily with novel approaches to high-temperature chemistry and molecular electronic structure. Current research in progress includes the following areas of study.

1. Low-lying Electronic States Initial efforts in this area are directed towards the study of HO_2 and AlO ; however, the apparatus which has been constructed is a general purpose apparatus for the study of mainly free radical systems. The perhydroxyl radical is an important intermediate in many reaction systems, in radiation chemistry, photochemistry, atmospheric chemistry, and in combustion and other thermal reactions.
2. Chemiluminescence A major aspect of the research effort involves the study of dynamic systems and the characteristic features of the energy distributions for those product molecules which are formed in a given chemical reaction. These studies are designed specifically to provide necessary information for understanding the luminescence process, which, among other facets, has important implications for chemical laser technology. The research efforts involve an orderly study of chemiluminescence phenomena in the pressure range from 10^{-6} to 10 torr. The studies are being carried out in beams, flows, and flames.
3. Metal and Molecular Aggregates Interest centers primarily on the study of metal aggregates. Although it is an intuitive assumption that the electronic properties of small metallic particles could be intermediates between atomic properties and the bulk metallic phase, this picture is only qualitative, and little quantitative experimental or theoretical information is available. Initial efforts are directed toward the aggregates Ag_n , Al_n , Pb_n , Sb_n , and Bi_n , where n varies from 2 to $\times 30$. Techniques are being developed to extend these studies to aggregates of those species whose boiling points exceed 2500° centigrade. This will open the door for species such as Pd_n , Rh_n , Rd_n , and other aggregates of the transition metals.

The physical significance of this work lies in the elucidation of factors inherent in vapor phase nucleation and heterogeneous catalysis. Silver and palladium have been used extensively as catalysts. Small aggregates of silver are known to catalyze electron transfer from reducing agents to silver halide crystals. Palladium is a well-known catalyst for hydrogenation. Rhodium, of course, is known for its role in the methanol-acetic acid conversion. The techniques developed for the study of metal aggregates might be applicable also to the study of molecular aggregates. The overriding purpose of these studies rests in the hope that they will represent a bridge between present knowledge of the molecular structure of small inorganic molecules and knowledge of the bulk structure of metals and solids.

During the past year, Professor Robert J. Silbey's group has been working in several areas of theoretical physical chemistry. The construction of potential energy curves for diatomic molecules from limited experimental information has been one of their main interests. They have shown how to use the mathematical techniques of Padé approximants and continued fractions to continue the potential curves analytically. In other words, from limited experimental information about a small portion of the curve, information can be obtained about a much larger portion of the curve by using their techniques. They have applied these techniques successfully to a large number of diatomics, and are attempting to use them further to treat larger molecules.

The lifetime of electronically excited molecules near metal mirrors was studied experimentally by Kuhn a few years ago. Until recently, the data was not explainable by the theory usually employed. In the past year, Professor Silbey's group noticed the similarity of the exact theoretical expressions for this effect to the expressions for a radio antenna near the surface of the earth. The latter problem first was treated almost 70 years ago by Sommerfeld. The group has adapted his theory to the present problem, and computed the lifetime as a function of the distance of the molecule from the mirror; the results are in excellent agreement with experiment. Work is continuing on this problem, since it is the classical analogue to the transfer of energy from one molecule to another.

Also during the past year, Professor Silbey has derived the rate expressions for the relaxation of excited molecules (either electronically or vibrationally) by the coupling of the states of the molecule to heat reservoirs of various types. For example, relaxation of a vibrationally excited molecule into a phonon heat bath has a very different temperature dependence from relaxation into a heat bath consisting of two-level systems. He intends to exploit this difference in further work.

Finally, Professor Silbey's group has computed the energy levels of an ion in a triply degenerate electronic state interacting with a triply degenerate vibrational state. This is an example of the dynamic Jahn Teller effect encountered in many solid-state systems. They have been able to calculate the energy levels for all coupling strengths for the first time, and presently are in the process of calculating the optical line shape as a function of temperature, to compare with experiment.

Professor Waugh and his group for the past several years have been involved principally in the development and application of special (and sometimes exotic) techniques in nuclear magnetic resonance, primarily of solids. Their current work is centered on the exploitation of a conceptual framework, called coherent averaging theory, which has led to the discovery of these techniques. At the same time, a number of illustrative experimental applications are being pursued to demonstrate the efficacy of the techniques in a variety of physical, chemical, and biological fields. These include 1) the study of anisotropic chemical shielding of nuclei and its relation to the electronic structure of molecules and intermolecular forces; 2) the high-resolution nuclear magnetic resonance (NMR) study of molecules tightly adsorbed on solid surfaces, with possible applications to catalysis; 3) the study of the structural and dynamic behavior of components of cell membranes; and 4) the study of structure phase transitions in solids.

GLENN A. BERCHTOLD

Department of Earth and Planetary Sciences

The Department is entering the tenth year of its occupancy of the Green Building, and this is a good time to take stock of its progress. At the present time, the Department is composed of a relatively young faculty, diversified in the major fields which compose the earth and planetary sciences: planetary geophysics, oceanography, planetary astronomy, geology, and geochemistry. Student enrollment has increased some 50 percent over the years to 110 graduate students and approximately 70 undergraduates. It is heartening that the most recent growth has been in the undergraduate enrollment.

Research volume has increased to some \$3 million, which is many times its level at the beginning of the decade. The Department has been involved deeply with new programs such as the Joint Program in Oceanography with the Woods Hole Oceanographic Institution, the Interdisciplinary Science Program, and with several new laboratories such as the Planetary Astronomy Laboratory, the Wallace Astrophysical Observatory, the Geophysical Underground

Observatory (under construction), and the electron microprobe laboratory. The faculty also is involved with important national programs as principal experimenters or investigators. For example, it is represented on the Deep Sea Drilling Project, the International Program for Ocean Drilling, the Apollo Lunar Exploration Program (the five lunar observatories are still alive and telemetering data back to Earth), the continuing examination of lunar rocks, the Viking Program, the Jupiter Fly-by, the Mars-Venus Fly-by, the FAMOUS (French-American project for the exploration of the Mid-Atlantic Ridge) Program, the International Geodynamics Project, and MODE (the Mid-Ocean Dynamics Experiment). These projects bring currency and excitement to the Department, heighten student interest, and also favor the Department with diversified sources of support. The tenth year in the Green Building finds the Department of Earth and Planetary Sciences a dynamic one, an overcrowded one, with increased funding and student involvement, but with a faculty which has remained constant in size over the past decade.

The Department's commitment to undergraduate education remains strong. A program of subject evaluation by students has been instituted. The undergraduate research participation has grown to the point where there are as many undergraduate students in research projects as there are registered in the Department. Approximately 25 percent of the graduating class received either Hertz fellowships or National Science Foundation (NSF) fellowships, an indication of the quality of students in the Department and hopefully a statement about the quality of the education they receive.

Personnel Changes

Peter Molnar and Tanya Atwater have joined the Department as assistant professors. Professor Molnar is working on the application of plate tectonics to regional geology, and Professor Atwater is a marine geophysicist interested in the processes which lead to the formation of suboceanic plates. Professor Richard Naylor has left the Department to take up duties as chairman of the Department of Geology at Northeastern University. Professors Carl Wunsch, John Lewis, and Thomas McCord were advanced to the rank of tenured associate professor.

Research Results

Professor John Edmond and his students have overcome an important sampling problem and opened up a whole new area of investigation in marine chemistry. They have developed an in situ filtration package for the quantitative recovery of suspended particulate material in the ocean from very large volumes of seawater. This material originates in particles derived from organisms as well as wind- and river-borne matter. By its chemical interaction with the water column, it controls the distribution of a wide variety of dissolved species in the water. As a result of this technique, the analysis of these materials no longer is limited by low concentrations.

An undergraduate project supervised by Professor Edmond involves the chemical dynamics of estuaries. An ardent and enthusiastic band of students has been studying the estuaries leading into Massachusetts Bay, and have gathered and interpreted an immense amount of data. Their research, soon to be published, has resulted in a completely new approach to estuarine problems. Their efforts recently have been expanded to include the chemistry of the Amazon estuary and fresh water plume.

David Williams, a graduate student in the Joint Program in Oceanography with the Woods Hole Oceanographic Institution, has been working with Dr. Richard Von Herzen of that Institution and Professor John Sclater. Mr. Williams has discovered clear evidence for hot springs at the crest of the mid-ocean ridges encircling the world. He has suggested that these springs originate in hydrothermal circulation of seawater through the new oceanic

crust soon after it is created on the sea floor. These results have potential implications for geothermal power and ocean floor mineral resources. They also have fundamental importance, because hydrothermal circulation may be the major process by which the earth loses its internal heat.

Professor Atwater is involved in a joint project with colleagues at the Woods Hole Oceanographic Institution (WHOI) and Scripps Institution of Oceanography in which near-bottom geophysical instruments are used to study the Mid-Atlantic Ridge. The preliminary bathymetric and magnetic results indicate that most of the basement rocks in the Atlantic Ocean floor originate along an amazingly narrow band, two to four kilometers wide, in the very center of the rift. The rocks then were broken, tilted, uplifted, and translated to form the mid-ocean ridge mountains, and eventually subsided to form the deep ocean floor as the sub-oceanic plate cooled.

Professor John B. Southard also has been involved in a cooperative program involving WHOI (with Dr. Charles Hollister) and the Scripps Institution of Oceanography. Using deep-towed instruments developed at the Scripps Institution of Oceanography, they found large-scale erosional furrows and other ocean-current generated features on the flanks of the Blake-Bahama Outer Ridge, a major depositional feature in the western North Atlantic. These newly discovered features are a striking demonstration that the erosive power on the bottom of the ocean is much more effective in shaping the subsea topography than had been supposed previously.

Professor Lewis has been taking a new tack in explaining the evolution of the planets and their varying chemical composition. His approach is to postulate a very simple and thoroughly quantifiable equilibrium chemical model, and to predict a host of bulk compositions, internal structures, and volatile contents of the planets and their satellites. Most of his predictions which are verifiable are turning out to be correct. With this approach the initial conditions of planets can be postulated with more confidence, so that the subsequent evolution, differentiation, and formation of atmospheres become more amenable to numerical modeling.

Plate tectonics is to the earth sciences what the double helix was to molecular biology. It is easy to understand why members of the Department are involved heavily in this concept on many fronts. Professor Sean Solomon is conducting the first global quantitative tests of models for the forces driving plate tectonics. He believes that buoyancy forces at both spreading centers and subduction zones are important elements of the driving forces, and that drag beneath plates is the major resisting force. Professor Patrick Hurley has been working on the late Precambrian and Paleozoic rocks of North Africa. He finds in the geological record an array of features diagnostic of a subducting lithospheric plate during this period. His age measurements on these rocks enable him to reconstruct a sequence of events including plate collision, plate separation, plutonism, and continental collision which not only are of fundamental geological importance, but also help to explain the development of the great North African oil basins.

The stresses which move the large plates also produce earthquakes, and various members of the Department are involved in many different aspects of research connected with earthquake prediction. Professor William F. Brace has done the pioneering work which has led to the explanation of those premonitory phenomena which have proved most successful in prediction. He is studying cracks and pores in rocks and how they change before and after an earthquake rupture. Measuring physical properties of rocks stressed in the laboratory and examining their cracks and pores (using the scanning electron microscope and other modern techniques) have led to a first look at the actual effects of stress, temperature, and pressure on cracks in rocks. Professor Keiiti Aki has solved several important problems on rupture propagation under various conditions of stress and fault zone properties. Also, he has shown that there is a similarity between the coda of small earthquakes and strong

earthquake motion, suggesting a new empirical approach to predict the latter from the former. This has important applications to the design of structures in earthquake-prone regions.

Professor Frederick A. Frey has been studying igneous rocks recovered from the seafloor as part of the Deep Sea Drilling Project. He finds no systematic compositional changes in these rocks as a function of distance from the mid-ocean ridge axis where the seafloor is created in the spreading process. Furthermore, the trace element chemistry of the rocks indicates that they are the best candidates for primary magma recovered from the seafloor, an important fact because it enables statements about the original mantle material from which they were derived to be made.

A result which demonstrates the intellectual advantages of combining several disciplines in the earth and planetary sciences stems from the progress which Professors Charles Counselman and Irwin Shapiro have made in the application of ground based radio-interferometric observations to the measurements of plate motions on the earth's surface. They already have established a geodetic tie across the United States with an estimated error of less than 25 centimeters, and they expect to monitor plate movements with centimeter-per-year measurement accuracy over the next few years. If this experiment succeeds, it will be the most important recent development for plate tectonics and earthquake prediction. This group also completed this year the most accurate experimental test yet performed of the prediction of Einstein's theory of general relativity that electromagnetic waves will be deflected when passing by the sun.

The group under Professor McCord has been involved in the development of advanced instrumentation for use on optical telescopes. They have designed and built silicon diode-array vidicon imaging systems, for use in both direct imaging through interference filters and two-dimensional spectroscopy using a prism spectrometer. Useful data has been collected during the past year while observing with telescopes at Kitt Peak, Mount Wilson, Mauna Kea, and M. I. T. 's Wallace Observatory. A new astronomical instrument is the vidicon spectrometer, which has been developed from the silicon diode vidicon system. Digital vidicon photographs of spectra can be taken, which makes this device extremely useful in the study of planetary surface composition from spectral reflectivity. These instruments have made it possible to improve remote sensing compositional analysis on planetary surfaces, the moon, and asteroids -- data which is, of course, basic to any understanding of the evolution of the planets.

The research group led by Professor Roger Burns works in the area of the crystal chemistry of the moon and the earth's interior, using high-pressure spectral observations in the laboratory. The group also is involved in theoretical calculations connected with the interpretation of the reflectance spectral profiles of the moon in terms of the composition of the lunar surface materials. An important result this year was to verify theoretically the remote sensing diagnosis of the distribution of titanium and iron silicate minerals on the moon's surface. The group currently is turning its attention to the problem of the formation and economic importance of the ferro-manganese nodules that lie in large abundance on the seafloor.

A consequence of plate tectonics which is receiving increased attention is the connection between plate movements and the origin of mineral deposits. In this connection, Professor John Dickey has advanced a hypothesis for the origin of podiform chromite deposits which relates ore deposition to magma fractionation along accreting plate boundaries in the oceanic lithosphere.

Professor Shapiro was elected to the National Academy of Sciences this year. Twenty-five percent of the Department's tenured faculty now hold this honor. Professor Brace received

the Rock Mechanics Award from the American Institute of Mining, Metallurgical, and Petroleum Engineers. Professor Press was awarded the Distinguished Public Service Medal by the National Aeronautics and Space Administration.

FRANK PRESS

Department of Mathematics

Curriculum

This year the curriculum development and revision efforts within the Department took place on various levels. An introduction to linear algebra was incorporated for the first time in the basic freshman calculus subject, 18.01-02 Calculus; though not strictly speaking a part of calculus, it has become so important in recent years that it was felt appropriate to introduce all freshmen to it. Professor George B. Thomas, Jr. wrote notes which are being revised this summer. In addition, some experiments also were conducted in the spring term, linking computers with the calculus subject through two small classes on computer related calculus, 18.023 Topics in Calculus and 18.404 Seminar in Applied Mathematics, using respectively the LOGO and the MACSYMA languages. On the sophomore level, a new complex variables subject, 18.04 Complex Variables with Applications, primarily for mathematicians and electrical engineers, was given in both fall and spring terms, while an extensive set of notes was written by Professor Hartley Rogers, Jr. for 18.05 Introduction to Probability and Statistics, which was introduced in 1972-73, primarily for students in the biological and social sciences. The revision of the applied linear algebra subject 18.700 Linear Algebra (initiated several years ago by Professor William G. Strang) continued, with the issue of a complete set of notes (written by Professor Strang) which ultimately will appear in book form. Two new upperclass subjects were introduced, 18.411 Applied Algebra and 18.903 Introduction to Algebraic Topology, both of which were received well by the students who took them.

Personnel

One of the most significant events in the Department of Mathematics is the appointment, effective July 1, 1974, of Herman Chernoff as Professor of Applied Mathematics. Professor Chernoff, who is one of the world's most distinguished scholars in the field of mathematical statistics, comes to M. I. T. from Stanford University, to spearhead the organization of a select group of statisticians in the Department which will form the nucleus of a new statistics program at the Institute.

There were several changes of appointment within the existing faculty. Professor Rogers was appointed Associate Provost on February 1, 1974, but retains an active teaching role in the Department. Seymour Papert, Professor of Applied Mathematics and co-director of the Artificial Intelligence Laboratory, was appointed the first Cecil and Ida Green Professor of Education within the Division for Study and Research in Education. Professor David Schaeffer has been promoted to associate professor, and Drs. Michael Fredman and Paul Wang have been promoted from instructor to Assistant Professor of Applied Mathematics.

Professor Alexandra Ionescu-Tulcea of Northwestern University was appointed visiting professor for the spring term. Professor Michael Rabin, Rector of the Hebrew University of Jerusalem, came as a visiting professor in the fall term, but his visit was brief due to his responsibilities in Israel.

Professor George P. Wadsworth formally retired on June 30, 1974, having been on leave during the past academic year in order to complete work on a book to be published in the coming year. He first came to M. I. T. as an undergraduate, obtaining his Bachelor of Science in 1930 and receiving his Doctor of Philosophy in the Department in 1933. He was an instructor in 1934-38, then was appointed assistant professor, associate professor, and finally full professor in 1967. His work with Professor Norbert Wiener and with the Department of Meteorology during World War II was significant, and was followed by his appointment as director of the Operations Evaluation Group attached to the Office of the Chief of Naval Operations. His work in applying the theories of Professors Wiener and Norman Levinson on filter design and prediction was fundamental to the founding of the Geophysical Analysis Group at M. I. T., and to the development of instrumentation which has had an enormous impact on seismic exploration in the United States. Professor Wadsworth's contributions to the Department of Mathematics through 40 years of research, teaching, and student advising have been most valuable. He will be missed.

Faculty members on leave this year were Professor Nesmith C. Ankeny, Professor Warren Ambrose (who was on leave at the University of Santiago and happily was able to leave that country shortly after the military coup in the fall of 1973), and Professors Daniel G. Quillen and Dennis P. Sullivan, both of whom visited the Institut des Hautes Etudes Scientifiques in France, for the year; Professor Alan Needleman for the fall term; and Professors Alberto P. Calderon, Richard M. Dudley, Daniel M. Kan, Daniel J. Kleitman, Bertram Kostant, James R. Munkres, Strang, and Thomas for the spring term.

In an outstanding achievement by a Department member, Institute Professor Levinson proved the strongest result yet known concerning one of the most famous and challenging unsolved problems in mathematics -- the so-called Riemann hypothesis. The conjecture is that all of the zeroes of Riemann's zeta function $\zeta(s)$ lie on the line where the real part of s is equal to $1/2$. Professor Levinson proved that more than one-third of the zeroes lie on this line.

KENNETH M. HOFFMAN

Department of Meteorology

Student enrollment and interest in the Department has remained at a high level in spite of the increasing overhead and present research assistant stipend rates. The enrollment of 53 students in September, 1973, exceeded that which had been predicted. Five doctoral degrees and nine master's degrees were awarded in spite of the small number of regular faculty in full attendance. Professor Frederick Sanders' undergraduate seminar on weather forecasting now attracts approximately 15 undergraduates each term and as many as 25 during the January Independent Activities Period (I. A. P.) Total graduate enrollment in the Department in the fall of 1974 again is expected to be in the low 50s. Among the graduate student body will be the Department's first American black student -- after 14 years with no such representation. This event, hopefully the sign of a much healthier representation of native minorities in the fields of meteorology and oceanography, is the result of the Department's collaboration with the University Corporation for Atmospheric Research in affirmative action.

Curriculum

Curriculum changes in the past academic year have been small. Some significant developments already have been designed for the coming year, however. Among these are the institution of a subject on the climate of the past (Professor Reginald E. Newell) and a subject on small-scale turbulence in the ocean and atmosphere (Professor John E. Hart). Further changes will include a reorientation by Professor Peter H. Stone of Professor Victor P. Starr's subject on the general circulation, so as to form a logical two-term sequence with

the subject 19.63 Atmospheric Models, now given by Professor Stone. The combined approach to ocean and atmosphere contained in Professor Hart's new subject on turbulence also will characterize efforts by Professors Jule G. Charney and Henry M. Stommel to combine their presentation of the dynamical theory of large-scale motions in the atmosphere and ocean. A remaining important area of meteorological subjects, including radiation, chemistry, weather radar, and cloud physics also is scheduled for revision, especially with the anticipated retirement from teaching of Professor Henry G. Houghton in one year.

Research

Departmental activity has reflected significant participation in several areas of concern in both meteorology and oceanography. For example, the possibility of the stratospheric operation of sizable commercial fleets of supersonic aircraft is one which has potentially significant environmental impact. The first results of the Departmental effort to explore this, involving Professors Ronald G. Prinn and Norman A. Phillips, together with Dr. Frederick Alyea and Research Associate Derek Cunnold, began with an attempt to predict the existing distribution of ozone in the stratosphere which is not affected by the additional source of nitric oxide from high-flying aircraft. The observed ozone maxima in high latitudes and the annual spring maximum and fall minimum have been predicted well by the resultant model, as have many of the statistical fluctuations and correlations in ozone. Having been successful with respect to the undisturbed atmosphere (for which verification data exists), this combined dynamical-photochemical model now can be extended more confidently to treat the unknown situation of a hypothetical source of nitric oxide from aircraft. In an interesting by-product, the National Aeronautics and Space Administration (NASA) has expressed interest in the application of these techniques to examine the potential effects of chlorine released by the solid rocket propellant used in the space shuttle operations.

Climate and climate change is another area of considerable interest, in this country and worldwide. This concern has been aroused most recently by the extended drought in sub-Saharan Africa, and by the sensitivity of food production in India to the vagaries of the monsoon. The effect of human intervention on large-scale climate is as yet a matter of speculation -- as opposed (for example) to the well-established small-scale effects of increasing snowfall by the judicious seeding of clouds on the windward sides of mountains. Agricultural practices, however, can change the surface albedo (the reflectivity to solar radiation), thereby affecting the amount of solar insolation retained to heat the air.

Professor Charney has been engaged in the completion of the theory of deserts he began on his recent sabbatical year. According to this theory, the relatively high albedo of deserts plays an important role in modifying the air circulation pattern so as to reduce precipitation in the vicinity of deserts. As a complement, Professor Newell's new research project on climate of the past approaches climate from a historical perspective. In this approach, the climatic record is constructed from meteorological observations from the immediate past, historical research, glacier and tree-ring data for the past 2,000 years, and a variety of geological indices (ocean cores, pollen, and so forth) for the past 100,000 years. The different data then are considered together, with respect to their consistency and implications for circulation patterns in the atmosphere. The hypothesis is that external events (such as changes in the solar "constant") are not necessary to explain global climate changes.

The summer of 1973 saw the successful completion of the Mid Ocean Dynamics Experiment (MODE), organized by Professor Stommel with Professor Alan Robinson of Harvard University. During the three-month operation in an area near Bermuda, experimenters from 13 United States institutions and three foreign institutions observed the three-dimensional distribution of currents, temperature, density, and the distribution of bottom pressure. With a few exceptions, instrumentation performed well, and analysis of the data now is under way. The main results so far appear to be a careful documentation of the extent to which transient

large-scale eddies dominate the oceanic interior. Most of the kinetic energy is in time periods which are comparable to the three-month observation period, however. This indicates that a longer experiment is necessary, and it is likely that a combined US-USSR experiment ("POLYMODE") suggested for several years from now will be needed to establish quantitative statistical measures of the transports of vorticity, energy, and material by these eddies. One surprise of last summer's experiment has been the simultaneity at periods of four to five days of bottom-pressure fluctuations observed at several points in the array. This is the first observational evidence that Rossby-wave oscillations on an ocean-wide basis are more than a theoretical possibility.

The Department's remote computer terminal, presently connected to the IBM 360/95 at the Goddard Institute for Space Studies (GISS) in New York City, has proved very worthwhile. An early dial-up telephone connection to the CDC 7600 at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, is anticipated. Faculty, staff, and students all have made good use of this increased computational power, on both meteorological and oceanographic problems which are related to the NASA mission of GISS. Considerable use still is made of the IBM computer at the Information Processing Center at M.I.T., for both sponsored and unsponsored research, but the large blocks of free computer time available at GISS and NCAR cannot be duplicated at M.I.T.

Personnel

The past academic year has featured an exceptional number of faculty personnel changes. Professor Edward N. Lorenz has been on sabbatical leave, continuing his research on predictability while visiting the National Center for Atmospheric Research and several meteorological institutions in the Southern Hemisphere. The Department was fortunate to have Professor John A. Young of the University of Wisconsin as visiting professor in Professor Lorenz's absence. Professor Young's current research area is the atmospheric boundary layer, and this fits in very well with student and faculty interests. Professor Delbar Keily retired in July, 1973, and Professor Starr retires in July, 1974.

Two new appointments become effective in July, 1974 -- those of Professor John E. Hart and Professor Peter H. Stone. Professor Hart, who has done considerable work in the experimental and theoretical aspects of geophysical fluid dynamics and hydrodynamic instability, comes to the Department from the University of Colorado. In addition to his current interests, Professor Hart plans to enter the field of physical oceanography. Professor Stone has been with the Department for two years as a visiting professor, while also engaged at the Goddard Institute for Space Studies. His far-reaching interests in dynamical meteorology and dynamical climatology of the Earth and other planets will add much to the Department's strength in these important areas.

The final change is the decision by Professor Phillips to join the National Meteorological Service at the end of the current academic year. Professor Charney will become head of the Department.

NORMAN A. PHILLIPS

Department of Nutrition and Food Science

The past academic year, like the previous one, witnessed growth in both the research activities of the Department and in the numbers of undergraduate and graduate students. During the 1973-74 academic year, 1,301 publications (i.e., research papers, reviews, books, and chapters of books) emanated from its faculty and students. A faculty meeting was held at the M.I.T. Endicott House on March 16, 1974, to discuss Department policy objectives and future planning. A report on this meeting and Departmental activities for the year will be distributed to the Visiting Committee.

One of the significant developments of this past year was the establishment of the International Nutrition Planning Program, affiliated with the Department and with the Center for International Studies. The Program has received an Agency for International Development (AID) institution building grant of \$685,000 for a five-year period, in addition to research grants from the World Health Organization (WHO), the National Science Foundation (NSF), and AID. The Program's activities extend to several countries, and it has been providing workshops for planners from developing countries; it will initiate an Advanced Study Program at M. I. T. in September, 1974.

While funding has increased in most areas of the Department, there are still no major Federal programs with a commitment to support those areas identified as food science and technology, although the National Academy of Sciences-National Research Council (NAS-NRC) Committee on Food Science and Technology, of which Professor Samuel A. Goldblith is chairman, is attempting to make some headway toward resolving this problem.

Undergraduate Education

The new undergraduate curriculum in the Department, known as Applied Biology, Course VII-2, is developing well. This program permits students to explore a variety of disciplinary areas leading to graduate study in nutritional biochemistry and metabolism, experimental medicine, food science and technology, biochemical engineering, toxicology, and neuroendocrine regulation. A revision of the curriculum has been effected; it should supply students with a strong interdisciplinary background which will contribute substantially to their ability in government, industry, or university careers.

In addition to the establishment of a formal faculty advisory system which helps a student to choose a coordinated set of goals that will permit him or her to pursue a defined professional goal, a "Faculty Handbook on Career Guidance in Applied Biology" is being prepared for the faculty of the Department. A program to promote a sense of identity among the undergraduates enrolled in applied biology has been developed.

The number of undergraduate students enrolled in Course XX subjects has increased from 146 in the fall term of 1971 to 296 in the spring term of 1974. A total of 52 undergraduate students were registered in the applied biology option in the spring term of 1974. A similar steady growth rate has occurred in the Undergraduate Research Opportunities Program (U. R. O. P.) in the Department, as shown below.

Student Enrollment in U. R. O. P.

<u>Academic Year</u>	<u>Fall Term</u>	<u>Spring Term</u>	<u>Total</u>
1969-70	6	6	12
1970-71	7	14	21
1971-72	34	56	90
1972-73	60	86	146
1973-74	94	97	191

The success of this program is measured not only by the number of students enrolled, but also by the fact that over the past two years, over 45 papers have been published in first-rate scientific journals which had an M. I. T. Course VII-2 undergraduate as a coauthor.

During the summer of 1974, 32 students are working on U. R. O. P. sponsored projects. The decision to give only credit for U. R. O. P. in the fall and spring terms, rather than offering the possibility of pay, may have an effect on enrollment in this subject. However, this

remains to be seen. Funding for U. R. O. P. will be reserved for work in the summers only.

In May and October, 1973, the first and second Symposia on Undergraduate Research in the Department were held, and several of the papers presented comprised the entire January, 1974, issue of the Tech Engineering News. An undergraduate subject which has shown considerable growth in enrollment is 20.02 Laboratory in Applied Biology. It has grown from 15 students in 1969-70 to 53 students in 1973-74. The new undergraduate subject in mammalian physiology was completed by 83 students.

Outside of formal classwork with undergraduate students, the Department's faculty have been active as advisors to undergraduate thesis students, U. R. O. P. students, and premedical, freshman, and sophomore students -- a total of 367 students.

Graduate Education

The Department's graduate student enrollment continues to grow, from 108 in September, 1972, to 111 in September, 1973, and an expected enrollment of 125 in September, 1974.

In response to the Endicott House meeting and the advice of the Department of Nutrition and Food Science Visiting Committee, three separate task forces have been set up to review intensively the present programs and future directions of the Department. This will be a critical examination, to be discussed by the entire faculty in October, 1974; it will include specific recommendations. As graduate education is interwoven inextricably with research as well as teaching, senior graduate students will serve on all three task forces. The three task forces will cover: 1) food science and technology and biochemical engineering; 2) nutritional biochemistry and metabolism and toxicology; and 3) the emerging role of the Department in undergraduate education at M. I. T.

Conference, Symposium, and Summer Courses

On September 25, 1973, the Eleventh Annual Underwood-Prescott Memorial Lectureship was presented to Walter A. Mercer, Director of the Western Research Laboratory of the National Canners Association and vice-president of the Association, for his outstanding work on the reuse of water in food production. A symposium, Ecology, the Environment, and the Food Industry: New Horizons and Hazards in Resource Management, was held in Kresge Auditorium in conjunction with the presentation of this lectureship; there was a large attendance from many universities, sectors of government, and industry.

During December 2-6, 1974, an International Conference on Nutrition and Agricultural and Economic Development in the Tropics will be held at the Institute of Nutrition of Central America and Panama (INCAP) in Guatemala City, with the assistance of the Department of Nutrition and Food Science and other organizations.

Four one-week courses were held during the summer of 1973 which helped to maintain the close ties of the Department with industry's training needs. The courses and their attendance follow.

1. Enzymes and Their Use in Analysis and Clinical Diagnosis
Directors: Professors Jean-Pierre Flatt and George Wolf
Attendance: 32
2. Fermentation Technology
Director: Professor Daniel I. C. Wang
Attendance: 56

3. Physical, Chemical, and Biological Aspects of Food Deterioration
Directors: Professors Samuel A. Goldblith and Marcus Karel
Attendance: 47
4. Advances in Human Nutrition Knowledge
Director: Professor Vernon R. Young
Attendance: 31

This summer (1974) six one-week courses will be offered:

1. Enzymes and Their Use in Analysis and Clinical Diagnosis
Director: Professor Wolf
Dates: June 24 - 28
2. Advances in Human Nutrition Knowledge
Director: Professor Young
Dates: July 22 - 26
3. Fermentation Technology
Director: Professor Wang
Dates: July 22 - 26
4. Properties and Reactions of Foods: Nutritional and Quality Implications
Directors: Professors Karel and Goldblith
Dates: July 29 - August 2
5. Experimental Pathology and Toxicology
Director: Professor Paul M. Newberne
Dates: August 12 - 16
6. Engineering Lower Food Prices -- Technological Needs in Food Distribution
Directors: Senior Lecturer Gordon F. Bloom (Sloan School of Management)
and Professor Goldblith
Dates: August 19 - 23

Personnel

Promotions within the Department during the past year were: Dr. Ronald C. Shank to Associate Professor of Food Toxicology; Dr. George Wolf to Professor of Physiological Chemistry; Dr. F. James Levinson to Assistant Professor of International Nutrition; and Dr. William M. Rand to Associate Professor of Biostatistics.

New appointments during the past year were: Nicholas Catsimpoilas, Associate Professor of Physical Biochemistry; Charles S. Davidson, Visiting Professor of Medicine and director of the Clinical Research Center; Dr. John D. Fernstrom, Assistant Professor of Nutritional Biochemistry and Metabolism; Dr. Leif Hambræus, Visiting Professor of Human Nutrition; and Dr. Cho Kyun Rha, Associate Professor of Food Process Engineering.

Faculty members leaving by the end of the academic year were Visiting Professor Zeki Berk, Professor Jean-Pierre Flatt, Visiting Professor Leif M. Hambræus, Visiting Professor Isaias Raw, Visiting Professor Dewey D. Y. Ryu, and Visiting Professor Donald B. Zilversmit.

Professor Steven R. Tannenbaum was on sabbatical during this past academic year; he served as Visiting Professor of Food Science, Faculty of Agriculture, the Hebrew University

of Jerusalem, where he helped to reorganize the Department of Food Science and Technology.

Awards

Professor Charles S. Davidson, Visiting Professor of Medicine, Director of the Clinical Research Center, and William Bosworth Castle Professor of Medicine at Harvard Medical School, was awarded a Mastership in the American College of Physicians. Professor Fernstrom was named the Alfred P. Sloan Foundation Fellow in Neurobiology for two years. Professor Goldblith was appointed a public trustee of The Nutrition Foundation, Inc., and public member of its Executive Committee. Professor Hamish N. Munro was elected to membership in the National Academy of Sciences. Professor Nevin S. Scrimshaw received an honorary Doctor of Science from the University of Rochester Medical School, his medical alma mater. Dr. William G. Thilly received from M. I. T. the Everett Moore Baker Award for outstanding undergraduate teaching. Professor Richard J. Wurtman received the Ernst Oppenheimer Prize of the Endocrine Society for significant endocrinology work by a person under 45 years of age; he also was named the Foster Elting Bennett Lecturer of the American Neurological Association.

Clinical Research Center

This past year was one of continued expansion and increasing utilization of the Clinical Research Center (C. R. C.). The procedure room, equipped as a noninvasive cardiovascular monitoring facility, was used heavily by the M. I. T. Arteriosclerosis Center. Approximately four patients per week were subjected to analysis of leg pulse form and exercise electrocardiography. These studies were done in conjunction with the project on regression of arteriosclerosis following diet and drug treatment for hyperlipidemia.

Because of its steady increase in size and number of persons involved, a separate but contiguous and interrelated Arteriosclerosis Center has been established by Professor Robert S. Lees. Professor Lees relinquished his position as director of the C. R. C. because of increased demands on this program and the additional responsibilities of the Noninvasive Diagnostic Laboratory at the Massachusetts General Hospital. Professor Scrimshaw assumed the position of acting program director of the C. R. C. , until Professor Davidson took charge as the new program director on January 1, 1974. Dr. Carl Apstein, the C. R. C. 's assistant director, left in May, 1973, to join the Boston University faculty as Assistant Professor of Medicine. His position as assistant director was filled by Dr. P. K. George, an internist, and Dr. William P. Steffee, an internist/nephrologist, who were appointed co-assistant directors of the C. R. C. The number of research patient days of Center care furnished to discharged patients was 2,244, with an average length of stay of discharged patients of 12 days. Assignment of trainees to the C. R. C. facilities included 30 interns for one year, 25 postdoctoral fellows for two years, and four medical students for three months each. Seven preclinical and eight clinical investigators used the C. R. C. , working on 12 projects begun earlier and initiating 10 new projects.

Further progress has been made on the computer system which handles patient data for storage and retrieval for research purposes on the C. R. C. 's PDP-12 computer. Several new computer programs have been written as part of a renewed, intensive effort to provide automated assistance to all aspects of the C. R. C. 's functions. Details of all protocols studied within the unit are preentered into the computer, so that positive control can be maintained over administrative procedures, diet formulation and calculations, sample distribution, automation of laboratory methods, data analysis, and summary. Primary emphasis has been directed toward serving the investigator in a manner that will provide him with direct access to updated information related to all of the above parameters.

Administration

After 19 years of executive service in the Department, Professor Goldblith will devote half of his time to the Institute as director of the Industrial Liaison Office, and the other half to the Department of Nutrition and Food Science as Underwood-Prescott Professor of Food Science, effective September 1, 1974. On this date, Professor Karel will assume the duties of deputy Department head.

NEVIN S. SCRIMSHAW

Department of Physics

The events of the past year have indicated that the recent decline in the choice of physics as a field of study has ended and that a modest growth is now under way. At the graduate level the student population, which is controlled almost entirely by the availability of funds, remained about constant, but the number of students declaring physics as an undergraduate major was increased substantially. The number of degrees awarded during the academic year was: 83 Bachelors of Science, eight Masters of Science, and 37 Doctors of Philosophy.

During the summer of 1973, a special Departmental faculty-student task force, headed jointly by Professors Rainer Weiss and Lee Grodzins, began an intensive study of undergraduate physics education at M. I. T. The task force continued its work into the academic year, and produced a detailed report. Its main recommendations concerned: 1) an increased emphasis on physics as a science of the real world, rich in laboratory and observational experience; 2) the development of more effective ways of fostering close intellectual ties between students and faculty; and 3) the creation of a vigorous physics community within M. I. T. Considerable progress in implementing these recommendations already has been made, including (with budgetary help from the administration) plans for the establishment of an undergraduate physics complex embracing laboratories, classrooms, offices, and informal meeting areas.

Following the completion of the undergraduate study, the Department has begun a similar review of its graduate educational programs.

Since its inception in 1957, the research journal, Annals of Physics, has had its home in the Department of Physics. The journal's editorial offices have been located in the Center for Theoretical Physics, and it has been under the continuous editorship of Professor Philip M. Morse, with Professors Herman Feshbach and Bernard T. Feld (plus Professor Richard Wilson of Harvard University) as assistant editors. In 1973, the responsibility for the pedagogic publication, the American Journal of Physics, also came within the Department, when the editorship of the Journal was taken over by Edwin F. Taylor, Senior Research Scientist in the Department of Physics, with the help of Professor Anthony P. French, Consulting Editor. (For further details, see the report of the Provost.)

Research

Astrophysics

The principal areas of interest in this field have continued to be radio, infrared, and X-ray astronomy, astrophysical plasmas, and high-energy problems. However, a growing interest in optical astronomy led to a design study for a 120-inch telescope.

Observations of X-ray sources from the OSO-7 satellite included the X-ray star Her X-1, the supernova remnant IC 443, and Cygnus X-1 (in which a sudden absorption dip favored the identification of this source as a black hole). An advanced photon-counting system was used to look for optical counterparts of rapid periodic variations in several X-ray sources. Preparation for future satellite work included the completion and delivery to Goddard Space Flight Center of a flight unit for the M. I. T. X-ray observatory on SAS-C (scheduled for launching in 1974). Development of an associated optical spectroscopic system for faint stars was begun. On a more distant time scale, preparations are under way for two very large X-ray satellites, HEAO-A and HEAO-B, scheduled for launch in 1977.

The continuing sounding-rocket program has emphasized measurements on soft X-rays (0.15-1.5 keV); a survey was completed of one-third of the galactic plane (from Cygnus to Norma) and the X-ray structure of the Cygnus Loop. A survey of the Large Magellanic Cloud is in preparation.

The infrared astronomy program has been partly ground based, using conventional telescopes with cooled bolometers and image tubes, and partly balloon borne. At least six new H II regions were discovered with a balloon borne far-infrared bolometer (50-350 μ). A large-aperture bolometer, used (in collaboration with the Smithsonian Astrophysical Observatory) at the 50-inch telescope at Kitt Peak National Observatory, detected a new, extended source at the nucleus of M82 and another cold nebula near M17; confirmed a bright, previously unidentified source in the AFCRL catalogue; and was used in observations of NGC 7027 and Comet Kohoutek.

Radio astronomy has included both galactic and extragalactic work. Additional evidence has been obtained for maser action in interstellar gas clouds, in one instance (V1057 Cygni) involving an unprecedentedly strong magnetic field (1.5 milligauss). A search has failed to reveal any red-shifted absorption lines for the 21-cm H radiation from quasars, despite abundant optical absorption. It was concluded that the absorbing gas clouds are close to the quasars.

A new program for observing nonthermal radio properties of galaxies has examined about 400 galaxies at 11-cm wavelength, and detected radio sources in more than half of them. Similar measurements indicate an enhanced volume emissivity from the interstellar gas in the neighborhood of the sun, perhaps corresponding to density conditions at the inner edge of a galactic spiral arm.

In the study of interplanetary plasma, the most notable achievement was a set of measurements obtained in the Mariner Venus-Mercury fly-by (a first in the case of Mercury). Theoretical studies of space plasmas have been based largely on space-probe data, but also have included purely theoretical studies of magnetohydrodynamic waves, magnetic merging processes, and models of the magnetosphere.

In high-energy astrophysics, theoretical work has emphasized the problems associated with X-ray sources, and explanations that do not involve the assumption of black holes.

Experimental Nuclear and Particle Physics

The research activities of the members of the Division of Nuclei and Particles* have continued very actively and productively, despite the pressure of budgetary stringencies. Research and technical development were carried out in the broad fields of nuclear reaction and heavy-ion physics, medium-energy physics, and high-energy particle physics.

* See also the report of the Laboratory for Nuclear Science, under whose aegis much of the research of members of the Division is carried out. That report contains a more extensive discussion of this work and many of the details of the program which are not covered here.

Notable accomplishments and results were achieved this year in many aspects of the overall program; among the highlights are the following.

1. Nuclear Reaction and Heavy-Ion Physics An experiment at Brookhaven National Laboratory on the fusion of heavy ions led to the discovery of several resonant states in the collision of carbon nuclei upon carbon nuclei. These states have a very high angular momentum, and may open up a qualitatively new class of nuclear structures.
2. Medium-Energy Physics The Bates Linear Accelerator has operated up to 400 MeV, and the first experiments are under way. Preliminary data has been gathered on an experiment on photo pion production near threshold. The 250-ton magnet for the energy loss spectrometer has been checked out, and meets all specifications. The inelastic electron scattering studies of nuclear structure, for which this device was constructed, will begin in the fall of 1974.

One of the first programs will be a series of measurements on the deformation of heavy nuclei; this is an extension to higher energies and higher resolution of a program originally undertaken by the M. I. T. group in collaboration with a group at the National Bureau of Standards, using the NBS linear accelerator.

3. High-Energy and Particle Physics Various groups are all in the data-acquisition phase of several experiments directed toward elucidation of elementary-particle dynamics and systematics. This work is proceeding at most of the major accelerators around the world. At Brookhaven National Laboratory, there is an ongoing experiment on heavy meson formation and mu-electron universality. At the National Accelerator Laboratory, experiments are being carried out on elastic and quasi-elastic scattering of hadrons; the study of the multiplicity distribution of particles produced in collisions with nuclei; and finally, utilizing a bubble chamber and auxiliary electronic detecting equipment to tag particles in a study of diffractive excitations of hadrons. At the Stanford Linear Accelerator, there is an experiment on the deep inelastic scattering of electrons, which is part of an effort to detect possible substructures in the nucleon. At CERN (the European Organization for Nuclear Research), two experiments on the intersecting storage rings are in progress. One is a study of correlations between particles emitted in high-energy proton-proton collisions, and the other is a study of low-energy particles emitted at 90° to the colliding beams of protons.

Most of these efforts are part of ongoing programs of research at the forefront of particle physics. Results from most of these experiments will emerge during the coming year.

Nuclear and Particle Theory

In particle theory, considerable work has been done on a new "extended" hadron model which incorporates some of the desired features of the earlier quark, parton, and dual models. The new class of models (the "bag") provides for a simple, classical way of confining quark-parton fields inside physical hadrons and thereby accounts for the nonobservance of free quarks or partons. At the same time, the constituent fields are free (or nearly so) inside the hadron. The interaction takes place only at the "walls" of the hadron (which in these models is made out of the constituent fields). Hence the scale dimension for current structure is set by the size of the hadron in a manner consistent with parton scaling results. The extended hadron has infinitely rising Regge trajectories, and a composite structure in qualitative agreement with the ideas of dual models. Work is under way on the development of a consistent relativistic quantum field theory for these systems, which so far have been studied only in semiclassical approximation. These calculations have been very encouraging. For example, the static parameters of the proton have been calculated (magnetic moment, g_A , etc.),

and results accurate to 10-20 percent have been obtained in the crudest approximation to the equations.

In strong interaction Regge dynamics, an understanding of how to calculate discontinuities across Reggeon-Reggeon cuts has been obtained which provides a clarification of the role that cuts play for scaling in inclusive processes and in the total cross-section. Other work in the area of strong interactions has included analysis of the diffractive dissociation experiments carried out by the experimental high-energy group at M. I. T.

In the area of field theory and parton models, analysis has been made of scaling behavior in the ratio of longitudinal to transverse virtual photo-absorption cross-sections.

Finally, the Department's effort during the past year has included a study of dynamical models of symmetry breaking in the context of field theory. The goal is to understand the observed pattern of symmetries in both weak and strong interactions in the context of an underlying field theory based on gauge invariant interactions, which is a very restrictive framework.

In the theory of nuclear structure, work has continued (Orsay collaboration) on self-consistent calculations of collective nuclear properties, in particular mass values. Relativistic Hartree-Fock calculations are being used to calculate effective nuclear charge distributions for use in the analysis of elastic electron scattering experiments.

Many features of nuclear reaction and scattering theory have been investigated. This work has included the study of quasi-equilibrium processes, random coupling models, and (Wisconsin collaboration) the effect of compound nucleus fluctuations in the final state of a direct reaction. In connection with the Bates Linear Accelerator program, an analysis technique has been developed for separating collective excitations from the quasi-elastic peak in electron scattering. Reexamination of scattering and muonic X-ray data indicates the adequacy of presently used wave functions.

Continued work on the pion-nucleus interaction has included optical model calculations of double charge exchange (Los Alamos collaboration); investigation of the pion two-nucleon interaction for purposes of reactions and elastic scattering; and the investigation of off-shell and correlation effects in the optical model, using a local density approximation. A coupled-channel separable potential model has been developed which gives the off-shell πN transition matrix directly from the measured elastic phase shifts. The effects of using such a "realistic" off-shell extrapolation have proved substantial for the zero-energy optical potential (applicable to pionic atoms), and a similar investigation presently is being carried out near the 3-3 resonance. A natural extension of the model will be incorporated into the optical potential of many-body effects arising from the intermediate propagation of excited mesons.

It has been shown that experimental data obtained at Saclay on the interaction of high-energy protons (1 GeV) with nuclei can be explained, using nuclear charge and matter densities obtained at M. I. T.

Solid-state, Laser, Plasma, and Atomic Physics

Studies of a variety of condensed-matter systems have continued. The technique of Brillouin scattering has been used in liquid helium-4 to measure the dynamic structure factor, $S(k, \omega)$, at temperatures sufficiently close to the λ transition so that conventional hydrodynamic theories no longer apply. Current theories of the dynamics in the critical region are unable to explain these results. This work may lead to new insights into the problem of the dynamics of critical fluctuations.

The magnetic equation of state for the Heisenberg ferromagnet EuS near its critical point has been determined experimentally. The scaling hypothesis is confirmed; the data fits the parametric equation of state proposed some years ago by Schofield, Litster, and Ho.

The existence of an order-disorder phase transition in a two-dimensional monolayer of pentadecylic acid on the surface of water has been demonstrated. Many isotherms have been measured; they have a shape similar to those of the Van der Waals gas. This work is the first clear evidence for a two-dimensional phase transition in monolayer systems, and it opens a new area of investigation in critical phenomenon problems.

In the neutron scattering program at the M. I. T. Research Reactor, polarized neutrons have been used to study the diamagnetic magnetization density in bismuth (Bi) metal. The magnetic properties of Bi (which is exceedingly diamagnetic) have been puzzling for many years. This work may help to clarify the electronic properties of this remarkable crystal.

A program of research on superconducting tunneling has as its general goal the identification of a consistent set of quantities by which to characterize the basic electronic properties of superconducting materials. This work has focused on the phonon spectra and other properties of high-temperature superconductors such as niobium (Nb) and some of its alloys.

Laser research has included the introduction of microelectronic techniques for obtaining frequency mixing with arrays of point-contact diodes; the first observation of Dicke super-radiance in the optical region; and the development of a new Raman spin-flip laser for spectroscopy in the 5μ region.

Work on atomic beams included studies of the Van der Waals molecule KAr and the use of Stark mixing spectroscopy to study excited states of atomic cesium. Reduction of Doppler broadening through the use of an atomic beam at right angles to a laser beam has given an improvement of several orders of magnitude in two-photon spectroscopy.

At the Francis Bitter National Magnet Laboratory (the report of q.v.), a major program concerning the properties of plasmas created and heated by carbon dioxide lasers is under way. In a recent, crucial experiment it has been shown that such plasma columns have a reduced density on-axis, and hence will focus laser beams. This condition is a necessary one for the achievement of fusion via carbon dioxide laser heating. Work on far infrared generation continues. In recent experiments, continuous-wave, nonlinear mixing has been demonstrated.

Also in plasma physics, the main objective of the Alcator experiment -- that of containing plasmas carrying high currents -- has been achieved. Plasma currents of 200 kiloamperes have been obtained in a circular cross-section of 18 cm diameter. These current densities exceed the previous record by a factor of four. A magnetic field of 55 kilogauss was used in these measurements; higher current densities are expected with higher DC fields. Several laboratories throughout the world presently are building devices patterned after Alcator.

Two more toroidal plasma experiments have been brought to operation. The first (Versator) was made from spare Alcator parts, and demonstrates the feasibility of simple, but meaningful toroidal plasma experiments at low cost. This experiment has attracted widespread interest. The second machine, Rector, features a rectangular cross-section, and will be used to study plasma equilibria in noncircular geometries. Theory suggests that this configuration may be especially advantageous for confinement purposes.

The 3° Kelvin cosmic background radiation in the spectral range 0.8-3 mm has been studied in high-altitude balloon experiments. The radiation has been found to be isotropic to 0.1 percent, giving an upper limit of 300 km/sec for the speed of the solar system relative to the universe at large.

The molecular microscope project has proceeded to the construction of a second-generation prototype. A resolution of 1μ is expected. This instrument will be used to investigate biological and semiconductor surfaces.

Personnel

The following faculty members received promotions during the year: to tenure, Professors Eric R. Cosman, Thomas J. Greytak, and Roman W. Jackiw; to professor, Professors Daniel Kleppner and Walter H. G. Lewin; to associate professor, Professors E. Victor George, Jochen Heisenberg, Margaret L. A. MacVicar, and Robert J. Taylor.

New faculty members in the Department will be Professor Elliott H. Lieb (a joint appointment with the Department of Mathematics) and Professors George Brandenburg, Claude Canizares, Robert Jaffe, and John Joannopoulos.

Visiting faculty during the year were Professors Hall Crannell, Ronald Mickens, Gian-Carlo Setti, Ramesh D. Sharma, George Siscoe, Michael Kirson, and Julius Kuti.

This year saw the retirement of Professors Victor F. Weisskopf and George E. Valley. Professor Weisskopf first came to M. I. T. as a professor in 1945, and served as head of the Department from 1967 to 1973. He was on leave as director-general of CERN (European Organization for Nuclear Research) from 1961 to 1965. Under his leadership the Department gained greatly in strength and intellectual prestige. Professor Weisskopf was made an Institute Professor in 1966, and his contributions to M. I. T. and to society were recognized further when he became the first Killian Award recipient in 1973.

Professor Valley was a staff member of the M. I. T. Radiation Laboratory from 1941 to 1945; he became an assistant professor in the Department of Physics in 1946, an associate professor in 1949, and full professor in 1957. Between 1951 and 1957 he served as assistant director and then associate director of the M. I. T. Lincoln Laboratory. More recently, he became concerned chiefly with undergraduate education at M. I. T., serving for two years as Institute Undergraduate Planning Professor and then, from 1969 until his retirement, as director of the Experimental Study Group.

The Department lost through resignation the services of Professors Steven Weinberg and Charles T. Grant.

During the year, Professor Ali Javan was elected to membership in the National Academy of Sciences, Professor John G. King was appointed Francis L. Friedman Professor of Physics, and Professor H. Eugene Stanley was named Helmholtz Associate Professor under the auspices of the Harvard-M. I. T. Program in Health Science and Technology.

HERMAN FESHBACH

Spectroscopy Laboratory

The main accomplishments and events of interest in the Spectroscopy Laboratory in the past year were as follows.

With the shipment of the M. I. T. 24-inch interferometrically controlled ruling engine to its installation point at Kitt Peak National Observatory, the grating-ruling project of Professor George R. Harrison has been completed, after 25 years of increasingly successful operation. When the project was begun in 1947, diffraction gratings were limited to ruled widths of eight inches, and possessed many optical shortcomings. Professor Harrison's application of

interferometric control to the ruling process has resulted in increases in resolving power, dispersion, light-gathering power, and purity of spectrum by factors ranging from 2 to 100. His gratings have been ruled as master gratings, and replicas made from them currently are in use throughout the world in astronomical, physical, chemical, and metallurgical laboratories. Continued operation of the 24-inch engine at Kitt Peak and the 16-inch M. I. T. engine now ruling controlled gratings at the Bausch and Lomb Optical Company will assure the scientific community of the availability of these master gratings for many years to come.

Professor Richard C. Lord and his group continued their studies of biological high-polymers by laser-Raman spectroscopy. Denaturation of the enzymes lysozyme and ribonuclease in aqueous solution by various chemical reagents produces changes in the structures of these proteins that can be followed for the first time by the Raman effect. Substantial progress has been made in measuring the relative amounts of helical, pleated-sheet, and random structures produced by denaturation. Application of the Raman technique to the systems neurophysin-oxytocin, block copolymers of synthetic polypeptides, and collagen have been undertaken in collaboration (respectively) with Professor Esther Breslow of Cornell Medical College, Professor Gerald Fasman of Brandeis University, and Professor Ioannis V. Yannas of the Department of Mechanical Engineering.

In the research of Professors Ali Javan and Michael Feld and their associates, considerable success has been attained in the determination of collision cross sections by laser saturation spectroscopy. A study was made of the velocity dependence of collision cross sections for molecules of a gas at room temperature. The interaction between a strong laser field and molecules having a velocity sufficient to Doppler-shift the laser field into resonance produces a nonlinear feature in the absorption profile of the molecules corresponding to molecules with a given component of velocity along the laser propagation direction. The feature is probed with a weaker laser field traveling in the opposite direction from the strong field and tuned to a frequency such that molecules interacting with the strong field also see the weak field Doppler-shifted into resonance. By utilizing different frequency shifts between the saturating and probe field (obtained in these experiments by acousto-optic modulation), collision processes can be examined as a function of molecular velocity. This method has been used to study the collisions between NH_3 molecules and other molecules, in order to investigate the intermolecular forces involved in the collisions.

A tunable source of high power at 5μ has been designed and built with a supercooled crystal of InSb and a CO laser as a pump to form a spin-flip Raman laser. In such a laser, the frequency of the light emitted by the crystal when it is irradiated by the CO pump depends on the strength of the magnetic field in which the crystal is located. A compact and efficient method of changing the magnetic field was devised with a permanent magnet having tapered pole pieces mounted on a movable platform. By changing the relative position of the magnet and the crystal, the radiation frequency can be tuned enough to cover the range between adjacent CO laser lines. Then, by switching the pump to another line, most of the region over which the CO laser oscillates can be covered. Use of a permanent magnet has obviated the need for costly and clumsy electromagnet or superconducting magnet systems. The device already has been used to do linear spectroscopy in NO, and work is currently under way on water vapor.

The first observation of "Dicke super-radiance," the coherent evolution of a strongly radiating state from an initially inverted population, was reported last year in experiments in which an HF laser was used to produce a population inversion on several infrared rotational transitions in an excited vibrational state of HF by optical pumping from the ground vibrational state. More detailed experimental studies have been conducted for comparison with a theory developed at M. I. T. which accounts for the effects of propagation on this transient emission process. Systems other than HF also have been considered for possible super-radiance schemes. A thorough understanding of this phenomenon is important because of its potential applications

in short-pulse generation, photon detection, and other areas.

Professor Jeffrey Steinfeld and his group have been concerned mostly with the applications of laser methods to high-resolution spectroscopy and molecular relaxation processes. A principal effort has been in the area of coherent optical transients in the microwave and infrared regions. The application of either a fast infrared pumping pulse or a sudden change in applied electrostatic field to an absorbing molecular system results in nutation effects on the absorption line. The decay of these transients reflects the T_1 and T_2 relaxation times of the transition, which in turn can be related to molecular collision processes. A tunable optical parametric oscillator ($\Delta\nu \sim 0.002 \text{ cm}^{-1}$) is being used to probe the infrared absorption line shapes of molecular gases at pressures up to 100 atmospheres, in order to test various theories of line broadening. A "jet-stream" tunable dye laser has been constructed with a bandwidth less than 0.1 angstroms, which will be used in optical double-resonance spectroscopy of complex band systems. In a related project, absorption coefficients at selected CO_2 laser lines are being determined for a variety of molecular gases, for the purpose of developing a trace gas contamination monitoring system based on laser-line absorption measurements.

Guests of the Spectroscopy Laboratory who took part in its research activities during 1973-74 included Professors David F. Eggers, Jr., of the University of Washington, Evan B. Carew of the University of Michigan, Ralf Steudel of the Technical University of Berlin (TUB-M. I. T. Exchange Professor), and Thomas B. Malloy, Jr., of Mississippi State University. Post-doctoral fellows included Noel Relyea of Cornell Medical School, Hiromu Sugeta of the University of Tokyo, and Michael C. Chen of the Department of Chemistry.

RICHARD C. LORD

George R. Wallace, Jr. Astrophysical Observatory

The George R. Wallace, Jr. Astrophysical Observatory is an active teaching facility and 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 telescope and to process data on-line, and a support building.

The Observatory is overseen by a steering committee, appointed by the Dean of Science and chaired by Professor Thomas B. McCord of the Department of Earth and Planetary Sciences. The committee members are Professors Alan H. Barrett, Bernard F. Burke, George W. Clark, Herbert W. Schnopper, and Susan G. Kleinmann, all of the Department of Physics; Robert A. Alberty, Dean of the School of Science; Bruno B. Rossi, Institute Professor of Physics, Emeritus; and Professor Irwin I. Shapiro of the Department of Earth and Planetary Sciences. Professor Herbert S. Bridge of the Department of Physics, Associate Director of 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.

An addition to the staff of the George R. Wallace, Jr. Astrophysical Observatory is Andrew Tomer, who functions as site manager and technical assistant to the chief engineer, Grant Snellen.

The Observatory is equipped with a 24-inch and a 16-inch cassegrain-coude telescope. The 16-inch telescope is used primarily for equipment testing and teaching. The 24-inch telescope is used for student projects, scientific research, and equipment testing when necessary. Both telescopes are used routinely. In addition to these two instruments, Michael Jordan

made a gift to the Observatory of a 10-inch reflecting telescope. An undergraduate student in the Department of Earth and Planetary Sciences currently is engaged in building a dome for this telescope. When it is installed on the platform, it will be used by Professor William H. Pinson of the Department of Earth and Planetary Sciences for his introductory astronomy subject. This telescope also will be available for use by other members of the M. I. T. community.

The computer control system for the 24-inch telescope has been constructed and installed at the Observatory. It is interfaced with the telescope and has been operational since the official turn-on ceremony of January 18, 1974. This newly designed telescope control and data-handling system operates the 24-inch telescope and its auxiliary instrumentation completely on-line. Designed to be operated easily by observers, this system automatically points, tracks, and scans objects, and handles and processes incoming data in real time. Observers are able to evaluate reduced data while their observing program continues. A closed-loop television monitor and guiding system has been developed. This enables observers at the computer to view the field of the telescope before and during the observation at the telescope. An automatic telescope dome controller which makes no use of computers also has been developed.

The 16-inch telescope is being reconstructed to improve the drives and to make it more reliable and easier for observers to use. The computer control room has been refurbished and rearranged, and two disk drives are being installed. All telescope optics are being recoated, and a chopping secondary mirror is under construction. This special mirror will be used for special infrared observations.

George R. Wallace, original benefactor of the Observatory, has made an additional gift earmarked for the construction of an infrared photometer system, and a silicon vidicon and intensified vidicon photometer system for the use of observers. The infrared photometer system has been constructed, and is available for use by visiting astronomers. The silicon vidicon and intensified vidicon photometer system is still under construction.

THOMAS B. MCCORD

Graduate School

The past academic year has seen an important reorganization of the Graduate School, accompanied by a modest growth in the total number of its students. Special attention has been devoted to problems and opportunities represented by certain groups of students; these include foreign, minority, women, and special (nondegree) students. As a result, some progress has been made in the improvement of graduate education for these categories of students. The Graduate School has had to cope with the severe financial straits of a great many graduate students. The deterioration in Federal fellowship support for graduate students in the United States has had a special impact upon M. I. T., which has enjoyed many Federal fellowships and traineeships over the past 15 years. Accompanying this fellowship loss has been a sharp escalation in the educational expenses of the student, due both to tuition increase and to an escalation in living expenses related to the inflation in the economy. To counteract the deleterious affects of these developments partly, the Graduate School has looked for non-Federal fellowship support, and with the cooperation of the Student Financial Aid Office, has made loans available; it also has developed a government supported work-study program for needy students.

Accompanying this financial strain on the typical student has been a rededication to scholastic pursuits, including thesis research. This trend is borne out by the fact that in the past academic year, M. I. T. 's Graduate School has been rated, by several indices, at the very top in terms of quality of faculty and academic programs. A happy by-product of this reputation is that M. I. T. students, upon receiving graduate degrees, are enjoying considerable success in finding jobs at excellent salaries.

The nature of graduate education continues to shift in the direction of becoming less rigid and structured in terms of course requirements, and is becoming broader and more interdisciplinary in scope. Students are less likely to pursue basic research for its own sake and are more interested in seeing it applied ultimately to the solution of societal problems. The interests of many students now cross departmental boundaries. To meet these needs, new interdisciplinary programs have been developed which lead to Master of Science, Engineer, and Doctor of Philosophy degrees.

Enrollment of Graduate Students

The enrollment of graduate students at M. I. T. has remained quite stable since 1965, despite the Vietnam War, Selective Service, economic depression, unemployment, and decline in financial support for students. In 1965 enrollment was 3,200, and by 1973 it had risen to 3,358, a modest increase from the previous year (see Table I). In addition to these regular students, there were 417 special graduate students in 1973, an appreciable increase from the figure of 339 in 1972. Forecasts (based on an increase in applications of seven percent) for the fall of 1974 suggest a small (two percent) increase in the number of regular graduate students. Most private universities are in a no-growth or diminishing size situation with regard to graduate students. Reasons for no-growth are primarily financial; the high cost to students, and the fiscal problems of the private university have brought this about. In contrast, the state universities (with low tuition and government support) have continued to grow in graduate enrollment at the rate of five percent per year. Compared

with other private universities, M. I. T. has fared relatively well, and can anticipate continued modest growth in graduate enrollment in the future. This success will have to be coupled with the ability to generate additional student support in the form of teaching and research assistantships, fellowships, and work-study opportunities.

Fellowships, Scholarships, and Assistantships

Federal graduate fellowships and traineeships have continued to decline in numbers, and in the past academic year the National Science Foundation (NSF) traineeships and the National Defense Educational Assistance fellowships have been phased out completely. Still in effect are NSF fellowships, primarily in science and engineering, and National Institutes of Health (NIH) traineeships in the health sciences. Compared with 1968, when Federal fellowships supported about 800 graduate students, the past academic year showed only about 390. In round figures, this represents a loss in Federal fellowship support for graduate students of approximately \$3.0 million. In the coming academic year, the number of Federal fellowships may decrease even further. Information on graduate student support is summarized in Tables III-A, III-B, and IV.

The impact on the Graduate School of the precipitous decrease of Federal fellowships is a matter of grave concern to M. I. T. On an emergency basis, the administration has allotted graduate fellowships in science and engineering from the Sloan Basic Research Fund. During the past academic year, 40 such fellowships were established. Since the income from this fund is primarily for faculty research, this fellowship program will have to be terminated next year with the award of 33 Sloan fellowships. A special challenge for the future will be for the Graduate School to generate new sources of funds to replace the lost Federal and Sloan fellowships.

Industrial, foundation, and private graduate fellowships prior to 1974 had decreased some 60 percent, in large part because of the recent recession. In an attempt to replace this loss, the Graduate School has urged each department, with the cooperation of the Development Office, to attempt to raise additional fellowships through their direct contacts with industry. This effort has enjoyed rather modest success, and only a few such fellowships have been generated. The Graduate School, with the help of the administration, also has devoted major attention to this problem and has raised money from industry, foundations, and private individuals to support 15 new fellowships. Since most of these fellowships are renewable, this will represent an added income of approximately \$120,000 per year for student support.

Assistantships constitute one of the most desirable forms of support for graduate students, since they also contribute to the assistant's education and training in research. About one-half of the student population is supported by assistantships; during the past year, some 1,073 students served as part-time research assistants, and 502 were employed as teaching assistants. Stipends paid to such students cover full tuition and most, if not all, of the students' living costs. While large state universities employ more teaching assistants than M. I. T., there is no university in the world which supports more graduate students as research assistants. This, of course, is a result of the large volume of research supervised by the faculty of M. I. T. The amount of sponsored research is expected to increase in the coming year, and this should make possible a further modest increase in the number of research assistants.

Since many graduate students look forward to academic careers, they enjoy extracurricular opportunities to sharpen their teaching skills as tutors. During the past year, some 50 graduate students lived in the undergraduate dormitories as resident tutors. This tutorial system not only provides room and board and teaching experience for graduate students, but is viewed by undergraduates as a valuable adjunct to their formal education in the

classroom.

A new type of student support, in the form of the Federal work-study program, became available during the 1973-74 academic year. In this program, financially needy citizens can be employed for up to 20 hours per week as teaching or research workers, with 80 percent of their stipends paid from a Federal grant. This work-study program, administered jointly by the Student Financial Aid Office and the Graduate School, will be continued at a level of funding in the coming year of \$245,000.

Practically all students who can demonstrate financial need are eligible for loans arranged through the Student Financial Aid Office. Such loans amounted to about \$1 million during the past year. They are designed to take care of financial emergencies only, and cannot be used as the sole support of a graduate education.

It appears that despite all of the various ways listed above of providing partial or full support for graduate students, there remain about 15 percent who receive no financial help from M. I. T. These are self-supported or receive assistance from family or personal loans. Since costs for the typical graduate student are about \$8,000 per year (living costs plus tuition for 12 months), it is unrealistic to assume that the graduate enrollment will increase as a result of attracting more students who are willing to pay full costs "out of pocket."

A single bright spot on the horizon with reference to Federal fellowships is a new energy educational program sponsored by the National Science Foundation. These traineeships are designed to support graduate students who pursue theses in three energy fields: coal-oil shale, solar, and geothermal. M. I. T. was awarded 12 energy traineeships, and with Purdue University, leads the nation in this regard. Special recognition goes to Dean Ronald S. Stone, who prepared and submitted M. I. T.'s application for these fellowships.

New Interdisciplinary Graduate Programs

As the interests of the Institute, its faculty, and students have broadened, there also have developed corresponding new graduate programs to accommodate these new concerns. Instead of creating new departments, interdisciplinary laboratories have developed where staff and students with mutual interests can carry on research. Certain interdisciplinary areas for graduate study have received formal approval by the Committee on Graduate School Policy, and are supervised by standing committees of the faculty. These are the areas of oceanography, economics and urban studies, instrumentation, materials science, operations research, and biomedical engineering. Additions to this list in the past year have been environmental engineering, and urban studies and architecture; the latter program leads to joint master's degrees in the Departments of Architecture and of Urban Studies and Planning.

Preliminary approval has been given by a faculty study committee for a doctoral degree in the history, theory, and criticism of art, architecture, and urban form. This program, when approved officially, will be established primarily in the Department of Architecture, but will require the cooperation of other departments and the Boston Museum of Fine Arts. Still under study are interdisciplinary programs in artificial intelligence, education, astronomy, transportation, and energy. The latter is receiving attention in view of the development of a large laboratory for cooperative research relating to several aspects of the energy problem (the Energy Laboratory). The participation of graduate students in this endeavor will be facilitated by the availability of these new Federal fellowships in the field of energy.

Minority Graduate Students

Over the past six years, strenuous efforts have been made to increase the number of minority graduate students, and to provide them with special tutorials, counseling services, and financial assistance. As a result of this program, the number of minority graduate students has risen from 16 in 1968 to 152 in 1973. It is expected that this number will increase further in the fall of 1974; however, it cannot expand indefinitely unless new funds can be found to support more students. The recruitment of minorities has included black Americans, Mexican-Americans, Puerto Ricans, and American Indians. Asian-Americans already are well represented at M. I. T., and hence no special recruiting attention has been devoted to them. However, the special problems presented by the Asian-American student will be studied by a faculty committee in the fall of 1974.

The Minority Graduate Program was supervised ably by Dean Clarence Williams until January, 1974, when he left the Graduate School to become Special Assistant to the President and Chancellor for Minorities. Despite his new responsibilities, he will maintain his interest in minority students until Dean John Turner takes over as Assistant Dean for Minorities in September, 1974. Assisting Dean Williams is an Advisory Committee consisting of faculty, administrators, and students. During the past academic year advisors for minority graduate students were appointed for each department.

Recruitment efforts have been aided by the inclusion with the application for admission of a special card which makes it possible for the minority student to identify himself or herself, and thereby to receive special assistance from the Dean for Minorities. Of some additional use was a Minority Locator Service supplied by Educational Testing Services. During the year, administrators representing 35 black southern colleges visited the M. I. T. Graduate School. These colleges graduate 60 percent of all black students in the country, and could be a valuable source of graduate students. Administrators of these schools were urged to have their outstanding students apply to M. I. T. As a result of this effort, a number of these students will be attending M. I. T. in September, 1974. In this recruitment effort, special attention also has been devoted to M. I. T.'s own minority seniors. The special Fort Fellowship competition has proven to be a successful way in which to attract these students to the Graduate School.

Women Graduate Students

Despite the fact that M. I. T. has been coeducational since its founding, it has never been a place where women have pursued graduate study in large numbers. Slow growth in numbers has occurred recently, from 201 in 1967 to 302 in 1973. This increase reflects in part the greater interest of women in graduate study as well as the improvement in housing, athletic facilities, and extracurricular activities for women at M. I. T. In order to recruit more women and to give them special counseling and financial assistance, Jeanne Richard has been appointed Assistant Dean of the Graduate School with special responsibilities for women. Assisting Dean Richard in an advisory capacity has been a group of women faculty members. Attention has been devoted to the recruitment of women, an effort in which assistance has been afforded by women graduate students. A special fellowship for continuing women graduate students, the Collamore-Rogers Fellowship, was established to honor an outstanding student and to publicize the excellent opportunities for women graduate students at M. I. T. A special stimulus to the recruitment of women graduate students was provided by the gift of \$1 million by Cecil and Ida Green. Interest from this endowment initially will be used to provide fellowships for six outstanding new women graduate students in the coming academic year. One result of the attention now being given to women by the Graduate School and individual departments is an increase in expected enrollment to 12 percent (up from 9 percent in 1973).

Foreign Graduate Students

M. I. T. has assumed a significant role in education at the graduate level for students from most countries of the world. The number of foreign students now has stabilized at 28 percent of the total graduate student body. This figure may decrease slightly in the fall of 1974 because of the increasing difficulty posed for foreign students in meeting the inflated costs of higher education. In addition, the US State Department has placed severe restrictions on foreign students' accepting jobs in the summer. It is no longer possible to assure foreign students financial aid from M. I. T.'s own scholarships and assistantships, because of heavy demands made on these resources by United States citizens. Foreign graduate students are permitted to compete for unrestricted funds on an equal basis with domestic students, but unfortunately there is not sufficient aid available to meet the severe need. Employment of the foreign degree candidate poses a special problem, since many foreign students cannot find jobs back home. Hence, over half of them stay in the United States, contributing to a labor glut in this country and to the "brain drain" from their native land. The Offices of Career Planning and Placement, the Advisor to Foreign Students, and the Graduate School are well aware of this problem, but so far have not made any major progress toward its solution.

Graduate Student Affairs

The Graduate Student Council has devoted considerable time and attention to examining and redefining its functions, and the results of this study have led to the Council's complete reorganization. It now intends to play a more active role in the future in campus affairs. Its first major undertaking will be carried out in cooperation with the Offices of the Graduate School, the Advisor to Foreign Students, and the Dean for Student Affairs, and will consist of an all-day orientation program for new graduate students. During the past year, the Council also operated the Muddy Charles Pub, which has become a social center for graduate students, faculty, and friends. The Council worked closely with the Graduate School office in many ways; it has nominated students to serve on the Committee on Graduate School Policy and other faculty committees. Thus, graduate students have had a voice in academic, administrative, and extracurricular activities at M. I. T.

Housing

A major addition to graduate student housing occurred when the beautiful high-rise Tang Residence Hall came into use last year. Tang Hall provides apartment-style living for 400 single men and women. Ashdown House, the oldest residence on campus, is now undergoing extensive renovation. When completed in the fall of 1974, this dormitory will provide excellent housing for single students. Despite this significant progress, only approximately one-half of the students who wish to live on campus can do so. Hence, under the leadership of Vice President Kenneth Wadleigh, preliminary plans are being drawn up for another apartment-style building which would house both single and married students.

Academic Concerns

Despite the apparent preoccupation with numbers, the Graduate School's real concern is for the quality of graduate education at M. I. T. According to several yardsticks, the School is doing exceedingly well in this regard. In a survey of graduate professional schools, M. I. T. ranked among the top half-dozen in engineering, architecture, and management. In the National Science Foundation and the Hertz Foundation fellowship programs, M. I. T. was first in the number of fellowships received. In the new NSF Energy Program, M. I. T. received 12 traineeships (one university was awarded 13; most received 0 to 4). Another favorable index is the fact that an association of seven distinguished graduate school deans

recently has elected the Dean of M. I. T. 's Graduate School, Irwin W. Sizer, to membership.

In a survey of women accepted for graduate study which examined both students who enrolled at M. I. T. and those who went elsewhere, Dean Richard found that although the quality of education at M. I. T. was considered high, the critical factor was financial aid. It appears that very few highly qualified women will come to the Institute unless they receive a fellowship to support their education.

There are some 400 or more special graduate students on campus, usually taking one or two subjects, but in some cases enrolled for a full academic load. Dean Stone made a study of this group, and found it both a most heterogeneous and overall a sadly neglected group of students. In its discussion of his report, the Committee on Graduate School Policy recommended that admissions procedures for special graduate students be regularized. Of great concern in this regard is the foreign student who views becoming a special student as an entrée to admission as a regular graduate student. Procedures now have been set up by the Office of Admissions which should help to correct such misunderstandings in the future.

Ever since World War II, a graduate student quota has been set for each department by the Academic Council. On an experimental basis, beginning in September, 1974, these quotas will be dropped, and the number of students admitted will be determined by each department in light of its academic, physical, and financial resources available for graduate education. The dean of each School, along with the Dean of the Graduate School, is responsible for monitoring the enrollment in each department and reporting to the Academic Council.

IRWIN W. SIZER

Table I-A Graduate School Quotas and First-Term Registration, 1973-74

	All Schools	Engineering	Science	Architecture and Planning	Humanities and Social Science	Management
Quota	3,478	1,670	1,006	221	281	300
Registration	3,358	1,556	934	239	280	349

Table I-B History of Quotas and Registration, All Schools, 1969-73

	1969	1970	1971	1972	1973
Quota	3,420	3,443	3,475	3,478	3,478
Registration	3,395	3,296	3,250	3,328	3,358

Table II Graduate Degrees Awarded, 1973-74

Advanced Degrees Conferred	M. Arch. M. C. P. M. Arch. A. S.	S. M.	Engineer	Sc. D.	Ph. D.	Total
September, 1973	9	209	21	13	125 3(WH)*	380
February, 1974	10	157	18	19 1(WH)	93 1(WH)	299
June, 1974	39	408	63	17	105 1(WH)	633
TOTAL	58	774	102	50	328	1,312

* Woods Hole Oceanographic Institution

Table III-A Graduate Student Enrollment
Fall Term 1973 -- Regular Graduate Students

	Foreign*	Women	Minority**	Total
School of Architecture and Planning	63	64	40	239
School of Engineering	495	41	27	1,556
School of Humanities and Social Science	66	49	26	280
Sloan School of Management	116	27	9	349
School of Science	214	137	19	934
TOTAL	954	318	121	3,358

* Includes Canadians

** Includes black Americans, Puerto Ricans, Mexican-Americans, and American Indians

Table III-B Summary of Graduate Financial Assistance for 1973-74

Total Regular Graduate Students	3,358	
Federal fellowships and traineeships	391	(12%)
Graduate student staff	1,575	(47%)
Industrial and foundation awards	156	(5%)
M. I. T. endowed and budgeted funds	197	(6%)
Students sponsored by external sources	477	(14%)
Total Awards	2,796	84%

Table IV Graduate Student Support

The sources of support for most of the M. I. T. graduate students in 1973-74 are listed. However, a single table is an incomplete reflection of the total picture, since support shifts constantly throughout the academic year in accordance with changing status, early termination of degree program, and so on. Because of the statistical problem created by this constant change, this table was devised to present a representative "snapshot," in effect. For purposes of this count, a full award was considered as at least full tuition support during the fall term, 1973.

Fellowships and traineeships awarded by M. I. T. :

Atomic Energy Commission Traineeships	13
National Defense Education Act Traineeships	25
National Science Foundation Traineeships	23
National Institutes of Health and Other Health, Education, and Welfare (HEW) Traineeships	140
Environmental Protection Agency Traineeships	5
Industrial and Foundation Fellowships	114
M. I. T. Endowed and Other Fund Fellowships	157
Sloan Research Traineeships	<u>40</u>
TOTAL	517

Fellowships awarded by sponsors to M. I. T. students:

National Science Foundation Fellowships	177
National Institutes of Health and Other HEW Fellowships	2
Housing and Urban Development Fellowship	1
Hertz Foundation Fellowships	15
Danforth Foundation Fellowships	14
US Department of Labor Fellowships	2

Graduate School

Ford Foundation Minority Fellowships	13
Environmental Protection Agency Fellowships	2
Federal Highway Administration Fellowship	<u>1</u>
TOTAL	227

Student assistantships -- Research	1,073
Teaching	<u>502</u>
TOTAL	1,575

Sponsored students

Many students are known to be receiving support from employers and sponsors. The following reflect Student Accounts billings for tuition to such employers and sponsors, who presumably provide stipends to such students by private arrangements.

U.S. government agencies	194
Industry and foundations	103
Foreign countries and international programs	<u>180</u>
TOTAL	477

TOTAL: Students considered to have received full awards --
academic year 1973-74. 2,796

Partial awards, loans, and miscellaneous programs -- tuition or lesser amounts.

Individual student support in many cases is derived from partial awards ranging from \$100 to \$3,000 each. In many cases, an accumulation of partial awards and/or loans provides a student with essentially complete support. As a result, the number of such partial awards does not reflect the number of student recipients.

Partial awards

M. I. T. endowed and special budget	93
Industrial and foundation	<u>35</u>
TOTAL	128

Table V Graduate Loans

Source	Number of Loans	Total Amount
M. I. T. Administered		
National Defense Loans	0	0
Technology Loan Fund		
Guaranteed	197	\$ 331,730
Nonguaranteed	170	263,105
Foreign/Subsidized	<u>152</u>	<u>257,175</u>
Total M. I. T. Administered	519	\$ 852,010
Bank Guaranteed Loans	<u>270</u>	\$ <u>162,030</u>
TOTAL Long-Term Loans	789	\$1,014,040
Short-Term Loans	<u>277</u>	\$ <u>132,562</u>
TOTAL BORROWED	1,066	\$1,146,602

Vice President, Administration and Personnel

The report which follows documents in detail a record of progress and accomplishment within those areas of administration which are the responsibility of the Vice President, Administration and Personnel. If there is a unifying theme among these reports, it is the manifest commitment of those who serve in the Institute's administration to improve the quality of their service, whether to students (including prospective students), faculty, or other Institute personnel. In the face of more restricted budgets and increasing workloads, often externally imposed, those who serve in these administrative agencies of the Institute continue to demonstrate a devotion to their work and to the continuing improvement of its scope and quality.

Because the activity of the past academic year is sufficiently well documented in the following reports, only those events or accomplishments which deserve special note will be singled out in this first section. Among them, surely, are the achievements of Director Peter Richardson and his colleagues in the Office of Admissions. Despite a nationwide downward trend in undergraduate applications to institutions such as the Institute, M. I. T. applications increased 20 percent over the previous year, with the number of women applicants up an astonishing 93 percent, nearly double that of the previous year. This latter success is the result of hard work by both the staff of the Office of Admissions and a group of M. I. T. undergraduate women who, among other initiatives, wrote a booklet entitled "M. I. T. . . . A Place for Women." This booklet, produced with the support of the office of the Dean for Student Affairs and the Office of Design Services, was distributed to at least 10,000 young women in secondary schools around the nation. As a result of these efforts, the Institute will enroll as the Class of 1978 nearly 1,050 freshmen, 20 percent of whom will be women.

Jack Frailey and his associates in the Office of Student Financial Aid continue to reach for better means of helping a growing group of M. I. T. students meet the rising costs of education. The Student Employment section worked much more aggressively to identify jobs for students, both on campus and in the greater Boston community. The Student Financial Aid Office was successful in obtaining a substantial increase in funds under the Federal College Work-Study Program, and thus was able to extend that program to graduate students for essentially the first time. The result of these efforts is the employment of more than 2,500 M. I. T. students in part-time work, on a payroll of approximately \$2.5 million. As a further measure to lessen the impact of rising costs on M. I. T. undergraduates, the Institute decided to hold the "self-help" threshold at \$1,750 for yet another year. This is the share of the student's "need" which he or she is expected to meet through taking a loan, a job, or a combination of the two. Costs above that amount, which cannot be met by the calculated contribution from the student and his or her parents, are provided by the Institute in the form of scholarship aid. The self-help threshold certainly will have to rise with inflation in subsequent years, but the decision to hold that threshold steady for one more year is important in lowering the base from which future increases must be made.

Robert Weatherall's report of progress in placing M. I. T. graduates is positive in most respects. He and his co-workers in the Career Planning and Placement Office are now much more accessible, since the Office is located in Building 10 in the center of the campus. He reports that more companies and government agencies came looking for engineers and

scientists than in any of the previous three years. Employment of graduates in architecture is a discouraging exception to this trend; this is documented more fully in Mr. Weatherall's complete report.

The past year has been an active one for O. Robert Simha and his colleagues in the M. I. T. Planning Office. Among the major projects to which the staff of the Office contributed significantly during the past academic year were major renovations to Ashdown House, a residence for graduate students; the new Chemical Engineering Building; the complete overhaul of an old Cambridge industrial building, to create a home for the Center for Cancer Research; the Cell Culture facility; and the Arteriosclerosis Center. The other major structure calling for significant planning and design was the new West Campus Undergraduate House, for which ground was broken in the spring of 1974, with the expectation that it would be available for housing the growing undergraduate population in the fall of 1975. In addition to these on-campus structures, members of the Planning Office staff were involved extensively in working with others in the city of Cambridge on the development and plans for the Kendall Square area, immediately adjacent to the Institute on the north and east. The nature of this development can influence greatly the character and quality of the Institute's environs, including the amenities available to its students and staff.

In the personnel area, there was continuing progress in the reorganization begun in the spring of 1973, and substantive achievements in several areas. Drs. Adam and Maureen Yagodka were appointed codirectors of the Office of Personnel Development in February, 1974, and their presence stimulated an intensive internal review of personnel development activities, as well as the beginning of several new programs, among which was the extended workshop on human processes in organizations. Designed to lay the groundwork for training in supervision and administrative skills, this program was extremely well received, and a number of requests presently are being met for workshops in individual departments. The presence of new and highly capable leadership in this area promises real progress in increasing opportunities for full and satisfying careers at the Institute.

Under the leadership of James J. Culliton, the Personnel Services group has gone far toward meeting the goals of the personnel reorganization in terms of increased service to individual department supervisors and to individuals within departments. The individual personnel officers have been effective in achieving identification with the departments and laboratories for which they are responsible. The decision to post all available nonacademic positions in Tech Talk has increased substantially the employment and placement workload within the office; at the same time, it has been a significant factor in opening up the Institute's staffing system, reducing the dependence of individuals on others for knowledge of vacant positions, and encouraging them to seek promotional opportunities actively. This posting policy, an important element of the Institute's Affirmative Action Plan, has been especially important in affording promotional opportunities to women in office and clerical positions.

The year has been an extremely active one for Robert J. Davis and staff in the Office of Personnel Relations, who are concerned with union relations, wage and salary administration, and benefits administration. At the academic year's end, negotiations had begun with representatives of union members at M. I. T. in anticipation of the expiration of the two-year contract at the end of June, 1974. Throughout the year, a great deal of effort has been invested in the development of a new position classification and salary administration plan for the Institute's administrative staff. This plan, intended to assure greater equity in setting and administering salaries for this group, has demanded great effort on the part of the staff and consultants of the Office of Personnel Relations, as well as many members of the administrative staff. It is expected that the system will be developed and installed fully by the end of the calendar year. Major improvements were made during the course of the year in the Institute's Group Life Insurance Program. In addition, a new tax-sheltered annuity program was introduced for members of the faculty and staff. Ideas for other benefit plans are under

consideration, and emphasis is being placed on the communication of benefits information and the provision of increased counseling regarding benefit coverages.

In addition to the reports of the major administrative offices mentioned above, three other reports are included in this review, covering matters which lie within the responsibility of the Vice President, Administration and Personnel. Included are the reports of Patricia A. Garrison, Administrative Assistant to the Equal Employment Opportunity Officer, on the Institute's Affirmative Action program for equal employment opportunity; Margaret Sand, the Child Care Coordinator; and Suzanne Weinberg, coordinator for the Lobby 7 Committee.

In the area of affirmative action, the Institute during the course of the past year has moved from an emphasis on the preparation of plans to an emphasis on implementation. Due to fine cooperation and diligent work on the part of many people within the departments, centers, and laboratories, the Institute's plan and the departmental plans were revised and resubmitted to the Office for Civil Rights of the Department of Health, Education, and Welfare. During this period, the Institute was advised that its Affirmative Action Plan was acceptable, and primary emphasis now is on following through on the policies and procedures developed as part of the plans to ensure the fulfillment of M. I. T. 's goals. Overall, the Institute has made reasonable progress toward meeting its goals for women faculty members, including visiting faculty. Not all departments have been equally successful in this regard, however. The most conspicuous lack of success has been in the effort to recruit black Americans for the faculty and staff. This effort will receive high priority during the coming year. It is hoped that with the passage of time since the recruitment of larger numbers of minority undergraduates into M. I. T. and other universities, the pool of minority (and particularly black American) doctoral program graduates and the proportion of minority members of the Institute faculty will rise.

This past year was the first full year of service for the M. I. T. Day Care Center, during which the former Technology Nursery School was reorganized as the Technology Children's Center, Inc., encompassing both the nursery school and the day-care program. These two programs, operated by the Technology Children's Center and independent of the M. I. T. administrative structure -- although utilizing M. I. T. facilities -- provided care for approximately 140 youngsters during the past year. Another 40 were accommodated through the Family Day Care Program, under the guidance of the M. I. T. Day Care Coordinator. These programs do not meet the full day-care requirements of M. I. T. 's employees and students, nor were they intended to do so. The primary aim was to provide some day-care and nursery school services, but another very important aim was to provide an information center and clearinghouse to assist people in need of such services in finding what they required, either on campus, in the Cambridge area, or near their homes.

This year's report includes for the first time a summary of the activities of the Lobby 7 Committee, which has sought to increase the use of the Building 7 lobby, the principle public entrance to the Institute, to better achieve its potential as a major public space, a source of information, an Institute crossroads, and a place of entertainment and education. The summary details primarily the richness and variety of the concerts, dramatic presentations, small exhibits, dance concerts, and major exhibitions for which Lobby 7 was the setting over the past year. With comparatively little cost in Institute funds, but with major investment of time and talent on the part of many artists, the lobby -- and the Institute -- have become livelier.

This year also saw the well-deserved promotion to staff of Betty Hendricks, who supervises the work of the Academic Staff Records Office with care and devotion.

These have been the highlights in activities under the responsibility of the Vice President, Administration and Personnel over the past year. The 1974-75 academic year surely will be one of challenge and promise, during which the pace of the Institute's progress will continue and accelerate.

JOHN M. WYNNE

Office of Admissions

In 1973-74, undergraduate applications increased 20 percent over the previous academic year, but the past several years of effort by a variety of groups at M. I. T. resulted in a 93 percent increase in the number of applications from women. This gratifying response followed the centennial celebration in 1973 of the graduation of Ellen Swallow Richards, the first M. I. T. alumna. In addition, a group of undergraduate women wrote a booklet, "M. I. T. -- A Place for Women," which described their impressions of life at the Institute. This was mailed with another more general booklet, "M. I. T. Today," to a select list, obtained from the College Entrance Examination Board (CEEB) Search Program, of about 10,000 women. A mailing of the general booklet was sent to approximately 7,000 men, whose names also were obtained from the CEEB at a later date. The publicity which the News Office developed around these events helped to direct more student interest toward M. I. T. These efforts appear to have been the major factors in the increase in applications.

The increase was all the more welcome since the academic and personal qualities of the applicants were at the same high level M. I. T. has known in the past. The selection process was a most challenging one; it is not easy to deny admission to such attractive applicants. The support of faculty volunteers again helped bring the task to a successful conclusion. The practice of considering men's and women's applications together, with the same criteria, was continued. The number of foreign students applying did not increase, but the group that did apply was highly qualified, and the choices that had to be made were difficult. The applicants represented a variety of nations and cultures that is unusual in American higher education.

The search for minority applicants with adequate preparation for the mathematics and science subjects required at M. I. T. is a major concern. A special mailing to about 1,000 minority group students, again selected through the CEEB Search Program, attracted a modest increase in applications, but the response was still short of the desired objectives. Studies of the minority applicant pool, both at M. I. T. and at other institutions, indicate that the number of properly prepared students is at best a few thousand throughout the entire country. However, there is evidence to suggest that the number may be even smaller. The basic problem is one that requires far-reaching changes in the educational environment at the elementary and secondary school levels, in addition to persistent imaginative recruiting, and well-developed support activities at M. I. T. for those who come.

With the changing job outlook, engineering is regaining its attractiveness to high-school students. In the main, undergraduate candidates are looking for a broad range of educational opportunities; many express an interest, as well, in the study of some aspect of science or mathematics. The Office of Admissions continues to articulate the real nature of M. I. T. to a variety of publics -- parents, teachers, and peers -- all of whom have an impact on students' decisions to seek admission, and if admitted, to attend. Often, the uninformed serve as sources of information, and it is an ongoing task to provide all concerned with accurate and timely information.

At the graduate level, the number of applications increased only slightly, but the increase was not distributed evenly across the various departments. This situation creates a variety

of different problems which demand differing responses.

The dedication, energy, and imagination of the individuals who collaborate in the work of the Office of Admissions are impressive. Tekle Tomlinson, who left the staff in March, 1974, to become Special Assistant to the Under-Secretary General of the United Nations Commission for Technical Cooperation, is missed particularly.

PETER H. RICHARDSON

Office of the Advisor to Foreign Students

During the academic year 1973-74, there were 1,413 citizens of other countries enrolled in the various programs of study offered by the Institute. Of this total, 374 were registered as undergraduates, while 1,039 were registered as graduate students. They represented 17.9 percent of the total student enrollment. These figures include those working toward degrees, as well as nondegree special students. The majority are recorded as holding temporary F-1 or J-1 visas. Approximately 200 hold immigrant visas. There were 117 women. A number of these students were married, and 373 spouses, mostly wives, were recorded as being in residence.

In terms of its international position, one of the most valuable national resources the United States has is its system of higher education. M. I. T. seems to be regarded by many outside of this country as an international educational resource with few peers.

This is reflected in the fact that the Office of Admissions received some 18,634 individual pieces of foreign-related mail between July, 1973, and March, 1974. Some 4,600 formal applications were dispatched to prospective candidates from abroad; 1,013 were mailed in October, 1973, alone. These figures represent all levels of foreign students seeking admission to M. I. T.

There were several significant changes in immigration regulations, or their interpretation, as applied to foreign students. Unless these are modified constructively or reversed, they are apt to have a profound effect on the number and socio-economic composition of the foreign student body in American institutions of higher education for a long time to come.

The first of these, known as the Foreign Affairs Manual crisis of July, 1973, relates to the issuing of new instructions to overseas consular posts for the issuance of foreign student visas.

The second, a directive in April, 1974, by the commissioner of the Immigration and Naturalization Service, informed the responsible officers that foreign student advisors no longer may issue summer work permits to their enrolled foreign students. Withholding this authority was explained as a move to protect jobs for American youth, Vietnam veterans, and minority groups. A foreign student has to show clearly an unforeseen change in economic circumstances since last entering this country in order to support a request for a summer work permit.

A further reduction in service to foreign students in this country was the announcement by the Department of State of the withdrawal of the privilege of having an expired visa revalidated in this country. This requires the student to obtain once again appropriate institutional documentation reaffirming continued financial support before a new visa will be issued.

International education, in all its aspects, has been an important hallmark of the foreign affairs of this country. Certainly, both M. I. T. and the United States are part of the world

community. To ignore the significant role of educational exchange between countries is simply self-defeating.

In April, 1974, the Chalmers International Students Award was established as a memorial to Professor Paul M. Chalmers, Advisor to Foreign Students at M. I. T. from 1944 to 1965. This Award was made possible by income derived from a fund created through a gift to M. I. T. from the sale of the assets of the International Students Association of Greater Boston. The selection committee was chaired by Professor Glenn C. Williams. The first students to share this Award were Arvind Khilnani, Class of 1974, from Pakistan, and John S. Lim, a graduate student from the Philippines.

Continued staff support has been extended to Charlotte Schwartz in the development of a program of orientation for entering freshmen. Beyond these activities, the staff of the Office of the Advisor to Foreign Students shares in counseling foreign students on a variety of problems, particularly those related to possibilities for employment and the visa clearance that such requests require.

The Return Home Seminar and the English as a Foreign Language Program have become affiliated with regular academic departments, beginning with the fall 1974 term.

EUGENE R. CHAMBERLAIN

Career Planning and Placement Office

The past academic year saw a continued upswing in the demand for M. I. T. graduates in most fields of study. More companies and government agencies came looking for engineers and scientists than in any of the previous three years. Mindful that national enrollments in engineering have decreased sharply, many employers made an extra effort to attract their share of candidates. One company, which has drawn heavily on M. I. T. talent in the past, threw a cocktail party for students whose interests matched its needs. It has been a number of years since the business of recruiting has been attended with such festivity.

Starting salaries moved upward in keeping with the market, but not as steeply as the consumer price index. Graduating students joined that large sector of the population which has suffered from the prevailing inflation more than it has contributed to it.

The demand for master's degree candidates in management remained strong, although less strong than the demand for engineers. The number of employers recruiting at the Sloan School of Management dropped slightly, and salary offers moved up hardly at all. In real dollars, this year's Sloan graduates started out distinctly poorer than the class ahead of them. However, at an average beginning salary of \$17,000 a year, a Sloan master's degree is still a highly valued commodity.

In contrast, the employment outlook in the field of architecture was grim indeed. With financial support from the Career Planning and Placement Office and the Department of Architecture, a graduate student in that Department, Paul Lipof, wrote to 1,100 alumni, 40 local chapters of the American Institute of Architects, 150 leading architectural firms, and 25 engineering concerns to locate employment opportunities for members of his class. In response he received some helpful leads and a good deal of friendly advice, but no news from anywhere of a specific opening. The employment situation was displayed with depressing clarity. On the last day of classes in May, 1974, no one on the graduate degree list in this area had found a job. At the end of June, a few students had better things to report, but a large number still were unemployed.

An important event during the year was the move of the Career Planning and Placement Office from the fourth floor of the Ford Building to beautifully designed quarters on the first floor of Building 10. In the Ford Building, those wanting to use the Office had to seek it out. Now it is in full view of students walking through the main Institute corridor. The number of students using the Office has increased considerably as a result. Using the director's appointment book as a measure, the number of students coming in for advice on jobs and careers has jumped 30 percent. Students who feel they have been helped recommend the Office to others, and the counseling load is likely to increase further.

Business also increased in the area of alumni placement. The number of alumni registering with the Office rose to over 500, from 403 the previous year. In January, 1974, the Office began publication of a four-page job listing (the M. I. T. Alumni Placement Gazette), which is sent approximately once every two weeks to all alumni who maintain a current registration. Each issue contains descriptions of 25 to 30 of the most attractive jobs reported to the Office since the last issue went to press. The Gazette has been received very well by alumni.

ROBERT K. WEATHERALL

Educational Council

For 80 percent of M. I. T.'s undergraduate applicants and over 3,000 secondary schools, the Educational Council members are the only face-to-face contact with an official Institute representative. Although the size of the Council has grown to over 1,050, this contact among students, schools, and Council members remains the central thrust of the efforts of the Educational Council. Most of the staff's effort, with the support of colleagues in the Office of Admissions, goes to maintaining, updating, and enhancing the value of this student-school-Educational Counselor interaction.

This year a major effort which received significant support from the Educational Council resulted in a doubling of the number of final applications from women. Effective follow-up, timely contact, and good counseling from Council members aided in this effort. These Council efforts also assisted in bringing about a significant (20 percent) increase in final applications from all sources. Part of the success of this field effort is attributable to previous membership programs, which have brought about significant increases in the number of alumnae and younger alumni in the Council.

In the organization area, the Council continues to examine ways of increasing the effectiveness of the locally managed Council regions. Several new regions have been organized, and several existing ones are undergoing reorganization. Two of particular note have been organized in Colombia and Mexico City, with the help of Eugene R. Chamberlain, the Advisor to Foreign Students, and Robert A. Schuiteman, the Associate Advisor to Foreign Students. The need for more effective recruiting will continue to place increasing burdens upon local Council groups. This in turn will demand new responses and support from the Council office at M. I. T. as well as new initiatives in the field.

In the area of publications and communications, the initial report of the College Decision Study and a brief highlights paper which was summarized in Technology Review have been completed. Admissions Information has been updated and rewritten to serve the needs of the Council members in the field as well as the admissions officers. This year, the Council worked closely with the Office of Admissions in interpreting to students and schools the Early Evaluation scheme. A special program was designed to mesh smoothly with the annual Alumni Officers Conference in September, 1973, exposing Council members to M. I. T. undergraduates; this program seemed most effective. The Council's film library received wide use with the addition of copies of the ABC-TV "What About Tomorrow" films and the

School of Engineering's "Energy for the Year 2000." It is generally believed that face-to-face communication is invaluable, and toward that end all Admissions and Council staff travel included a significant measure of interaction with Educational Council members in the field. In the area of new programs, a pilot effort has begun with the M. I. T. News Office to distribute Reports on Research to Council members and eventually to secondary schools.

The continuing challenge remains before the Council. M. I. T. 's need is for that most valuable of all resources, a steady stream of some of the finest young men and women the world has to offer. The intensity, desire, and commitment of the Council's volunteer alumni and alumnae to meet that challenge remain firm. The Council's role in Cambridge is to support in ever better ways these invaluable volunteer efforts.

This year a particular word of thanks is due the staff of the Office of Admissions for their support. As always, the accomplishments of the Council staff deserve recognition. Noteworthy this year was the promotion of Mary Manning to the position of assistant to the director of the Educational Council. The last thank-you is the most deserved, for it is to the current and former Council members who have enabled the Institute to extend its reach and broaden its grasp for the past 23 years.

WILLIAM J. HECHT

Office of Student Financial Aid

In dynamic programs, it often happens that abnormalities become the normal mode of operation, and that phenomena once thought to be temporary settle in and become part of the permanent scene. In the Institute's financial aid program, this seems to have occurred in some significant areas.

Need

Most notable is the continuing reduction in the number of applicants for assistance who are found to need help from the Institute. During academic year 1972-73, a total of 1,973 students were found to require Institute assistance; in 1973-74, the number dropped for the third year in succession. There is as yet no evidence that the reduction in numbers is centered in any particular section of the economic spectrum of the aid recipients. Nevertheless, it is hoped that this trend will decelerate and reverse. A continuing reduction in the percentage of students needing help, in the face of rapidly rising educational costs, may be taken as evidence that the cost trend is affecting the economic composition of the student body.

After three years of using the parents' income tax return as a vehicle for monitoring financial statements submitted in support of requests for student aid, the Office decided during the year to use the tax return as the primary vehicle for financial reporting. With the elimination of the Parents' Confidential Statement and resort to the simpler tax form, the process of determining the extent to which each applicant needs assistance should become simplified, more understandable, and more acceptable. Concurrently, the need for flexibility and the application of judgment in the dispensation of aid resources is well recognized, and a special effort was made during the year to examine the impact of the Office's decisions -- both on families caught in the inflationary spiral who may perceive college costs to be out of reach for the first time, and on students who wish to move toward earlier financial independence from their parents. This kind of scrutiny will be continued in the coming year, in order to reaffirm or modify philosophies and operations related to need determination.

Scholarships

Gifts from corporations, foundations, and private individuals again were at a disappointing level, less in dollar amount than the previous year. However, the Federal government's long-announced revamped grant programs came into effect to take up some of the slack. The Basic Grants Program, designed to provide an "entitlement" of gift aid to all students from low-income families, appeared on the scene, providing only a token resource for M. I. T. students because of its severe underfunding. However, the institutionally based Supplementary Grants Program provided more than twice the previous year's Federal gift aid dollars. Full funding of the Basic Grants Program promises to provide a helpful foundation of aid for the neediest of the Institute's students.

Loans

The precarious life of the National Direct Loan Program received a welcome boost when Congress maintained funding for fiscal year 1974 at previous years' levels, and forward-funded fiscal year 1975 as well. This action revealed that at least the present Congress has no intention of phasing out the Program quickly, as the administration had proposed. Loans to undergraduate citizens were funded almost entirely by this Program. Loans to all graduate students and to foreign undergraduates were provided through the Technology Loan Fund, which required augmentation in the form of an additional \$600,000 in capital, borrowed from local banks on a short-term basis. Loans made to undergraduates totaled about the same in dollars as in the previous year, but loans to graduate students increased substantially.

Employment

Staff members concerned with student employment at M. I. T. undertook this year a more aggressive role in identifying jobs for students, both on campus and in the greater Boston community. With the benefit of a substantial increase in funds under the Federal College Work-Study Program, a sizable program of graduate student employment also was implemented successfully. These combined efforts, plus maintenance of all of the traditional realms of student employment at the Institute, led to a payroll of approximately \$72.5 million, engaging 2,500 to 2,700 M. I. T. students in part-time work.

Staff

After four years of service on the staff, Benjamin F. Moultrie relinquished his position as assistant director in October, 1973, to resume full-time graduate study at the Sloan School of Management. Late in the fiscal year, Roberta F. J. Kurland joined the staff as assistant director, after several years of service on the Department of Architecture's supporting staff.

JACK H. FRAILEY

Office of Personnel Development

The Office of Personnel Development during the reorganization period was headed by Acting Director Robert Weatherall, until the appointments in February, 1974, of Adam and Maureen Yagodka as co-directors. Since then, the Office has placed considerable emphasis on internal development to integrate its various functions and to build a more responsive and cohesive organizational unit. Another point of emphasis has been the evaluation of the activities of the

Office. Several studies are under way, and procedures for evaluation are being established and implemented.

The Office also has introduced several new personnel development activities, among which was the extended workshop on human processes in organizations presented at the end of this academic year. This was a pilot workshop with a research component for supervisors and nonsupervisors from all parts of M. I. T. The results of the workshop will be documented comprehensively late this summer. Other new and emerging activities include responding to requests for the design of organization development research and training programs; expanding the orientation program to reach suitably larger segments of the M. I. T. community; and addressing the questions of career development expectations of M. I. T. employees.

During the year, the Office of Personnel Development has responded programmatically to approximately 1,500 members of the M. I. T. community. (Some individuals may be counted more than once in this estimate, since they may have used more than one functional service of the Office.) Functionally defined, the following program areas were addressed during the year.

Tuition Assistance Plan

With participation doubled and the pay-out increased ninefold, the Tuition Assistance Plan has come a long way since its inception in 1960. Changes introduced in fiscal year 1974 continued a succession of improvements which have brought the Plan from one originally restricted to directly job related evening courses for laboratory and office employees, with reimbursement at 50 percent, to a plan open to all persons employed for a long term at M. I. T. -- including part-time employees working half-time or more -- embracing both job related and career related study, day or evening, and paying 100 percent up to \$625 a year for off-campus courses, or 75 percent without maximum for one subject a semester at M. I. T. Approximately 500 M. I. T. employees have used this service during the past fiscal year.

The contribution that most education makes to the personal and career growth of most individuals is recognized increasingly among Institute supervisors and administrators. Thus, at the end of fiscal year 1974, the Office of Personnel Development was studying the feasibility of streamlining the Plan to make tuition assistance even more broadly available with a minimum of restrictions and paperwork.

Skills Training

A total of 40 classes and tutorials for M. I. T. employees were presented in the following subject areas: English as a Second Language, I, II, III; Typing, I, II; Introduction to Technical Typing; Technical Typing; Dictation Transcription; Shorthand I; Shorthand II; and preparation for the General Education Development (GED) examination in both mathematics and English.

Orientation

A total of 590 new biweekly employees participated in half-day orientation sessions presented by the Office of Personnel Development and the Benefits Section of the Office of Personnel Relations. Plans are being formulated to provide orientation services to additional newly arrived members of the M. I. T. community.

Career Counseling

While no formal program of career counseling exists, the Office has acknowledged requests for such services. Each other functional area described here has encountered and responded to expectations for career counseling in connection with other services offered. A more formalized, group oriented career counseling program is being discussed for possible future implementation.

Organizational Development Programs

This area of service is new to M. I. T. and the Office of Personnel Development. Essentially, it responds to particular interests of organizational subunits of the community in a consultative manner. It addresses their needs for research on organization management and personnel development issues, and proposes programs geared toward more effective use of human resources in the organization.

The Office presently is working with four organizational subunits in designing research and training activities to be implemented in the next fiscal year.

Evaluation and Research

Renewed emphasis has been placed on the function of evaluation and research in connection with all programs and services offered by the Office of Personnel Development. Evaluation results increasingly will be used as guides to program modification and development.

Personnel Development Programs

Through both new and continuing efforts, the Office has designed, supported, and presented development programs of community-wide interest. These programs, such as the Administrative Development Program and the pilot workshop on human processes in organizations, which have been offered to heterogeneous groups of M. I. T. employees, generally are considered to be avenues of personal and professional growth. During the year, a total of approximately 120 people participated in the following: 1) the Institute for Educational Management (Harvard University) for upper-level administrators; 2) the Administrative Development Program for mid-level administrative personnel; 3) the extended workshop on human processes in organizations for supervisors and biweekly employees; and 4) the career development workshop for members of the Administrative Development Program.

Other Activities

As in previous years, members of the Office of Personnel Development provided organizational and administrative support for the annual fall campaign on behalf of the United Way and for the spring all-Institute blood drive.

ADAM YAGODKA
MAUREEN YAGODKA

Office of Personnel Relations

Wage and Salary Administration

Wage and salary structures applying to all categories of Institute personnel were examined in relation to current economic trends and applicable market standards, and appropriate adjustments were made to existing scales. In addition, the performance and job duties of individual employees were reviewed and adjustments made on a merit basis, within the frameworks of approved budgetary guidelines and Federal wage and salary controls.

Development and installation of a formal position classification program for members of the administrative and library staffs was nearing completion at the year's end. This project was undertaken with the assistance of an outside consultant with considerable experience in the field of education, and involved considerable participation of the affected staff members. The need for a more formal program of salary administration has become apparent as the administrative functions of the Institute have increased in complexity and scope. A highlight of this need is the importance of assuring equitable treatment for minority and female members of the staff.

Benefits Administration

The Benefits Section continued to enlarge and improve its services to Institute personnel during the year. Major emphasis was placed on the communication of benefits information and the development of new and improved benefit plans, along with the ever-growing functions of counseling and advising personnel about benefit coverages and interpreting and explaining the benefit programs.

The preretirement seminars initiated several years ago were expanded to meet the increasing interest of older personnel, and the benefits orientation program for new employees was revised and improved. In the area of written communications, a revised manual of benefit programs for faculty and staff was prepared for publication, and work was nearing completion on the development of an annual report on the Retirement Plan for staff members and a Personal Benefits Profile to be distributed early in the next academic year.

Significant changes during the year included the introduction of a tax-sheltered annuity program and a major revision of the life insurance programs applying to faculty, staff, exempt, and biweekly personnel. Studies of other benefit programs, including especially the early retirement provisions of the Retirement Plan for staff members, were proceeding under the guidance of a subcommittee of the Personnel Policy Committee.

Union Relations

Two-year agreements with four unions representing 1,800 hourly employees in six bargaining units expired on June 30, 1974. Negotiations on the terms of new agreements opened in May, 1974, and were still in progress at the fiscal year's end.

ROBERT J. DAVIS

Office of Personnel Services

On July 1, 1973, the divestment of the Draper Laboratory was completed, with the Laboratory assuming autonomous operation as a separate corporation.

Total nonacademic employment at the Institute (including Lincoln Laboratory) in January, 1974, was 6,100 persons -- 4,200 on campus and 1,900 at Lincoln Laboratory. The Institute continued its efforts to increase the representation of minorities and women. Total minority representation at the Institute was 9 percent (5 percent black) and 30 percent women. Of the Institute's administrative staff, 28 percent are women, as are 12 percent of the sponsored research staff (22 percent of the sponsored research staff on campus are women). Only 4 percent of the Institute's administrative staff are black.

M. I. T. became the first institute of higher learning in the region to have an acceptable affirmative action plan, according to the director of the Office for Civil Rights, HEW (Department of Health, Education, and Welfare) Region I. This plan, which was published on March 1, 1974, includes individual department plans.

In the nine-month period July 1, 1973-March 31, 1974, 1,025 jobs were available on campus. During this same period, over 3,000 applicants were interviewed in the Office of Personnel Services. The posting of all positions in Tech Talk has become a major factor in providing promotional opportunities for present employees and recruiting individuals from outside the Institute. During this period, approximately 400 present employees were interviewed in the Office of Personnel Services for promotional opportunities, and 37 percent of those interviewed secured new jobs. In 1973, 69 persons were promoted to the exempt and administrative staff payrolls (36 to exempt and 33 to staff). Of this total, 83 percent were women, and 45 were promoted from the biweekly payroll.

JAMES J. CULLITON

Planning Office

During the academic year 1973-74, the Planning Office undertook a wide variety of assignments.

Long-range planning activities focused on five major projects that were undertaken this year: a comprehensive transportation circulation and parking study for M. I. T., the second phase of a plan for the development of the East Campus area, a utilization study of classrooms and lecture halls, an extensive development plan of the Kendall Square area, and a review of the Massachusetts Avenue Crossing plan.

Planning and administrative services for over 70 space change projects were provided during the year. Approximately 715 rooms were reassigned, under the direction of the Committee for Research and Space Planning. Some of these assignments were routine, while others involved extensive negotiations, coordination, and study to insure the validity, viability, or general acceptance of each assignment.

The Planning Office continued to meet the challenge of reduced budgets by continuing both its program budget orientation and its internal project control system.

A major stride was made in the design and development of another unique aid to the visually handicapped within the Institute community. Complementing the existing tactual map of M. I. T., an MBTA (Massachusetts Bay Transportation Authority) tactual map was accomplished, along with a braille directory and a tape cassette recording to instruct blind people in the use of the map.

The continued expansion of the consortium of institutions using the INSITE II system developed by the Planning Office featured the addition of two new members this year. To further enhance this effort, an Office of Facilities Management Systems has been formed within the Planning Office.

This year also saw the continued development of a set of concepts and techniques for measuring and evaluating the utilization of space in M. I. T.'s buildings. These concepts were applied at the Sloan School of Management, and proved to be an important resource in evaluating that School's space needs.

During the past year, building programs, proposals, and studies included: the preparation of a final program for undergraduate housing on the West Campus; a program for a waste heat management facility; a review and analysis of a Draper Laboratory development proposal; a Project MAC and Artificial Intelligence Laboratory relocation study; and a program for the furnishings and equipment for the Chemical Engineering Building.

The design review of projects under way included: major renovations to Ashdown House; the Chemical Engineering Building; the Center for Cancer Research; the Cell Culture facility; the Arteriosclerosis Center; the West Campus undergraduate housing; the landscape improvement for Amherst Alley and Kresge Plaza; the Geophysical Underground Laboratory, in Westford, Massachusetts; and renovation at Baker House. The development of performance specifications for a furniture program and the review of submissions for the Ashdown House renovation project also were accomplished successfully.

O. ROBERT SIMHA

Child Care Office

Fiscal year 1974 saw an increase in the number of families at M. I. T. requesting child care services. There were recorded 101 applications for family day care (FDC), 46 for the day-care center, and 136 for the nursery school, for a total of 283 applications. Enrollments, obviously, are lower: 42 in family day care, 19 in the day-care center, and 118 in the nursery school (including the summer session), for a total of 179.

The above figures reflect only actual applications and enrollments. The Office has tried to keep a log of requests for information, and it is estimated that it received almost as many requests for information as actual applications. These requests range from information about child care services to employment requests from teachers to requests of various kinds from people doing research. For example, the Office has just begun to work with a professor at M. I. T. who is starting a research project that involves day care. He came to the Office asking for help in funding and with a request to use the facilities. If his project continues, the Child Care Office will continue to advise on setting up his day-care unit. It is important to realize that while the major concerns of the Office are to assist people at M. I. T. in finding child care and to provide support to existing M. I. T. related child care services, it is very involved with many related issues, and that involvement continues to grow.

Although there are no statistics on the number of applications for family day care for fiscal year 1973, there is no question that there have been many more requests during fiscal year 1974. However, almost exactly the same number of children were placed this year as in the previous year. Similarly, the number of requests to become FDC parents also rose substantially. Twenty-five FDC homes were used this year, compared to 13 last year. It is clear that additional staff time will have to be made available if the number of children placed in FDC homes is to increase.

A good 75 percent of the families who used FDC have children under three years old. This substantiates the great need for facilities for infants and toddlers (up to 30 months old). Many of the families who used family day care actually expressed a preference for center care, but because of the lack of infant/toddler facilities were forced to use what they considered a less desirable service. This is not to say center care is better. Happily, few families found family day care unsatisfactory; even those who voiced a preference were pleased with their FDC experience.

Another encouraging sign is that a group of parents using family day care have indicated a desire to meet to discuss issues of parenting. An encouraging sign is that fathers have indicated that they would join such a group (as long as there were other fathers, of course). The Office hopes to get the group started by late summer.

There has been much activity within Technology Children's Center, Inc. (or T. C. C. -- the corporation which operates the day-care center and the nursery school). There were several resignations of members of the Board of Trustees who have served the corporation well for many years. Among those resigning was Helen Pounds, President, who had guided the Office gracefully through the establishment of the day-care center last year. The Board has not yet appointed a new president.

The day-care center currently is fully enrolled with 20 children. There are 19 children waiting for spaces for September, 1974. Only eight openings are anticipated. Several families who probably will not be admitted in September have expressed a desire to remain on the list until an opening occurs; several others have applied at this time, although their children will not be old enough until a year from now. Thus, the waiting list is healthy.

It was hoped that an increase in day-care fees this year could be avoided, but because of increased personnel costs, it has not been possible. Although teachers' salaries and benefits compare favorably with those of other day-care centers, the situation is still not entirely satisfactory. In an attempt to ease the burden traditionally carried by day-care teachers, the number of classroom hours has been limited to five per day. The teachers also have been given personal days and encouraged to take professional days as well by the provision of those benefits which others take for granted -- such as adequate sick leave, vacation, health insurance, and so forth. This still leaves them with relatively low salaries and little real job security. While some progress has been made this year, the Board continues to see this as a priority issue. The fee for full day care as of July 1, 1974, is \$43 per week per child, which represents actual costs. It is clear that unless other sources of funds are located, the fee for day care will have to increase each year. The implication, of course, is that parents no longer will be able to afford the service.

The nursery school, after experiencing a period of underenrollment, seems to be recovering. The spring session was nearly full, as is the summer session. It also continues to operate in the black.

Since most of the underenrollment occurred in Eastgate, that program must be looked at very carefully. One factor which had been apparent for the last few years was overcrowding. The legal maximum of 30 children had been reached, but the space had never been intended to be

used by that many children. Therefore, the number of children present at one time will be decreased to 20, and the space to be used will be redesigned as one classroom, rather than two. This planning will take place over the course of the summer, so that by September, 1974, the new program can be implemented.

An encouraging sign of people's growing awareness of the need for child care and their support of it, is the result of T. C. C. 's annual fund-raising drive. For a number of years, the president of the Board has sent a request for funds to a small number of "friends," and each year raises approximateley \$350. This year the list of friends was expanded. To date, \$1,040 has been received. One large donation (in the amount of \$500) was received from the Margaret Compton Trust Fund. The remainder came from 33 other generous people.

Early this year, the Child Care Office moved from Building 19 to Building 4, which has proved to be a happy experience for everyone involved. The move not only has provided a more comfortable and attractive space, but also has made the Office more accessible to those who have need of it. While this has caused some strain and congestion, it is generally felt that it has increased the quantity and quality of the services provided.

MARGARET SAND

Equal Employment Opportunity Program

Since the appointment of Patricia A. Garrison as the Assistant to the Equal Employment Opportunity Officer, many individuals and programs have become a part of the administrative body, to assist in making the Affirmative Action Plan a part of M. I. T. 's everyday managerial practices. Several activities of the past year strongly suggest that there is an internal commitment to affirmative action, a commitment which generates great enthusiasm and interest.

In September, 1973, a series of meetings was begun with each department, laboratory, and center at the Institute to explain the guidelines for writing an Affirmative Action Plan and to discuss organizational needs and/or concerns. These group meetings seem to have increased understanding of the program, knowledge of the logic required in writing a plan, and an awareness that may ensure effective implementation. By March, 1974, the Institute's Affirmative Action Plan and each departmental plan were revised in conformance with changes suggested by a Department of Health, Education, and Welfare (HEW) review. In April, the Institute plan and the accompanying departmental plans were resubmitted. The receipt of HEW's letter of acknowledgment shifted the program's emphasis from writing to implementing the plan.

One of the key steps in the implementation stage is the communication of the plan. Internal and external communication of the Institute plan has been effective. Employees have been informed by: 1) inclusion of the Affirmative Action Plan in Tech Talk; 2) special meetings held to discuss the program and to review progress; 3) articles and pictures in the Institute newspaper featuring minority and women employees in nontraditional jobs; 4) meetings with minority and women employees, to request their suggestions in implementing the Institute Affirmative Action Plan; 5) meetings with the Institute Equal Opportunity Committee; and 6) presentation and discussion of the program as a part of employee orientation and some training programs. External contact has been made by mailing copies of the Institute Affirmative Action Plan to all regular recruitment sources, and by notifying all subcontractors, vendors, and suppliers in writing of the affirmative action policy.

As of July 1, 1974, an analysis which outlines M. I. T. 's progress in minority and women employment by department and job classification has been completed. The survey's purpose was twofold: first, to identify the number and percentage of minority and women employees in each department and major job classification; second, to identify jobs, departments, and concentrations of minorities, women, or men. Overall, the Institute has made good progress toward its goals. Unfortunately, it has fallen short in the appointment of black Americans to faculty and staff positions.

The activity of this office during the past year has indicated vividly areas that should be of concern. The following are the office's proposed goals for 1974-75:

1. To improve utilization analysis by a careful survey of the local labor area.
2. To develop new goals and timetables. The survey data which indicates areas of underutilization and concentration will be used as one means of making projections of goals and timetables for 1976-79. Departments which to date have made no projections for 1973-75 will be encouraged to do so. Once these goals have been set, targets should be developed not only for hiring, but for training, transfer, and promotional opportunities as well.
3. To establish an internal audit-evaluation system to measure progress.
4. To develop and implement specific programs to achieve goals.
5. To assist in developing supportive in-house and community programs, e. g., Equal Employment Opportunity (EEO) Workshops.
6. To increase employment and advancement opportunities for women and minorities.

M. I. T. indeed has expressed its commitment to the affirmative action program. However, a written statement is only the beginning. To be effective, the statement's provisions must be adhered to, and all employees must be made aware that Equal Employment Opportunity is basic Institute policy.

PATRICIA A. GARRISON

Lobby 7 Committee

The Lobby 7 Committee is an experimental program of events and exhibitions in Building 7 Lobby, the large public entrance space to the Institute.

The activity in the Building 7 Lobby continued this past academic year with a wider variety of events and exhibitions. Aside from chamber, rock, and jazz groups which played in the series of Wednesday noon concerts, there were dramatic presentations, dance concerts, minstrel groups, and small exhibits. The focus of the first term was a large exhibit entitled "Weather," in which a great variety of departments and individuals from within and outside M. I. T. participated. "Weather" is meant to be a pilot exhibit for a series of large-scale participatory public exhibits based on subjects of universal interest and appeal. The object of these exhibits is to provide the M. I. T. community with a meeting ground for artists, scientists, and engineers. These exhibits will be of an experimental and educational nature, with the emphasis placed on the content process and workings of the various pieces.

The second term continued the series of Wednesday noon performances with chamber groups from M. I. T., Cambridge, and Boston. A local dance group, City Dance Theatre, performed

a four-part series in the spring, and the M. I. T. Drama Workshop presented work which was a continuation of an Independent Activities Period (I. A. P.) course under the direction of Deborah Fortson. The city of Brookline provided an exhibit on the work of Frederick Law Olmstead. The work of Professor Minor White's class during I. A. P. in Rome, entitled "Interface, " was on display during the last two weeks of the term. On May 1, 1974, Visiting Professor Otto Piene gave a repeat performance of the "Balloon Carpet," a network of helium filled balloons and tiny bells which was filmed by German television for a documentary on Professor Piene's work. The bursts of sound of the Topper Carew Band traveled through much of the main group of buildings and drew hundreds of listeners. Music for Public Spaces, a series supported by the Council for the Arts, was organized by Paul Earls, composer and fellow at the Center for Advanced Visual Studies, as a collection of sound written for large reverberant spaces; it included live and recorded music and the first performance of "Parhelion, " an electronic piece with lasers dedicated to Institute Professor Emeritus Gyorgy Kepes.

The graphics and publicity for the lobby program were designed by various groups at M. I. T. and outside the Institute. They were printed by the Visible Language Workshop in the Department of Architecture and by the Design Department of the M. I. T. Press. The lobby events provided them with an opportunity for producing some very beautiful and unusual experiments in graphics.

Efforts to improve the information services in the lobby continued. A room directory and the Tactual Map for the Blind, produced in 1972 as a thesis in the Department of Architecture, were placed in the lobby. Attempts to provide more graphic information in the lobby will continue next year. A feasibility study currently is being conducted on the placement of video monitors at critical paths in the Institute, with Lobby 7 being the prime location. M. I. T. V. (M. I. T. Television) used the lobby this year to play its weekly news program. This kind of service will be expanded in the coming year to include more information about the Institute in a wider range of locations.

SUZANNE R. WEINBERG

Vice President for Research

Despite funding uncertainties, rising inflationary costs, and cutbacks in many areas, the laboratories and centers reporting to this office made notable research contributions during the past year. These are highlighted at the end of this section.

Financial support continues to be a major problem for all of these groups, particularly in areas where funding has come primarily from those government agencies, such as the National Aeronautics and Space Administration (NASA) and the Atomic Energy Commission (AEC), whose own research budgets have been reduced drastically. Many attempts to obtain support from new sources have been frustrated by the present national economic climate. While the overall volume of sponsored research on campus is expected to show some increase over last year, it does not reflect the shifting of support away from some of the more traditional basic work performed in these laboratories to health related and other applied science fields.

During the past year or two, the Federal government has encouraged the more rapid transfer of basic technologic advances from the laboratory into new and marketable products by supporting joint efforts between universities and industry. There are now several groups on campus working in collaboration with industrial organizations, and it is hoped that this effort will increase. There are many modes of operation for this sort of arrangement, and with the cooperation of the Experimental Research and Development Incentives Program of the National Science Foundation, unique enterprises are now under way. The M. I. T. -Industry Polymer Processing Program, under the direction of Professor Nam P. Suh of the Department of Mechanical Engineering, and the Innovation Co-op Program, headed by Professor Yao T. Li of the Department of Aeronautics and Astronautics, are two examples. Both of these programs represent novel approaches to the problem.

A further effort by M. I. T. to encourage this technology transfer is reflected in the recently revised Institute patent and copyright policies, whereby the percentage of royalties allotted the inventor or author has been increased. It is hoped that this added incentive will encourage members of the faculty and staff to expose some of their ideas to a wider and more product minded audience. The M. I. T. Development Foundation also has been established to assist in the generation of new enterprises.

One of M. I. T. 's more indirect research resources for industry is the Undergraduate Research Opportunities Program (U. R. O. P.). Approximately 20 percent of the students participating in U. R. O. P. this past year engaged in projects away from M. I. T. Many of them were affiliated with government agencies, local hospitals, and other nonprofit organizations, but an increasing number developed common interests with industrial firms.

Under the direction of Professor Margaret MacVicar of the Department of Physics, U. R. O. P. is an administrative function of the Vice President for Research. In the past 18 months, well over 50 percent of the M. I. T. faculty, from all of the 24 departments, collaborated with U. R. O. P. students, often contributing research supplies and stipends. In combination with the M. I. T. general funds made available through U. R. O. P. , over \$500,000 in direct financial support went to undergraduate research activity.

The returns to students, faculty, and the Institute itself have been enormous. Students have won design competitions, published in leading journals, written research proposals to the government and other funding sources, made policy recommendations to government agencies, received patents, and written books under U. R. O. P. 's aegis. The research of faculty members has benefited from the fresh ideas of enthusiastic and eager undergraduates.

Roughly equal numbers of freshmen, sophomores, juniors, and seniors currently are participating in U. R. O. P. , and during the past year approximately two-thirds of the student body were active in all phases of project activity. Projects run for at least one term; many last two years, with the student typically devoting 12-15 hours per week. U. R. O. P. has only one firm rule: each student must have a faculty supervisor actively involved in the subject area, whether the student's project is on- or off-campus. U. R. O. P. projects may be undertaken for academic credit or for modest personal support, but not both.

For the past four years, M. I. T. has been working closely with the Detroit Institute of Technology (DIT) in a joint program supported by Federal funds to assist in developing new curricula and improving DIT's academic standing. In collaboration with the DIT faculty, a small group of faculty and staff from M. I. T. has helped to establish new course programs, improve the quality of teaching, develop realistic long-range plans, and in general assist the DIT administration in accomplishing these goals. Elaine Price, who has been the M. I. T. Staff Coordinator for this program under the supervision of the Vice President for Research, has resigned recently, and Martha S. Draper will perform these duties in the future.

In March, 1974, Professor John F. McCarthy, Jr. of the Department of Aeronautics and Astronautics was appointed director of the Center for Space Research, replacing Professor John V. Harrington, who resigned to accept a position with the Communications Satellite Corporation. Other changes in laboratory administration were the appointments of Professors Merton C. Flemings and Peter A. Wolff as assistant directors of the Center for Materials Science and Engineering. A void, as yet unfilled, was created by the untimely death in early spring of Professor Samuel J. Mason, formerly associate director of the Research Laboratory of Electronics. Earlier in the year, Professor John G. King had been appointed to fill the vacancy created by the retirement of Professor George G. Harvey, also associate director of the Laboratory.

ALBERT G. HILL

Center for Materials Science and Engineering

The Center for Materials Science and Engineering (C. M. S. E.) has been housed in the Vannevar Bush Building since 1965. The aims of the C. M. S. E. are to initiate, encourage, fund, and coordinate interdisciplinary research in materials which is based in large part on block-funding by the National Science Foundation and further supported by individual grants to faculty members and groups. Faculty, staff, and students of the Departments of Physics, Chemistry, Metallurgy and Materials Science, Civil Engineering, Mechanical Engineering, Electrical Engineering, and Chemical Engineering, participate in the C. M. S. E. ; however, funding support is not restricted to occupants of the Center. Beginning July 1, 1972, funding of a major part of the Center's programs came from the National Science Foundation; prior to that time, funding had been provided by the Advanced Research Projects Agency of the Department of Defense.

In addition to funding support, the Center provides and maintains a series of central (service) facilities supervised by senior faculty members, such as analytical services, testing laboratories, and shop facilities, in support of research throughout the Institute. The Center has more than 80 faculty and research staff members associated through the funding program.

Approximately forty advanced degrees are awarded to students each year through C. M. S. E. funded programs.

Some of the highlights of the Center's research, greatly abbreviated, are presented below as examples of the kinds of studies under way. The reader is referred to the Annual Report on Research in Materials issued by the C. M. S. E. for a more complete view.

Electron Microscopy Applied to Metallurgical Problems Involving High Resolution

Professor John B. Vander Sande

High-resolution electron microscopy via phase contrast (direct lattice resolution) and diffraction contrast (weak-beam microscopy) has been accomplished in the two areas outlined below, and has made a substantial impact on the current state of knowledge. Also, in each area, a better understanding of the limitations and potential of these techniques has been obtained.

Early Stages of Precipitation in Al-Zn-Mg Alloys The early stages of the precipitation reaction in homogenized and quenched Al-5 Zn-2 Mg have been followed, using and comparing bright-field microscopy and direct lattice imaging. Spherical Guinier-Preston zones have been observed and identified as small as approximately 18 angstroms (\AA) in diameter. The transformation from G. P. zones to the metastable precipitate η' has been characterized. Direct lattice imaging of the (111) planes (0.23 nanometers) provides the most accurate technique for bright-field and weak-beam microscopy. This work is the first detailed observation study of the early stages of precipitation in this alloy system.

Crystallization of an Amorphous Cu-Zr Alloy Initially amorphous, splat cooled Cu-40% Zr has been annealed isothermally at various times at temperatures in the range 400-450^o centigrade (spontaneous crystallization occurs at approximately 470^o C) and the kinetics and microstructure of the alloy have been determined. Extensive use of the direct lattice imaging technique has been made to observe the crystallization process. The equilibrium Cu₁₀Zr₇ structure has a grain size of approximately 500 \AA and each grain appears defect-free. An intermediate noncrystalline structure was found and its "lattice" image obtained. These latter data are the first images of a "microcrystalline" structure. (This work was done in conjunction with Professor Nicholas J. Grant.)

Optical Interactions in Semiconductors

Professor Peter A. Wolff

Sideband Generation In collaboration with Geschwind and Romerstein of Bell Laboratories, Professor Wolff and co-workers have demonstrated that intense (>5%) sidebands are generated on an Ar⁺ laser beam, when it is passed through an n-CdS crystal whose electrons are driven at the spin resonance frequency. Theory and experiment are in good agreement. This process can be viewed as a novel optically detected form of electron paramagnetic resonance (EPR). It also may be useful as a frequency shifter in the far infrared range.

Picosecond-Pulse Dye Laser A new technique for mode-locking dye lasers has been developed. Measured pulse widths (via second harmonic generation) are 3×10^{-12} seconds. This device is simpler, and far more stable, than other mode locked dye lasers.

Picosecond Carrier Lifetimes Theory predicts carrier lifetimes in the 10^{-12} second range when $\hbar\omega_p \approx E_G$. This condition is achieved in narrow gap semiconductors such as (Pb, Sn)Te. The effect has been observed recently by Professor George W. Pratt Jr.'s group in the Department of Electrical Engineering and can be used as the basis for an ultrafast infrared detector.

Narrow Gap Semiconductors — An Ultrafast Optical Device

Professor George W. Pratt, Jr.

In $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ and $\text{Pb}_{1-x}\text{Sn}_x\text{Se}$ alloys the energy gap can be controlled by varying temperature and composition. In fact, the gap can be made to go through zero, producing an inversion of the valence and conduction bands. As the gap decreases towards zero, recombination can take place via phonon or plasmon emission. Both of these recombination mechanisms are much faster than any other processes known to date. The lifetime due to optical phonon emission should be of the order of 10^{-12} seconds, and Professor Wolff of C. M. S. E. has estimated interband recombination lifetime via spontaneous plasmon emission to be also approximately 10^{-12} seconds. These lifetimes are to be compared with typical response times in a photoconductor of 10^{-6} to 10^{-8} seconds.

These very fast recombination mechanisms permit the construction of a correspondingly fast photoconductive detector using the PbSnTe or PbSnSe alloys. Thin films of these alloys have been grown using a vapor phase epitaxy (VPE) system specially built for the purpose and for lifetimes of the order of 10^{-11} seconds. They have been measured in a sample where phonon emission was responsible for the rapid recombination. Operated as a detector, this film had a response two orders of magnitude greater than a photon drag detector; by using pulsed currents, this may be extended to four orders of magnitude. Samples suitable for plasmon emission have been grown and will be examined in the very near future. All indications are that the Center will be able to make a major contribution both in the area of the physics associated with these processes and in the instrumentation field as well.

Fracture Studies of Composite Materials

Professor Frederick McGarry

In continuing studies, the sources of fracture toughness in fiber-reinforced plastic multi-layer structural composites were identified. The micromechanics of crack initiation and growth were established, and the effects of section thickness, specimen geometry, loading rate, and environment were noted. An analysis was undertaken to determine nearly all the stress conditions at the crack tip in generalized composites, computerized, and verified. Further, the applicability of linear elastic fracture mechanics to this class of material has been established.

Chemistry of Organic Surfaces

Professor George M. Whitesides

Procedures have been developed for etching the surface of polyethylene oxidatively to generate a dense packing of surface carboxylic acid moieties. These surface carboxyl groups have been used successfully to link a variety of organic molecules to the functionalized polyethylene surface. This surface chemistry offers a versatile method of manipulating the surface properties of organic polymers at the molecular level.

The usefulness of ESCA (Electron Spectroscopy for Chemical Analysis) in the analysis of organic surface functionality has been established, and the mean escape depth of X-ray photoelectrons from organic surfaces has been determined by measurements using oriented fatty acid multilayer films. Exploration of "model" organic surfaces, based on oriented multilayer films by ESCA and Attenuated Total Reflection (ATR) infrared spectroscopies, is providing the calibrations necessary to render organic surface analysis quantitative.

Synthesis of New Sulfur Crosslinked Polymers and Elastomers Using High Temperature Sulfur Vapor

Professor Richard J. Lagow

New highly crosslinked sulfur-containing elastomers have been obtained from the reaction of sulfur vapor with monomers such as 1 butene, ethylene, and 1 hexene. The properties of these materials appear very promising. Attempts are under way to adjust sulfur reaction rates so that the number of sulfur crosslinks is decreased to improve further the properties of these materials. Another interesting feature is that sulfur epoxide monomers are produced as by-products in the reactions.

Nonclassical Mechanics of Cracks

Professor Frank A. McClintock

Beyond the usual elastic or plastic analysis of cracks, Professor McClintock's search has been directed first toward their statistical nature in polycrystalline materials. A simple statistical model has been developed for the essentially static growth of cracks in a material whose grain boundary has a random distribution of strengths. An integral formulation of the elastic stress distribution has allowed the carrying out of numerical calculations with arrays of up to 3,000 grain boundaries, containing as many as 20 or 30 micro-cracks. Compared to perfectly homogeneous materials, precracking at weak spots ahead of the main crack results in an optimum increase in toughness by about 50 percent for a coefficient of variation of .15. The numerical results can be approximated roughly by a simple model in terms of the number of adjacent micro-cracks that cause macro-crack initiation in initially uncracked material. Large increases in macro-crack toughness can be effected when the grain boundary strengths are anisotropic by a factor of three, so that extensive delamination occurs in front of the main crack.

Optical and Magneto-optical Properties of Electronic Materials

Professor Mildred S. Dresselhaus

In the Group V Semimetals, the first quantitative model for the low-quantum-number magnetic energy levels about the L-point in the Brillouin zone, including the coupling between the $j=0$ valence and conduction levels and their k_H dependence, was developed. Confirmation for this model was obtained using magneto-reflection techniques. A reversal in the magneto-reflection line-shape between the lowest quantum number inter-band and cyclotron resonance intra-band transitions was observed and explained.

Three major contributions to the understanding of the electronic properties of graphite have been made in the past year. It was shown how an analysis of the H-point magneto-reflection spectrum could be made to yield both the sign and magnitude of the Slonczewski-Weiss-McClure band parameter Δ , which expressed the difference in potential energy between the A and B lattice sites in graphite, thereby providing a convincing identification for one of the minority de Haas-van Alphen periods observed in graphite. Studies of the anisotropy in the electrical conductivity at microwave frequencies have provided strong support for the involvement of a band conduction mechanism in c-axis conduction in graphite. There has been considerable controversy about this point in the literature. To explain anomalies observed in the magneto-reflection spectrum of graphite in the low-quantum-number limit, Dr. Gene F. Dresselhaus of Lincoln Laboratory has developed a new approach to the calculation of magnetic energy level structures based on the Bohr-Sommerfeld quantization condition. This approach may have significant consequences for graphite and other materials.

Brillouin Scattering in He⁴, and Raman Scattering from Rotons in He⁴

Professor Thomas J. Greytak

Dr. Greytak and co-workers have measured the dynamic structure factor, $S(K, \omega)$, at temperatures so close to the λ transition that the conventional hydrodynamic theories no longer apply. Current theories on the dynamics of the medium in the critical region are unable to explain the experimental results.

Extremely high-resolution Raman scattering has been used to measure the line shape of roton pairs in superfluid He⁴. These line-shape measurements confirm the earlier discovery, based on the position of the peak, that the rotons form bound states.

Characterization of InSb Single Crystals Subjected to Partial Regrowth

Professor Harry C. Gatos

Analysis of the InSb crystals grown in outer space (Skylab mission) established that diffusion controlled steady-state conditions, never accomplished on earth, were achieved during the growth of Te-doped InSb crystals. Furthermore, it was discovered that surface tension effects led to nonwetting conditions under which "free surface" solidification took place in confined geometry. In addition, it was possible for the first time to identify unambiguously: 1) the origin of segregation discontinuities associated with facet growth; 2) the mode of nucleation and propagation of rotational twin boundaries; and 3) the specific effect of mechanical-shock perturbations on segregation. Extensive use of central facilities at the Center for Materials Science and Engineering made possible the characterization of this material.

NICHOLAS J. GRANT

Center for Space Research

The Center for Space Research has continued a program of space science and engineering studies over the past year, involving projects under the supervision of approximately 20 faculty members from the Departments of Physics, Earth and Planetary Sciences, Nutrition and Food Science, Aeronautics and Astronautics, and Electrical Engineering. This research has been supported by approximately 55 full-time research staff and 45 hourly and biweekly personnel. Approximately 35 students have been involved directly under fellowship appointments and research assistantships, and 35 more as part-time employees.

Significant developments in the several ongoing and proposed space flight experiments are described here, and a summary of overall activity in the Space Center is presented. The reader is referred to the portion of the Department of Physics report dealing with cosmic ray and interplanetary plasma research for additional discussion of objectives and results from this research. Primary support for the Center's research comes from the National Aeronautics and Space Administration (NASA). The National Science Foundation and other sources make up less than ten percent of the total.

The Interplanetary Monitoring Platform (IMP-J) experiment, under the supervision of Professor Herbert S. Bridge of the Department of Physics, Associate Director of the Center, was launched into Earth orbit in October, 1973. Excellent data is being received from this new spacecraft, which followed an earlier launch made with IMP-H (now known as IMP-7) in October, 1972. Together, the two spacecraft will provide full coverage of the

interplanetary solar wind and will allow simultaneous studies of the Earth's magnetosphere for at least a one-year period. Senior Research Scientist Alan Lazarus and Drs. Joseph Binsack and Erwin Lyon assisted with the design and development of the experiment. Robert Butler supervised the design and development of the instruments.

The M. I. T. X-ray detector on the OSO-7 satellite, which was launched on September 29, 1971, has continued to operate effectively. It is expected to provide useful data on cosmic X-ray sources until the time of reentry, which will occur during the summer of 1974. Among the recent results from this experiment is an observation of a sudden absorption dip in the X-ray intensity of Cygnus X-1, which provided new evidence supporting the identification of this object as a black hole. Other results were published on the nature of the X-ray star Her X-1 and on the properties of the supernova remnant IC443. This research has been conducted under the supervision of Professor George W. Clark of the Department of Physics.

Preparations have gone forward for the flight of the M. I. T. X-ray Observatory on the Third Small Astronomy Satellite, SAS-C. Now scheduled for launch in the summer of 1975, the X-ray Observatory will provide data of unprecedented accuracy on the positions, spectra, and time variations of hundreds of galactic and extragalactic X-ray sources. The first of two flight units was completed at the M. I. T. Laboratory for Space Experiments and was delivered to the Goddard Space Flight Center of NASA in early June, 1974. The Observatory will be launched from a base off the coast of Kenya, and during the succeeding months its use will be directed, hour by hour, from an operations headquarters at the Center for Space Research. Professor Clark is also the principal investigator on this experiment. Co-investigators are Professors Hale V. Bradt and Walter H. G. Lewin of the Department of Physics, and Dr. Herbert W. Schnopper of the Space Center.

The X-ray astronomy experiments from sounding rockets are under the supervision of Professors Bradt and Saul A. Rappaport, also of the Department of Physics. Much effort has been concentrated on soft X-ray measurements (0.15 to 1.5 KeV) with a survey of about one-third of the galactic plane from Cygnus to Norma; a study of the X-ray structure of the Cygnus Loop; the first report of a central object in the Cygnus Loop; and more recently a survey of the Large Magellanic Cloud. These measurements have been made with a one-dimensional X-ray telescope and multi-anode proportional counter. Fast-timing experiments also have been carried out with other astronomical observations.

The Mariner-Venus-Mercury interplanetary plasma experiment, under the supervision of Professor Bridge, was launched in November, 1973. The spacecraft made its scheduled encounters with Venus and Mercury, and a second intercept with Mercury is due in September, 1974. The encounter with Mercury was the first intercept by a spacecraft, and showed that Mercury has a magnetic field strong enough to stand off the solar wind. The observation of such a strong field was unexpected, and it is not certain whether that field is intrinsic to the planet or is induced through an interaction with the solar wind.

The solar radiation (SOLRAD) experiment comprises a pair of identical satellites to be placed in a circular equatorial orbit of about 20 earth radii. The satellites, oriented toward the sun, will provide 100 percent real-time continuous monitoring of the solar X-ray, ultraviolet, and energetic particle emissions. The solar-wind-monitoring instrument was designed under the supervision of Dr. Alan Lazarus by several students who made major contributions to the concept, detail design, and testing. Launch is scheduled for November, 1975.

X-ray astronomy experiments from high-altitude balloons under the supervision of Professor Lewin have continued. On June 21, 1974, an outstanding nine-hour flight at a 135,000-foot altitude was accomplished. The launch was made from the National Center for Atmospheric Research at Palestine, Texas. X-rays from the Perseus and Coma clusters of galaxies were the object of the experiment. Preliminary examination of the results

indicates that excellent data will have been obtained. Drs. George R. Ricker, Jr. and Anton Scheepmaker assisted with the design and development of the instruments.

The Astronomical Netherlands Satellite (ANS) X-ray spectroscopy experiment, for which Dr. Herbert W. Schnopper has provided a two-crystal spectrometer, is proceeding toward a planned launch in 1974. The objectives of this experiment are to observe hard X-rays from cosmic sources in the 2 to 40 KeV energy region.

The High Energy Astronomy Observatory (HEAO) experiments of Professors Lewin and Bradt have been redefined under the restructured Mini-HEAO program. After proceeding into the hardware contract stage for the two separate X-ray astronomy experiments originally proposed by Professors Lewin and Bradt for the HEAO-A mission, a major redirection of the total mission by NASA resulted in a much reduced effort by M. I. T. In the new program, no flight instruments will be provided. M. I. T. will assist in the design of the X-ray experiments and in the analysis and interpretation of the data. The new planned launch date is in 1977.

The Mariner-Jupiter-Saturn interplanetary plasma experiment is under the supervision of Professor Bridge. Co-investigators include Professors John W. Belcher, Stanislaw Olbert, and Vytenis M. Vasyliunas, all of the Department of Physics, and Drs. Binsack and Lazarus of the Space Center. The breadboard design of the experiment is progressing. Two separate spacecraft will be launched within one month of each other in 1977. An encounter with Jupiter is planned for 1979, at which time the experiment will study the magnetosphere in more detail than was possible in the Pioneer 10 and 11 experiments. The spacecraft then will leave Jupiter for an encounter with Saturn. The plasma investigation will make use of Faraday cup detectors, one pointed along the Earth-spacecraft line and one at right angles to this line. The Earth-pointing detector will determine the macroscopic properties of the plasma ions, obtaining accurate values of their velocity, densities, and pressure. The side-looking detector will measure electrons in the energy range from five electron volts to one kilo-electron volt.

The flight preparations for the X-ray telescope on the High Energy Astronomy Observatory, HEAO-B, have begun, with responsibility for the focal plane curved-crystal Bragg spectrometer assigned to M. I. T. A large high-vacuum computer controlled facility for developmental testing has been placed in operation, and an engineering test unit of the final-flight hardware has been constructed. The HEAO-B presently is scheduled for launch in 1978. Professor Clark is the principal investigator for this experiment.

The Surface Electrical Properties Experiment (SEP) was carried out on the lunar surface in December, 1972, as part of the Apollo 17 mission. While the total yield of experimental data did not come up to original expectations because of operational problems connected with the lunar Rover, good data was obtained for a portion of the Rover trips over the lunar surface. This data has been analyzed at M. I. T. and at the University of Toronto in conjunction with the Johnson Spacecraft Center in Houston, Texas. The studies confirm the absence of water in the lunar subsurface, at least in the Tarus-Littrow region which was the Apollo 17 landing site. The data indicates that the relative dielectric constant increases with depth (from about 3.5 at the surface to 6-7 at 100 meters), and the dielectric constant remains in the 6-7 range from 100 meters to 2.5 kilometers below the surface. The measured loss tangent is no larger than 0.5 and possibly as small as 0.002. Electromagnetic scattering at frequencies of 1-32 megahertz (MHz) is absent in the Tarus-Littrow region, which implies that subsurface "boulders" of dimensions in the range of 10-300 meters are not present within 1-2 kilometers of the surface. This research was carried out under the supervision of Professor Gene Simmons of the Department of Earth and Planetary Sciences and Professor John V. Harrington of the Departments of Electrical Engineering and Aeronautics and Astronautics. Professor Jin-Au Kong of the Department of Electrical

Engineering at M. I. T. and Professor David Strangway of the Department of Physics at the University of Toronto assisted with the data analysis and interpretation of results. The actual design and construction of the equipment used on the lunar surface was performed by a team under the direction of Dr. James E. Meyer, on loan to the Center from the Lincoln Laboratory. The major part of the construction was done under subcontract at the Raytheon Corporation.

Using funds supplied to the Center by the basic NASA grant for space science and technology research, Professor Clark has designed and constructed a new system for analyzing the optical spectra and time variations of faint stars. This new system, which will be used at the Cassegrain focus of a telescope to record the energy and arrival time of each detected photon, employs an echelle spectrograph and a photon-recording vidicon camera. It will be completed in time to carry out optical observations of objects in coordination with X-ray observations from the SAS-C satellite.

Other continuing projects under the basic NASA grant include: observations on celestial objects in the infrared spectral ranges by Professor Susan G. Kleinmann of the Department of Physics; the further development of a precise pointing control system for X-ray telescopes mounted in long-float, high-altitude balloons, by Professor Walter H. Lewin of the Department of Physics; and the development of vidicon imagery devices for optical telescopes, by Professor Thomas B. McCord of the Department of Earth and Planetary Sciences. In addition, exploratory research has been supported by these funds which has led to proposals to NASA for the electromagnetic exploration of the moon's crust and upper mantle by Professor Simmons; for radar altimeter and radiometer experiments on the Pioneer Venus orbiter by Professors Gordon H. Pettengill and Irwin I. Shapiro of the Department of Earth and Planetary Sciences and Professor David H. Staelin of the Department of Electrical Engineering; for a large-area high-time resolution X-ray experiment on the Apollo-Soyuz Test Program by Professor Bradt; and also for the Apollo-Soyuz, a study of the potential biological effects of illumination on astronauts, by Professor Richard J. Wurtman of the Department of Nutrition and Food Science.

New efforts, supported by the NASA basic funds, are under way to develop concepts and proposals for space experiments related to the new payload capabilities of the NASA Space Shuttle system. Three separate regimes for space experiments are envisioned which are expected to be of prime interest to M. I. T. faculty investigators:

1. An extension of the existing astronomical observatory role for space missions to heavier and more sophisticated observatories. At the same time these new facilities may become less costly, because of the ability of the Space Shuttle to revisit, refurbish, and/or return components to Earth for servicing and repair.
2. A continuation and expansion of the Earth resources role for studies of the physical properties of the Earth's surface features and atmosphere. Again, these investigations will be facilitated greatly by an order-of-magnitude increase in payload weight and observational time to be made available by the Space Shuttle.
3. A relatively new regime of space experiments, which has been touched upon only lightly to date, will come into being, permitting physical science, engineering, and life science studies to be conducted in the unique space environment. As planned, free-space, zero-gravity (0-g) experimentation will be possible, as well as research at 0-g in a shirtsleeved environment using enclosed laboratories and manned by scientists and engineers drawn from ordinary walks of life with a minimum of special astronaut training required. It is felt that M. I. T. research investigators face exceptional opportunities in this new regime, and the Center

is prepared to assist and encourage the initiation of research in this new area as well as in the other more established areas.

For several years, the Center for Space Research has cooperated in the building up of a productive research program in theoretical astrophysics. The research of Professor Philip Morrison of the Department of Physics has been a central feature in this effort, and while the early support for his research, as well as for others, received a large assist from the Center's basic NASA funds, financial support has been shifted recently to other sources, principally the National Science Foundation. The Center continues to provide administrative support for Professors Morrison, Kenneth Brecher, and other associates of the Department of Physics. Within the past year, a new project was established under the NASA funding for Professor Paul C. Joss, also of the Department of Physics, for research on comets, stellar evolution, X-ray sources, and related phenomena.

In November, 1973, Professor John V. Harrington went on leave from M. I. T. to take a position as Vice President for Research and Engineering at the Communications Satellite Corporation. Professor Harrington had been the first director of the M. I. T. Center for Space Research, having taken up these duties in June, 1963. His vision and leadership in developing new research programs and the space experiment payload design and fabrication facilities within the Center contributed greatly to the success of the several space missions for which the Center has had a prime responsibility.

Professor Herbert S. Bridge, Associate Director, succeeded Professor Harrington as acting director of the Center until March, 1974.

Administrative support and research facilities have been provided in the Space Center for the program of man-vehicle oriented research by Professors Laurence R. Young, Renwick E. Curry, and Charles M. Oman, all of the Department of Aeronautics and Astronautics. Major studies have been carried out in the field of motion sickness, disorientation, and the underlying physiological mechanisms associated with spatial orientation. These areas of research have become of major interest because of the repeated cases of motion sickness and disorientation by astronauts in both the American and Russian programs. New interdisciplinary research efforts in these general areas are considered of prime importance to the future program of the Center.

Closely allied to the research of Professor Young and his associates has been the work of Professor Richard Wurtman's group, which also has made use of the facilities and funding support of the Space Center over the past several years. There are now strong indications developing in the space program that the dose-response relationships between light exposure and biological effects of light on humans need further study and refinement, in proposed long-duration space flights. This area of program development also is being pursued energetically.

The overall activities of the Center have continued to show a more diversified format, and further efforts in these areas are indicated for the future. Total research volume for the year presently is projected at about \$4.8 million, exclusive of major subcontracts. In order to provide financial stability and better interdisciplinary representation in its program, it is the goal of the Center to expand the total level of research volume by 50 to 100 percent.

JOHN F. MCCARTHY, JR.

Energy Laboratory

In the past year the Energy Laboratory has strengthened its role as the focal point for energy related research at the Institute. The Laboratory's first year of operation was spent in confronting organizational and policy issues. This fiscal year has seen substantial research under way and active development of many new research areas. During this time, the Laboratory has made significant progress in increasing its visibility both within and outside of M. I. T.

This progress is evidenced by an increase in the number of both grants and contracts from various sources. The Laboratory's first grants from the New England Electric System and the General Electric Company have been supplemented by major \$500,000 general support grants from both Exxon and the Ford Motor Fund. Approximately half of these funds has been allocated by the Laboratory for use during 1974-75 in a number of specific research areas which are under development. In addition, the Laboratory has received several grants for the support of specific research areas, including \$200,000 from the Rockefeller Brothers Fund for support of energy policy studies; \$20,000 from General Electric for energy resource and policy research; and \$100,000 from J. B. Hawley, Jr., President of Northern Pump Company, for support of a program for the evaluation of methanol as an automotive fuel. Several M. I. T. Corporation members, encouraged by Corporation Member Robert Sprague, have established a fund for energy policy studies, and part of the gift of the Class of 1924 has been allocated to the Energy Laboratory, a portion specifically for library development. The total research volume of the Laboratory, including sponsored research as well as grants, has increased from \$800,000 in fiscal year 1974 to a projected \$3,300,000 in fiscal year 1975.

To support this increase in activity, additional full-time personnel have been hired, and a larger number of faculty members have become involved in Energy Laboratory programs. Graduate student research assistants now total 30 from more than ten different departments. As a special laboratory, the Energy Laboratory does not appoint faculty members. Thus the full-time personnel (Division of Sponsored Research staff) appointed by the Laboratory form only a portion of its manpower. A major part of the Laboratory's research is carried out by some 65 faculty members from ten different departments and Schools. Many of the researchers have undertaken energy oriented projects which require new full-time staff, expanded facilities, administrative management, and/or faculty participation from other departments. Such projects have become an integral part of the Energy Laboratory's program and represent a firm lease for future growth.

During the past year, significant activity has developed on energy economics, management, and policy. Based on many years of work by faculty members of the Sloan School of Management and various M. I. T. departments, research expanded in three major areas: energy sector modeling, energy data and management information systems, and policy studies. Work is continuing on an econometric model of the natural gas sector of the United States economy, in an attempt to analyze Federal policies regarding the field price regulation of this fuel. A second activity is a study of inter-fuel competition in the U. S. economy, based on a model of the energy sector including electric power. A new activity, undertaken during the past year, concerns energy data and management information systems for policymaking in the energy area. As a result of a voluntary effort to assist during the tight oil supply conditions of the winter of 1973-74, a project has evolved on the construction of an energy management information system for New England. Discussions between M. I. T. officials and members of the Federal administration led to a set of short-term policy studies. In December, 1973, a policy paper was prepared on gasoline rationing, and in the winter and

early spring a study was done on the emerging Federal policy regarding energy self-sufficiency. This study was presented to senior government officials in March, 1973, and published in the May issue of Technology Review. These policy studies draw upon the research of M. I. T. faculty members plus that of associates in other institutions, government, and industry, and have a goal of developing a format which will be of use to the public and to policymakers in this critical area.

In the electric power area, a major effort involving joint support by New England Electric Systems and Northeast Utilities has led to the establishment of an Energy Laboratory Electric Power Program (E. L. E. P. P.) of research for the New England electric power industry. The Boston Edison Company is aiding this regional activity, and the more widespread involvement of other New England electric power companies is being sought. The E. L. E. P. P. is focused on waste heat management, nuclear power safety research, and systems planning and operation.

Major projects have been under way during the past year dealing with waste heat management, under the sponsorship of the E. L. E. P. P., the Duke Power Company, Consolidated Edison, and the Empire State Electric Energy Research Corporation. Research on methods of improving the environment and economic characteristics of cooling towers has continued. In an attempt to minimize the environmental impact of power-plant heat rejection, work has been conducted on rejection systems having no interaction with water bodies and a negligible or zero water consumption. Emphasis has been on both heat-transfer-coefficient enhancement and a low cost for the heat-exchanger surface. A project -- both theoretical and experimental -- toward improved prediction of cooling pond performance has been initiated under the sponsorship of the Virginia Electric Power Company and the Stone and Webster Engineering Company. Under the sponsorship of the U. S. Atomic Energy Commission's Directorate of Licensing, a critical evaluation of the physical validity, degree of field verification, and computational utility of mathematical models for environmental impact prediction has been carried out.

Another project in this group attempts to improve the performance of heat-pump systems by the use of automatic control. Computer simulations are being refined to indicate the most effective control parameters and possible improvements, and some preliminary hardware design has been undertaken. Investigation also is being made into solar energy assisted heat-pump systems. A heat pump with a variable compression ratio combined with the simplest possible solar collector forms a low-operating-cost solar system with the prospect of moderate investment. Work is under way in the design of the compressor for the heat pump and of the complete system.

The Nuclear Power Reactor Safety Research Program, sponsored by the E. L. E. P. P., is focused on issues of concern to the New England utility companies, including: 1) light-water reactor physics parameters for transient analysis; 2) fuel performance analysis during normal and transient conditions; 3) thermal/hydraulic core performance analysis; and 4) structural analysis and design for missile protection.

In the systems area, the Atomic Energy Commission is supporting research to demonstrate the feasibility of a supplementary control system (fuel switching) by actual operation, using real-time meteorological and air quality monitoring data. Other continuing studies of electric systems include: 1) determination of power system expansion sensitivities to a variety of economic and environmental factors, including power plant siting; 2) development of detailed load (demand) models suitable for pricing, new technology, and sensitivity studies, as well as for long-range forecasting; and 3) development of new data processing techniques for air quality monitoring data.

In the fossil fuels area, research projects span a broad range of activities. In conjunction with the Department of Chemical Engineering, the Energy Laboratory currently is developing computer simulations of various fuel-to-fuel conversion processes. The pollution characteristics of various fuels and combustion techniques are under active study, as is the removal of sulfur and nitrogen compounds from fossil fuels and their derivatives. Laboratory work on coal gasification is proceeding, and the possibility of direct electrochemical conversion of fossil fuels to electric energy is under examination.

Research on magnetohydrodynamic power generation involves three fronts: 1) cycle optimization work, which has led to the development of a model which takes full account of public utility economics as well as the available engineering data on the energy-conversion devices themselves; 2) materials research which has focused on the high-temperature thermochemistry of the refractory materials needed for the insulator and electrode walls of magnetohydrodynamic (MHD) generation; and 3) fluid-mechanical studies, which have yielded new insights into the nature of certain types of instabilities in linear and disk-type MHD generation and of the process of inter-electrode breakdown and arcing phenomena. A closer coupling between the fluid-mechanical and materials research efforts is being sought, particularly because of the critical nature of the slag layers expected in practical coal-fired generation.

Two projects on automotive research are currently in preparation, with extensive activity planned for the coming year. The first is a program to develop a sound technical framework for evaluating changes in conventional spark-ignition engines to improve lean engine operating characteristics. The second involves an attempt to place in perspective the Federal government's role in the development of new automotive engine technology for the period 1975-1990. Current Federal programs on advanced automotive engines will be evaluated in the context of automotive industry efforts and resource limitations likely to be in effect through the 1980s.

Projects on energy productivity are under active development. One activity of the past year has been assisting the Bureau of Administration and Finance of the Commonwealth of Massachusetts in devising methods to reduce the consumption of fuel oil. Energy Laboratory staff members already have formulated a methodology which enables the Bureau to estimate and monitor the requirements for fuel oil based on such factors as degree-days and thermostat setback. In addition, an Emergency Energy Committee was formed in November, 1973, by Governor Francis W. Sargent to assist his staff in the preparation of plans to meet the threat of a major energy shortage last winter. The Committee, chaired by Professor Henry Jacoby of the Sloan School of Management, included Professor James A. Fay and Dr. James J. MacKenzie of the Department of Mechanical Engineering, and Dr. James W. Meyer and Professor David C. White of the Energy Laboratory. A plan, the "Massachusetts Energy Conservation Contingency Plan," was distributed by Governor Sargent in draft form in January, 1974. Professor White and William J. Jones, Research Associate in the Department of Physics, also have been helping the Federal Power Commission on the technical aspects of energy conservation in the generation, transmission, distribution, and utilization of electric power.

The Energy Laboratory, in conjunction with Lincoln Laboratory, is planning a program of advanced solar research, concentrating initially on the investigation of heat mirrors, photo-electrolysis, and solid electrolytes. The Laboratories are aware of the need to investigate methods of utilizing solar energy as heat or as photon interactions to another energy source (electricity or chemical fuels), and recognize the problem of storage of energy as inherent in the use of an intermittent source such as solar energy.

Of increasing interest in the past few years has been the possibility of using methanol (wood alcohol), which can be made from coal, waste, and biomass, as a clean, easily stored vehicle fuel. Dr. Thomas Reed of Lincoln Laboratory wrote a review for Science magazine

on the success of Lincoln Laboratory experiments with blends of 10 percent methanol and gasoline in unmodified cars. One reader of the article, J. B. Hawley, Jr., a Minneapolis industrialist and owner of gas and oil wells, has donated \$100,000 to establish a methanol program within the Energy Laboratory. The next academic year will see work with various government agencies and industries in testing methanol as an automotive fuel and in the investigation of new methods of production.

Other studies and projects in the energy field are being discussed, and proposals are being prepared for a variety of sponsors. As the governmental reorganization for energy research becomes defined more clearly, several proposals for block grant support in specific technical areas will be submitted to the relevant Federal agency. The M. I. T. Energy Laboratory expects to experience continued growth during the coming years as priorities for energy research become better articulated.

DAVID C. WHITE

Francis Bitter National Magnet Laboratory

This was a year of substantial progress in all aspects of the Laboratory's program, even though funding uncertainties and national inflation hindered efforts to exploit newly developed ideas fully.

The Alcator plasma fusion experiment, conducted in collaboration with the Research Laboratory of Electronics, was operated successfully at liquid nitrogen temperature with circulating currents exceeding 200 kilo-amperes at 55 kilogauss. Measurements of the plasma temperatures are in progress.

The step-tunable high-intensity far infrared source obtained by noncollinear mixing of two CO₂ lasers, which first was developed on a pulsed basis in 1972, now has been operated in the continuous wave mode. This broad band source should have important technological applications and provide a new tool for research. The extension to continuous operation was achieved in a collaborative program with the Solid State Division of the Lincoln Laboratory.

Recent experimental studies have shown for the first time that a plasma produced by CO₂ laser induced gas breakdown in the presence of a strong magnetic field can act to trap the impinging laser radiation. These initial measurements indicate that it may be possible for a laser produced plasma to serve as a dielectric waveguide, thus facilitating the heating of a long plasma column by high-power laser radiation. The attainment of dielectric waveguiding has important implications for the application of laser heating of magnetically confined plasmas for controlled thermonuclear fusion.

The Laboratory has measured the upper critical field of niobium-germanium thin film superconductors prepared by Dr. J. R. Gavaler of the Westinghouse Research Laboratories. This material has the highest critical temperature of any known superconductor. The Laboratory also has measured upper critical fields of ternary molybdenum sulfides prepared at the Laboratory. Both these materials show promise for improving the performance of magnets and other superconducting devices.

In collaboration with Professor Richard H. Holm of the Department of Chemistry, the Laboratory is using Mössbauer spectroscopy in external magnetic fields to study the electronic and magnetic properties of synthetic analogs of the active sites of the nonheme, iron-sulfur proteins. It is expected that this work will allow researchers to understand the often unique physical properties of the proteins themselves.

A program of high-magnetic-field, high-resolution nuclear magnetic resonance studies of biological molecules has been initiated. A commercial unit, operating at seven teslas, is in operation. Plans for construction of the Laboratory's own prototype seven-tesla magnet, using multi-filament superconducting wire, are well along. It is hoped that a 12.5-tesla magnet with a homogeneity of one part in 10^9 can be built.

A new system for producing magnetic fields greater than 25 teslas for periods of the order of one second has been demonstrated successfully. The Laboratory's motor-generator power supply is switched on and off electronically to provide the required power pulse. This technique is expected to provide fields up to approximately 50 teslas for periods of 0.1 to 0.5 seconds, and will fill the gap between the Laboratory's 22-tesla continuous magnet and the present pulsed systems which have pulse durations of the order of milliseconds and smaller.

Design of the next generation 25-tesla hybrid superconducting and water-cooled magnet has been completed under the sponsorship of the Katholieke University of Nijmegen, the Netherlands. Construction will begin in the coming year.

A superconducting magnet has been completed for use in the magnetic catheter system being developed jointly with the Massachusetts General Hospital. With the much stronger fields of this magnet now available, studies of nonsurgical treatments of brain disorders by magnetically guided and propelled catheters will be resumed.

In approximately one of every 12,000 live births, the esophagus is incomplete and the two ends are separated by too great a distance for direct surgical connection. In collaboration with the Massachusetts General Hospital, the Laboratory has developed a magnetic system which gradually stretches and induces growth of the two ends toward each other. Small iron slugs are placed in the two ends, and a solenoid magnet, into which the baby is placed, exerts easily controllable forces on the slugs. In the first patient, the esophagus was joined surgically after 55 days in the magnet.

Student participation in the work of the Laboratory continued at a high level. Twenty-eight undergraduate students were affiliated with the Laboratory in various capacities. Twenty-four M. I. T. graduate students were based at the Laboratory, and numerous others from M. I. T. and other universities used the high field facilities in their research. Approximately 3,400 hours of magnet time were used in 1973-74 -- 30 percent in Laboratory projects, 23 percent by other M. I. T. organizations, 28 percent by non-M. I. T. organizations, and 19 percent in collaborative programs of the Laboratory and other organizations.

BENJAMIN LAX

Laboratory for Nuclear Science

The Laboratory for Nuclear Science provides support for research in nuclear and elementary particle physics by faculty members and associated research staff. It supports the activities of the Center for Theoretical Physics in these fields, and provides a computing facility for the theoretical and experimental programs and for some of the activities of the Center for Space Research. It also supports experimental research programs in three areas: 1) nuclear structure physics, with current emphasis on heavy ion physics; 2) intermediate energy nuclear physics, centered at the Laboratory's Bates Linear Accelerator in Middleton, Massachusetts; and 3) elementary particle physics, with current programs at six accelerator facilities, four in this country and two in Europe.

Progress of the theoretical studies is reported by the Center for Theoretical Physics. Here are presented some salient developments of the experimental programs.

Nuclear Structure Physics

Research in this area has shifted almost entirely to the study of processes involving accelerated heavy ions, such as carbon, oxygen, or neon. Because of the large momenta of these ions, their trajectories can be localized in small regions of the nuclear surface. Two groups in the Laboratory, in collaboration with workers at the University of Rochester, the Niels Bohr Institute in Copenhagen, and Brookhaven National Laboratory, have used this feature to obtain very spectacular interference phenomena, somewhat analogous to a rainbow, involving details of the nuclear force field.

Great interest attaches to reactions in which heavy ions fuse with the target nuclei, since these ultimately may permit the production of super-heavy nuclei. A study of fusion reactions has been carried out by means of a novel flight-time spectrometer developed at Brookhaven by Laboratory staff members.

Other interesting results have been obtained in the study of quasi-molecular resonant states in heavy ion collisions and in the search for fission isomers.

Bates Linear Accelerator

This facility is designed to produce a very uniform beam of electrons with energy up to 400 million electron volts. During the spring and summer of 1973, a series of intensive studies was undertaken by the Laboratory staff and by two study groups of the sponsoring agency to delineate the future of this facility. As a result of these studies, the Bates Linear Accelerator (LINAC) is considered a pivotal facility for the national program in intermediate energy physics. The initial research program gives priority to studies of nuclear structure by inelastic electron scattering, using a magnetic spectrometer of advanced design. In the fall of 1973, matching grants by M. I. T. and the Atomic Energy Commission were provided to bring the accelerator and spectrometer into operation. In January, 1974, full-energy acceleration was achieved, other design objectives having been reached previously. The spectrometer was assembled completely and all components tested by June, 1974. A powerful on-line computer facility has been installed. Some preliminary experiments on pion photoproduction have been carried out with simpler instrumentation.

Elementary Particle Physics

The program in high-energy physics was faced with pressures due to the generally stringent government funding in this field, but all major projects continue to progress vigorously. The national effort has been focused increasingly on the exploitation of the large accelerator at the Fermi Laboratory in Batavia, Illinois. The development of the required new elaborate experimental facilities is being carried out by large groups of workers from several major institutions, who plan to exploit them independently after initial joint experiments. Staff members of the Laboratory are playing pivotal roles in two such collaborations. Initial results concerning the strong interactions of mesons and protons have been obtained by both groups.

Several of the older experiments carried out with accelerators of the Brookhaven, Argonne, and Stanford Linear Accelerator Laboratories have produced significant results during the past year.

Early in 1973, a joint Harvard-M. I. T. team announced the very surprising observation that the production of mesons by colliding electrons and positrons does not increase with increasing energy, as had been expected. This result was obtained with the Cambridge Electron Accelerator.

ator, which since has been closed down. In January, 1974, it was confirmed by a group at the Stanford Linear Accelerator. This may be the first indication of a structure of the electron.

During the past year, further results on inelastic collisions of electrons with protons and neutrons were presented by members of the Laboratory. Interpreted in the framework of the "parton" model developed to explain earlier experiments of this group, the latest results throw light on the number, charge, and angular momentum of these constituents of elementary particles.

Another group has completed installation and begun operation of a major experiment at Brookhaven National Laboratory designed to throw light on another aspect of electromagnetic interactions through the observation of charged particle pairs.

In the field of "strong" interactions of elementary particles, the bubble chamber group has published results concerning the reactions of mesons and antiprotons with nucleons in which the reaction products are emitted close to the collision direction. These results appear to lead to a simpler and more comprehensive model of such reactions than had been considered previously. Other experiments in progress are producing novel and challenging results concerning the annihilation of antiprotons and very-high-energy reactions with complex nuclei.

Logistics

Laboratory staff during the past year totaled approximately 410 persons. This included 50 academic staff members, 64 graduate students, at least 76 undergraduates from M. I. T. and neighboring institutions (e. g., Northeastern University work-study students), 50 research staff members at the doctoral level, and 172 employees in supporting categories (engineers, technicians, machinists, administrative, and computational). A total of 15 Doctor of Philosophy degrees, three Master of Science degrees, and eight Bachelor of Science degrees were completed during this period by students engaged in thesis research within the Laboratory.

A breakdown of the support under the Atomic Energy Commission contract for fiscal year 1974 is as follows: operational costs (salaries, wages, employee benefits, materials, services, and travel) -- approximately \$2,585,000 for experimental and theoretical high-energy physics; \$1,700,000 for medium-energy physics; and \$850,000 for nuclear structure theory and experiments. Equipment funding under the AEC program during this period totaled \$1,011,000, broken down as follows: \$261,000 for high-energy physics; \$700,000 for medium-energy; and \$50,000 for low-energy physics. An additional sum of \$50,000 was supplied for general plant projects associated with the Bates LINAC facility.

MARTIN DEUTSCH

Lincoln Laboratory

This year Lincoln Laboratory has continued to make steady, significant progress in all principal research programs without major alterations in scope or content. These programs include radar and infrared sensors, reentry vehicle phenomenology, communications, digital signal processing, electro-optics, and air traffic control, with substantial supporting research in solid-state devices and microelectronics.

Intensive efforts continue in the fabrication and testing of the next Lincoln Experimental Satellites, LES-8 and 9, scheduled for launch late in 1975. These satellites will employ UHF (ultrahigh frequency) and millimeter wavelength communication repeaters, three-axis stabilization, and radio-isotope thermal electric power supplies. The Schottky barrier diodes

developed for use as mixers in the 37,000-megahertz receivers for the satellites are proving to be useful as harmonic mixers and detectors of far-infrared laser radiation. In this application, they permit frequency measurement with unprecedented ease and stability in the 0.1-1.0 millimeter (300-3000 gigahertz) region of the spectrum.

A new long-range infrared radar system now going into operation at the Firepond Research Facility on Millstone Hill in Westford, Mass., uses a 1-kilowatt carbon dioxide laser transmitter with a 48-inch optical aperture pointing mount to direct the transmitted beam and to collect return reflections. Heterodyne detection permits precise, high-resolution Doppler measurement to complement the high angular resolution provided by the narrow infrared beam.

The development of the Discrete Address Beacon System (DABS) is the major element of Lincoln Laboratory's work in air traffic control. This system will enable controllers to handle increasingly greater traffic volumes and densities with the aid of automated interrogation of, and communication with, individual aircraft. The completion of the DABS system engineering design was a noteworthy milestone in this project. Other related activities include the development of a precision approach landing monitor and the modernization of airport surveillance radars.

New technology for the control and manipulation of wide-bandwidth elastic waves on the surface of piezoelectric crystals has yielded several devices of unusual interest. A reflective array compressor, now used for pulse-compression in the Laboratory's high-resolution ALCOR radar system, is mounted on a single ten-inch panel and supplants the equivalent of eight full racks of conventional delay-lines and associated electronics, with a comparable reduction in fabrication cost. Grating-reflection techniques also have been used in a compact, high-performance 16-element bandpass filter bank for a real-time radar-frequency spectrum analyzer. An adaptive analog signal-processing device that generates the convolution of two input signals uses the surface waves to distort the carrier distribution in a silicon slab very close to the crystal surface.

In January, 1974, after months of careful preparation, the Laboratory's computer center made a relatively painless transition to an IBM 370/168 computer, replacing a 360/67 installed seven years ago. The 360/67 provided the Laboratory's first opportunity for time-sharing on a significant scale, as well as batch processing, but its capacity no longer could meet the Laboratory's needs. There are now more than 100 terminals at locations throughout the Laboratory, and sometimes there are as many as 75 simultaneous users. Indeed, time-sharing use has increased very substantially since the installation of the new system, which has provisions for further expansion as needs require.

The Laboratory's Education Program was initiated a year and a half ago, to help Lincoln personnel maintain and extend their scientific and engineering knowledge, skills, and effectiveness. After the first term, eligibility was extended to engineering and technical assistants, programmers, and other exempt personnel, as well as staff members. Total enrollment for three terms to date has been 553, and has included more than 40 percent of those eligible. Most of the subjects, developed and taught by Lincoln Laboratory staff members, have dealt with communications, solid-state theory and applications, optics, digital processing, and other areas related to Laboratory programs; the curriculum also has included two subjects prepared by the M. I. T. Center for Advanced Engineering Study.

GERALD P. DINNEEN

Research Laboratory of Electronics

The Research Laboratory of Electronics (R. L. E.), the first of the Institute's interdepartmental laboratories, was established to encourage interactions between teaching and research in the Departments of Electrical Engineering and Physics. Over the years the Laboratory's projects have involved participants from as many as a dozen academic departments. The research groups, currently numbering approximately 30, conduct their studies in three broad areas: communication sciences, general physics, and plasma dynamics.

The research in R. L. E. is conducted primarily by faculty members and students. Approximately 90 members of the faculty are affiliated with the Laboratory, working with approximately 270 graduate students and nearly 100 undergraduates. The research spans a broad spectrum of topics and thus provides a wide variety of opportunities for student thesis work. During the past year, the research in the Laboratory provided the basis for 25 doctoral, 10 engineer's, 45 master's, and 35 bachelor's theses.

Major support for the research is provided by the Joint Services Electronics Program of the Army, Navy, and Air Force, and by the Atomic Energy Commission, the National Science Foundation, the National Institutes of Health, and the National Aeronautics and Space Administration.

General Physics

The Laboratory's research in general physics is based largely 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 make use of extremely high-frequency vibrational waves, liquid helium temperatures, and computers. A few of the research topics in this area follow.

Professor John G. King and Research Associate James Weaver have continued the development of two types of molecule microscopes. These instruments will provide useful spatial and temporal resolution for the study of neutral molecule emissions from biologically significant surfaces and from semiconductor materials, all in order to understand gas production, diffusion mechanisms, and surface binding properties. Dr. John W. Coleman and his co-workers have continued the development of a high-resolution Auger electron microscope which requires the development of new large-aperture, aberration electron lenses and a precise electron energy analyzer. Not only will the final instrument make possible the direct visualization of light atoms, but many of the components of the instrument in preliminary form are useful in the molecule microscope project.

Professor Malcolm W. P. Strandberg has been able to demonstrate nonlinear effects in microwave spectroscopy. A second harmonic of intensity of 0.1 microwatt has been generated in a few cubic centimeters of ammonia gas by a strong 14-gigahertz electromagnetic field.

The group has finished an empirical study of the interaction of 10-gigahertz phonons with polycrystalline tin at liquid nitrogen temperatures. The study examines the bonding of tin to a piezoelectric crystal, the surface reflection loss, bulk electronic attenuation, and loss by grain boundary scattering. The work indicates that an extensive modification of the usual model of boundary loss must be made to describe the actual effects observed at a bonding interface.

The atomic resonance and scattering group, under the direction of Professors Daniel Kleppner and David Edward Pritchard, both of the Department of Physics, has completed several radio frequency resonance experiments on the diatomic molecule KAr. KAr is a van der Waals molecule -- a new class of molecule bound together only by long-range electrostatic forces and having very small binding energies. (The binding energy of KAr is only 0.005 electron volts; most covalent and ionic molecules have binding energies between 1 and 10 eV.) These molecules are attractive candidates for research, because their constituent atoms maintain their atomic identity to a high degree.

In collaboration with Professor Peter Zimmerman of the Department of Physics, Professor Kleppner has made measurements on excited states of atomic cesium using a newly developed technique called Stark mixing spectroscopy, to permit access to states which normally are forbidden.

Using an atomic beam at right angles to a laser beam has reduced Doppler broadening drastically and enabled Professor Pritchard, Dr. Theodore W. Ducas, and Jerome Apt to increase the resolution attainable in two-photon spectroscopy by several orders of magnitude.

During the past year, Professor Jin Au Kong has studied interferometry techniques for various dipole antenna configurations, with special attention directed toward subsurface probing and communication. Microwave emission properties of Earth are studied with applications to passive remote sensing from spacecraft and satellites. In optics, optics of bianisotropic media and integrated optics using nonisotropic media are being investigated. The computer system MACSYMA has been used to help in analytical and seminumerical computations.

Professors Dirk J. Muehlner and Rainer Weiss, both of the Department of Physics, report that they have made measurements of the spatial isotropy of the blackbody background radiation that is alleged to be a remnant of a primordial cosmic explosion. With a balloon-borne differential radiometer sensitive in the spectral region between 3 and 0.8 mm, the region embracing the blackbody peak, they have determined that the radiation is isotropic to 0.1 percent. The isotropy indicates that the earth is moving at less than 300 km/sec relative to the co-moving reference frame determined by the expansion of the universe.

During the past year, Professor Alan H. Barrett of the Department of Physics, Dr. Philip Myers, and several graduate students have continued their study of interstellar gas clouds in the spectral lines of OH, CH₂O, CO, CH₃OH, and CS. Observations of the CH₃OH, methanol, with high spectral resolution have revealed detailed structure in the five lines studied. Distinct features are evident on a scale of 0.5 km/sec or less, and appear to be indicative of angularly small sources radiating by maser amplification.

Professor Bernard F. Burke of the Department of Physics and his students have been searching for hydrogen absorption lines in quasars. Despite the existence of strong optical absorption lines in a number of quasars, with well-determined velocities, no corresponding 21-cm red-shifted radio lines could be detected. This implies that the absorbing clouds are located close to the quasar. Kwok-Yung Lo has been studying the occurrence of H₂O and OH maser sources, and has detected 12 new examples, some associated with T Tauri stars, some with HII regions, and some with infrared emission objects.

Mr. Lo and Kenneth P. Bechis, following up their discovery of a new class of maser associated with the "new" star V1057 Cygni, have demonstrated that the OH radiation probably originates in a region where the magnetic field is 1.5 milligauss. This would be the strongest magnetic field ever detected in the interstellar gas.

Professor Richard M. Price of the Department of Physics reports that research under the radio continuum structure of galaxies includes studies of the structure of our own galaxy and approximately spiral galaxies. The object of the study is to determine the distribution of large-scale magnetic fields and relativistic electrons in spiral galaxies through observations of the nonthermal radio emission due to their interaction (synchrotron radiation).

Professors Madhu S. Gupta, Robert L. Kyhl, and David H. Staelin, all of the Department of Electrical Engineering, have concentrated on the design and fabrication of low-temperature millimeter wave mixers. Significant progress was made toward fabricating a low-noise 3-mm wavelength mixer and modeling the nonlinear mixing mechanism in order to optimize the mixer design. Professor Gupta's work on IMPATT diodes resulted in a new equivalent circuit useful for device characterization.

Professor Shaoul Ezekiel of the Department of Aeronautics and Astronautics and his students have developed extremely stable fixed-frequency, as well as tunable, lasers for performing ultrahigh-resolution spectroscopy in molecular beams. A spectroscopic resolution of one part in 10^{10} has been obtained. This is believed to be the highest resolution yet achieved in the visible region of the spectrum, and it is being used to study the hyperfine structure in molecular iodine with unprecedented precision.

Plasma Dynamics

A major goal of the plasma dynamics program is extension of the basic understanding of phenomena 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).

The gaseous laser research under the direction of Professor E. Victor George is concerned with the plasma physics and quantum electronics of high-energy-density, high-peak-power gaseous lasers. This work includes studies of high-pressure rare gas excimer lasers, which operate in the vacuum ultraviolet region of the spectrum, and high-pressure CO_2 lasers. The ultimate goal of the latter work is the generation of intense, subnanosecond laser pulses at a wavelength of $\sim 10\mu$.

During the past year, experimental work in the field of magnetically confined plasmas has come to fruition and produced some significant new results.

The main objective of the Alcator experiment, which consists of producing and confining plasmas capable of carrying high currents and high current densities, has been achieved. Plasma currents of approximately 200 kA have been obtained over a circular cross section with a nine-centimeter radius. These correspond to average current densities of approximately 785 A/cm^2 and are larger by about a factor of four than the record values obtained one year ago in the French TFR (Tokamak de Fontenay aux Roses) device. The reason for producing high current densities is to have a strong ohmic heating effect on the plasma itself in order to achieve temperatures of thermonuclear interest. The total current of 200 kA is also a record value. The toroidal magnetic field adopted for these experiments was 55 kilogauss, so larger currents should be obtained in the future both by raising the value of the magnetic field and by raising that of the plasma radius.

This work, under the supervision of Professors Bruno Coppi and Robert Taylor and Dr. Ronald Parker, is a collaborative effort of R. L. E. and the Francis Bitter National Magnet Laboratory.

The quadrupole linear device SLIM has been used by Professor Peter Politzer and his students to produce, for the first time, steady-state plasma flows and turbulence in magnetic field configurations that are of interest to theoretical models proposed for the conversion of magnetic energy into plasma kinetic energy in solar flares, and so forth.

A series of results on the theory of noncollisional transport processes in high-temperature, inhomogeneous plasmas has been presented in a sequence of written papers which have been published in leading journals. Oral papers (both contributed and invited) also have been presented at national and international conferences. Some of the highlights of this series are: the combined numerical and analytical solution of the basic integral equation for magnetically trapped particles, which has led to finding new types of plasma micro-instabilities; the finding of new nonlinear scattering processes in magnetically confined plasmas; the theory of "catalytic" (microwave induced) resistivity; and the finding of impurity driven collective modes that have a strong bearing on the dynamics of thermonuclear plasmas.

In the relativistic electron beams research under the direction of Professor George Bekefi, suppression of electrical breakdown in a vacuum gap between two electrodes subjected to intense voltage differences is a problem of quite recent interest. The need to insulate the space between conductors so that currents of millions of volts across gaps 0.1 to 10 cm wide can be maintained without breakdown for at least short periods of time ($\approx 1 \mu\text{sec}$) arises, for example, in the design of high-voltage transmission lines and energy storage systems. Experiments were carried out on pulsed field-emission diodes with gaps 2 to 6 mm wide, subjected to potential differences of 100-250 kV. In the presence of a sufficiently strong magnetic field, electron currents, typically 10-30 kA, are reduced by \sim three orders in magnitude. The desired magnetic insulation is found to last over the entire 50-nanosecond voltage pulse.

Professor Abraham Bers of the Department of Electrical Engineering and his students have achieved the first implementation of symbolic calculations on a computer (MACSYMA) for studying nonlinear wave-wave interactions in a plasma. This has allowed them to explore such interactions for complex geometries of toroidal fusion plasmas.

Jointly with the MACSYMA staff of Project MAC, a Workshop on Symbolic Computation in Plasma Physics was organized. Twenty-five research workers from various universities, the Atomic Energy Commission national fusion laboratories, and foreign laboratories attended this workshop (October 29-30, 1973) to become acquainted with the capabilities of the MACSYMA system and its possible use in plasma research.

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 bio-engineering 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 the understanding of languages, which form the basis for communication.

The optical communication research of Professors Robert S. Kennedy and Jeffrey H. Shapiro, both of the Department of Electrical Engineering, and their students has progressed in three principal directions.

Fundamental questions in detection, estimation, and measurement theory for abstract quantum systems have been addressed. These abstract studies have led to theoretical and experimental investigations of promising new physical detection systems.

New statistical characterizations for turbulent propagation media have been explored. These results are being applied in investigations of adaptive spatial and temporal optical communication systems for the turbulent atmosphere.

A new project has been undertaken, in cooperation with members of the Center for Materials Science and Engineering, to assess the ultimate reliability of low-visibility line-of-sight optical communication links. This work includes both theoretical and experimental aspects of propagation modeling, and signal-processor design.

In the detection and estimation theory group, Professor Arthur B. Baggeroer has been working with the staff at Woods Hole Oceanographic Institution on data processing methods used in exploration of the continental margins. Preparations are being made for investigations off the Brazilian coast, using a multi-channel one-kilometer array. Work on adaptive array processing and the estimation of spatial process has continued, while work on spectral analysis has demonstrated the relation of high-resolution methods to several problems in the processing of geophysical data. Professor Harry Van Trees, Jr. of the Department of Electrical Engineering was on leave of absence, serving as the chief scientist of the Defense Communications Agency.

Application of information-theoretic ideas to data processing problems by Professor Peter Elias and his students has given lower bounds to some of the costs of systems which store, access, and update information, and has suggested techniques for designing systems whose costs approach those bounds.

The cognitive information processing group, under the direction of Professor Murray Eden, has continued studies of the ways in which humans process visual information and the development of automatic procedures and computational techniques for performing similar tasks. Professor Barry Blesser and Research Associate David Ozonoff, continuing their collaboration with the Radiology Department of the Peter Bent Brigham Hospital, have been studying several aspects of the process of radiological diagnosis. They have shown that clinically significant differences exist between multiple independent readings of the same chest X ray by different radiologists. By analyzing the nature of the differences, it may be possible to design image-processing techniques to increase the reliability and consistency of radiologic diagnosis.

In the quantitative analysis of human leukocytes and leukocyte images, substantial progress has been made by Professor Ian T. Young and Dr. Stephanie E. Sher. A technique for describing analytically the shape of cellular structures and substructures, based on the concept of bending energy, has been developed. A procedure for measuring the adhesiveness of cell membranes also has been developed. This technique appears to have wide application in such areas as tissue transplants, immunoassays, and leukemia studies.

Dr. Goesta Granlund is continuing his studies of chromosomes based upon his technique for the analysis of integrated density profiles. His work offers the possibility of both statistical karyotyping and chromosomal "fingerprinting."

The wirephoto project conducted for the Associated Press by Professors William F. Schreiber and Donald E. Troxel, both of the Department of Electrical Engineering, has resulted in a production contract for 1,500 laser scanner facsimile machines at Radiation, Incorporated, and a larger contract for dry silver paper at the 3M Company. The development of the

"electronic darkroom," a computer based picture-editing, storage, and dispatching system, continues.

Professors Eden and Blesser and their colleagues have been carrying out psychophysical experiments to determine the features which create confusion in the recognition of hand-written and printed characteristics. The goal is to provide the basis for constructing a machine capable of recognizing both hand printed English characters and multifont printed characters.

Professor Jonathan Allen has continued his work on the development of a system for conversion of unrestricted English text to speech. A high-speed processor for speech synthesis is being developed as part of this system.

The communications biophysics group, under the direction of Professor William M. Siebert, has continued its studies of sensory physiology, psychophysics, and the application of engineering technology to clinically significant problems.

Experiments in the Eaton-Peabody Laboratory by Professors Thomas F. Weiss and William T. Peake on the inner ear of lizards have demonstrated that the motion of this receptor organ and electric responses from its receptor and nerve cells can be measured, making it possible to study the transduction process in the inner ear more completely than previously. Lecturer Nelson Y. S. Kiang has been investigating possibilities for recording electric responses from the auditory nerve as a clinical diagnostic test.

The recent results of Lecturer Nathaniel I. Durlach and Professor Louis D. Braida and their students on auditory intensity perception indicate that the loudness of a stimulus can be determined by summing resolution increments, if proper account is taken of the range of intensities to which the listener is exposed. Research on binaural interaction, supervised by Professor H. Steven Colburn, has included: development of a model based on a statistical description of auditory-nerve firing patterns; further experiments on the resolution of inter-aural time and other attributes of binaural images; and development of a new experimental technique to measure fusion of binaural images. The knowledge gained in these and other psychophysical and physiological studies is being applied to the development of improved hearing aids.

Work on the production and perception of music, supervised by Lecturer Adrianus J. Houtsma, has been concerned primarily with the design of guitars, including a comparative study of acoustic and electric guitars; a study of string design to achieve optimal tuning; and the construction of a theoretical model of the acoustic guitar.

In his continuing study of eyelid reflexes and their modifiability through simple learning procedures, Lecturer Robert D. Hall has shown that representation of the cornea in the brainstem of the rat is extensive; on the other hand, sensory information from the cornea that reaches the cerebral cortex is meager and may be restricted to a small part of the motor area. Work in biomedical engineering under the direction of Professors Roger G. Mark and Stephen K. Burns is carried out both in R. L. E. and at the Biomedical Engineering Division of the Harvard Medical unit at Boston City Hospital. Projects during the past year have included the development of a variety of instruments for cardiological purposes. Some of these feature the application of minicomputers and micro-processors.

Another project has examined the operational characteristics of the Nursing Home Telemedicine Program and has compared its costs and benefits with conventional methods for providing primary care in nursing homes.

The research of the Speech Communications Group, under the direction of Professor Kenneth N. Stevens, continues to explore the unique human capabilities for generating speech-sound patterns and for auditory processing of these patterns. Among the current research activities which contribute toward a theoretical description of these capabilities are studies of the physics and physiology of laryngeal vibration and modeling of the tongue structures and their motor control. Recent work also has included investigations of the timing and intonation in sentences. These studies are contributing toward improved practical procedures for the machine generation of sentences from discrete phonetic specifications.

The research conducted by the linguistics group, under the direction of Professor Morris Halle, continued to pursue essentially the same issues as in prior years. Their objective is to learn all they can about the mental capacities of humans by studying the structure of language and the use to which it is put. As in the past, major emphasis (measured in man-hours) has been placed on syntactic studies. Of the seven doctoral dissertations completed during the year, five were in the area of syntax and semantics. A topic that appeared frequently in these dissertations, as well as in work by other members of the group, was the question of anaphors and co-referentiality. Although a definitive answer is yet to be found, the increased complexity of the data that can be accounted for and the sophistication of the proposed treatments suggests that the group may be approaching a solution that will enjoy wide acceptance.

Work in other areas of linguistics continues apace. Among the more noteworthy developments are studies on prosodic systems in different languages. These appear to lay the foundation for a new theory of tone and accent which will allow researchers to resolve various classical puzzles -- for example, the nature of the tone rules in terrace-tone languages of the kind widely represented in West Africa and the reconstruction of the accentual system of Indo-European languages.

Another topic that has attracted considerable interest lately has been word formation. The character of the word formation component and its role in a grammar have been investigated in two dissertations. The results of these investigations, which were limited to English, are highly suggestive; it appears that word formation once again will become a major topic of research. These investigations dovetail neatly with studies by other members of the group dealing with cyclical rule application in phonology.

Important insights into the nature of language often can be obtained by investigating the changes which languages undergo in the course of their evolution. This fact continues to motivate much research into the history of various linguistic phenomena. Particularly interesting results are emerging from historical investigations of the evolution of relative clauses in Australian and American Indian languages.

Studies on topics situated on the borderline between linguistics and other fields are continuing as in past years. Mention should be made here of Professor R. Paul V. Kiparsky's just completed contribution to the study of matrices; Judith Kornfeld's dissertation on psycholinguistics; and Professor Hale's contributions to the design of teaching materials for elementary education in Navaho.

Finally, it is appropriate to note a number of investigations that directly approached the theoretical foundations of the science of language. These include Professor John R. Ross's attempts to develop a nondiscrete logic to serve as a basis for a new linguistics, and Professor David H. Perlmutter's efforts (jointly with Dr. Paul Postal of International Business Machines, Inc.) to replace transformational syntax by a syntax in which grammatical relations are the primitive entities.

HENRY J. ZIMMERMANN

Office of Sponsored Programs

Although during the past fiscal year there was no real growth in the total volume of sponsored research on campus, there was a significant increase in programs related to health, energy, and other national concerns.

At the same time, new campus research facilities have become available, as a result of several major building projects. The Sherman Fairchild Building was occupied early in the year by the Department of Electrical Engineering and the Research Laboratory of Electronics, while the Seeley G. Mudd Building at the close of the year was partially occupied by the Center for Cancer Research.

Graduate student support continued to decline, primarily as a result of decreased Federal fellowships and traineeships. On the other hand, graduate research assistants held at slightly above the level of 1972-73; however, concern over the ability of research projects to support this level has led to efforts to find ways to reduce the cost of research assistants to research grants and contracts.

New Research Facilities

In September, 1973, the Division for Study and Research in Education was established under the direction of Professor William T. Martin as an innovative program to foster research on an interdisciplinary basis, into fundamental issues involved in the teaching and learning process. Initially, the Division is offering elective subjects, carrying on research, and conducting a broad-ranging seminar on certain aspects of educational innovation.

On October 4-5, 1973, the \$17.5-million Sherman Fairchild Building was dedicated in ceremonies highlighted by a symposium in which all six former United States presidential science advisers took part. There was also an address by Dr. H. Guyford Stever, Director of the National Science Foundation, at a special luncheon for Members of the M. I. T. Corporation. Comprising 220,000 square feet of floor area, the Fairchild Building is the largest single building project at M. I. T. since the present Cambridge campus was built in 1916. It was completed three months ahead of schedule. The Department of Electrical Engineering moved in during the summer of 1973, consolidating most of its campus facilities in the west tower, while the Research Laboratory of Electronics occupied most of the east wing and three floors of the west.

Partial use of the Seeley G. Mudd Building by the M. I. T. Center for Cancer Research began in early January, 1974, when the virology research group occupied the fifth floor of the building. By June, 1974, the immunology group and administrative offices were housed on the first floor and the Center's animal quarters on the sixth floor. The Center, headed by Salvador E. Luria, Institute Professor and Sedgwick Professor of Biology, is scheduled to complete occupancy by the fall of 1974, with the dedication ceremony to be held in March, 1975.

Also moving into the Seeley G. Mudd Building will be the regional Cell Culture Facility, established under a grant from the National Science Foundation. The Facility, under the supervision of Professor Phillips W. Robbins of the Department of Biology, will grow and supply virus and mammalian cell cultures to biomedical researchers in the Boston area. It is scheduled to commence operations on the third floor of the building in early August, 1974.

In March, 1974, the School of Architecture and Planning formed the Laboratory of Architecture and Planning, charged with fostering research which will contribute to the understanding, education, and practice of architecture and planning and closely related fields. It is directed by Dean William L. Porter, with David L. Judelson as assistant director.

By the close of the fiscal year, foundation and basement work for the new Chemical Engineering building had been completed and construction was proceeding above ground. The new facility, whose cost is estimated at \$15.8 million, will enable the Department of Chemical Engineering to strengthen teaching and research in chemical engineering, including the related interdisciplines of energy resources, environmental quality, biology, medicine, and management.

Campus Research Volume

The total volume of campus sponsored research performed in fiscal year 1974 by academic departments and interdepartmental laboratories (excluding subcontracts in excess of \$100,000) is expected to exceed \$75 million, once final figures have been compiled. This represents a five percent increase over the comparable volume for fiscal year 1973, which in turn represented an increase of 8.6 percent over fiscal year 1972.

The five percent increase in 1974 research volume is spread fairly evenly among sponsors, except for a somewhat greater increase in support from the National Science Foundation and a decrease in research sponsored by the National Aeronautics and Space Administration.

The preliminary estimate for fiscal year 1975 is that total campus research volume (excluding major subcontracts) will increase over nine percent, to a total of \$82.5 million.

Graduate Student Support Programs

During the fiscal year 1974, approximately 391 graduate fellows and trainees received \$2.5 million in Federal support independent of specific research projects (but including National Institutes of Health training grants), compared with 495 students who received \$3,082,000 in fiscal year 1973. Thus the decline that began with the high point of 800 students in 1969 has continued. Next year, the total number of graduate fellows and trainees supported by Federal programs will decrease to about 350.

In fiscal year 1974, graduate research assistant salaries were approximately \$6,708,000, paid to an estimated 1,070 graduate students, compared with salaries of \$6,155,000 paid to 1,035 graduate students in fiscal year 1973. For fiscal year 1975, the number of research assistantships is expected to remain at approximately the same level, although their cost to research projects will increase.

Increasing concern has been voiced over the high cost of research assistants and whether they can continue to be supported at current levels as the cost of research escalates and project budgets remain relatively fixed. As a result, several studies were conducted during the year on the financial impact of reducing the total cost of research assistants to research grants and contracts. The implications of several alternatives for accomplishing this end were explored within the faculty and administration. Such a step presently is being considered seriously for implementation in fiscal year 1976.

Personnel Changes

During the year, the following changes occurred in the staff of the Office of Sponsored Programs. Charlotte A. Lathrop, formerly assistant director of government programs

Vice President for Research

at Simmons College, joined the staff in July, 1973, as assistant to the director. Paul C. Powell, who joined O. S. P. in 1973, was promoted to assistant director. David J. Harrigan, who has been on the O. S. P. staff since 1968, was promoted to project officer in January, 1974, thereby assuming responsibility for a broad range of special financial and legal assignments. Mary Lou Atkinson, formerly administrative officer of the Urban Systems Laboratory, joined the O. S. P. staff as assistant to the director in January, 1974. Robert P. Greene joined the O. S. P. staff in February, 1974, as program officer with responsibility for providing administrative services to new energy research activities. Charles F. Kiefer shifted to a part-time status within O. S. P. in February, 1974, in order to continue his studies. He left the Office at the end of the fiscal year.

GEORGE H. DUMMER

Vice President and Treasurer

Operations

Total operations in 1973-74 were \$223,822,000, down from \$269,616,000 in 1972-73, primarily because of the divestment of the Charles Stark Draper Laboratory effective July 1, 1973. The current expenses for instruction and research in the academic departments increased in 1973-74, and departmental and interdepartmental sponsored research was above the level of 1972-73. There was a decrease in Lincoln Laboratory operations, because expenses for outside materials and services and subcontracts to other organizations were lower than in the preceding year. While the Institute's expenses for administration, libraries, and medical services were changed little in total from the preceding year, the expense for plant operations and maintenance was up substantially, reflecting in part the steep rise in energy costs, as well as the additional support required to service the continuing expansion of the physical plant.

To meet the operating expenses for the year 1973-74, unrestricted resources of \$2,528,000 were required, compared to \$757,000 in 1972-73; in addition, \$2,781,000 was drawn from the Research Reserve, to reflect partially the financial effect on operations of the reduced level of sponsored research resulting from the divestment of the Draper Laboratory.

Gifts

Gifts, grants, and bequests received in 1973-74 were as follows.

	1973-74	1972-73
Gifts for endowment	\$ 3,904,000	\$ 2,127,000
Gifts for buildings	5,553,000	5,450,000
Gifts for current use -- invested	3,854,000	5,402,000
Industrial Liaison Program	1,260,000	1,488,000
Other funds for current use	<u>4,904,000</u>	<u>3,940,000</u>
Total gifts to funds	\$19,475,000	\$18,407,000
Grants-in-aid	<u>3,191,000</u>	<u>3,257,000</u>
Total	\$22,666,000	\$21,664,000

Vice President and Treasurer

The endowment was increased in 1973-74 by additions to the funds for professorships, for fellowships, and for research support. Capital gifts and grants received for buildings included funds for the Chemical Engineering Building, for the Seeley G. Mudd Building for cancer research and other related medical research activities, for the Sherman Fairchild Building, for the George R. Wallace Geophysical Observatory, and for other facilities nearing completion or completed during the year. Major grants for academic departmental programs were included above in Gifts for current use -- invested, the Industrial Liaison Program, and Other funds for current use. Unrestricted gifts of \$1,040,000 included \$161,000 in bequests to the Institute. Gifts reported by the Alumni Fund for 1973-74 were \$2,917,000.

Funds

The book value of the funds was \$343,964,000 on June 30, 1974, compared to \$342,058,000 on June 30, 1973.

	1973-74	1972-73
Endowment funds:		
For general purposes	\$ 76,067,000	\$ 75,773,000
For designated purposes	117,832,000	113,658,000
Net realized gains from investments	<u>40,652,000</u>	<u>39,896,000</u>
Total endowment funds	\$234,551,000	\$229,327,000
Building and expendable funds	66,131,000	70,685,000
Other funds	<u>43,282,000</u>	<u>42,046,000</u>
Total funds	\$343,964,000	\$342,058,000

New net patent resources of \$931,000, \$1,202,000 from allowances for use of facilities for sponsored research, and the gifts and bequests of \$1,040,000 provided total unrestricted resources of \$3,173,000 during the year. In 1972-73, unrestricted resources from the same sources were \$3,775,000.

During 1973-74, of the \$3,173,000 total of new unrestricted resources, \$2,528,000 was allocated to operating expenses, with the remainder of \$645,000 (along with \$2,682,000 from funds accumulated in earlier years) used to fund special charges in the amount of \$3,327,000. Two of the major special charges, as shown in Schedule E, were associated with the M. I. T. Press and the projects for housing for the elderly in Cambridge.

The accrued operating losses of the M. I. T. Press included the writedown to net realizable values of receivables and inventories, and required funding as special charges in 1973-74. The 1972-73 report of the Treasurer noted that total costs might be in excess of the selling price to be received by the Institute from the Cambridge Housing Authority for the three housing projects for the elderly developed under the auspices of M. I. T. In 1973-74, the Turnkey housing main buildings were completed, and sold to the Authority for \$16,592,000, compared with costs of \$17,212,000. Approximately \$500,000 remains to be expended for

an auxiliary building under this program, and the Institute expects to recover fully the cost of this building. Provision has been made for project costs of \$739,000 in excess of probable receipts, \$200,000 of which was reserved in 1972-73, with \$539,000 funded in 1973-74 within the total amount for special charges of \$3,327,000.

As noted earlier in this report, \$2,781,000 from the Research Reserve was used in 1973-74, to reflect in part the reduced reimbursement for indirect expenses on sponsored research at the Institute occasioned by the divestment of the Draper Laboratory. Special limitations related to indirect expense reimbursement on sponsored research applied only to that year, and therefore, it is estimated that the financial effect on the Institute in 1974-75 and thereafter of the divestment of the Draper Laboratory will be diminished substantially.

The Research Reserve was \$10,410,000 on June 30, 1973, and \$8,689,000 on June 30, 1974. The decrease in Other expendable funds for designated purposes from \$49,510,000 on June 30, 1973, to \$46,224,000 on June 30, 1974, was partly attributable to the use of the Research Reserve for the first time during this past year.

The appropriations of unrestricted resources for operations, for student aid, and for special charges were \$5,855,000 in 1973-74, compared to \$2,674,000 in 1972-73. These appropriations in 1973-74, together with the use of the Research Reserve in the amount of \$2,781,000, brought the total appropriations to \$8,636,000, as shown in a footnote in Schedule E.

The unallocated investment income for distribution to funds was \$21,325,000 on June 30, 1974, and \$21,148,000 on June 30, 1973.

Plant

The increase in the book value of the educational plant from \$182,063,000 to \$190,029,000 during 1973-74 included the addition of the Sherman Fairchild Building, the Seeley G. Mudd Building, continuing construction of the Chemical Engineering Building, the modernization of Ashdown House, the initiation of construction of the new undergraduate dormitory, and the transfer to educational plant of properties previously held in the investment portfolio.

Funding of the Sherman Fairchild Building and its maintenance and of the Ashdown House renovations was completed in 1973-74, and the funding of the Chemical Engineering Building and the Seeley G. Mudd Building neared completion during the year. The total funding of the new undergraduate house is yet to be secured.

The total mortgage indebtedness of \$27,440,000 consists of \$10,793,000 of Federal government loans and \$16,647,000 of other loans as of June 30, 1974.

The part of the Chemical Engineering Building financed through the Massachusetts Health and Educational Facilities Authority is included within the unexpended building resources of the Institute on June 30, 1974, in the amount of approximately \$5 million.

Investments

The year-to-year change in the endowment and other investments is shown in the following table.

General investments	June 30, 1974		June 30, 1973	
	Book	Market	Book	Market
Fixed income	\$151,863,000	\$127,769,000	\$153,445,000	\$141,980,000
Equities	107,169,000	177,360,000	104,509,000	214,647,000
Real estate				
For present or future Institute use	12,990,000	12,990,000 ¹	12,985,000	12,985,000 ¹
Other real estate	28,863,000	31,024,000 ²	28,651,000	30,920,000 ²
Due from Educational plant funds	5,628,000	5,628,000	5,250,000	5,250,000
Total	\$306,513,000	\$354,771,000	\$304,840,000	\$405,782,000
Separately invested Students' notes receivable ³	17,436,000	16,488,000	18,923,000	19,572,000
	16,917,000	16,917,000	15,570,000	15,570,000
Total	\$340,866,000	\$388,176,000	\$339,333,000	\$440,924,000

¹At cost

²At values determined by professional appraisers

³Net of reserve

The decrease of \$52,748,000 in the market value of the portfolio was due to the decline in the market for common stocks and the market for fixed income securities during the year ended June 30, 1974. The market value of the total portfolio declined from \$440,924,000 to \$388,176,000. The composition of the portfolio of general investments at market values on June 30, 1974, was 50 percent in equities, 38 percent in fixed income securities, and 12 percent in real estate.

Total investment income received during the year was \$19,399,000, compared to \$18,321,000 in 1972-73. After the deduction of administrative expenses, there remained \$19,099,000 of investment income for operating and other expenses.

The investment income distributed to funds was \$18,651,000 in 1973-74, compared to \$17,739,000 in 1972-73. After providing for an adjustment and after the distribution of investment income to funds, \$177,000 was added to the unallocated investment income reserve for future distributions to funds. In 1972-73, \$582,000 was added to this reserve, and in 1971-72, \$825,000 was added.

The Northgate Community Corporation, organized to provide student and faculty housing in Cambridge and nearby communities, continued in 1973-74 the program begun the preceding year of selling properties as part of a plan of liquidation. Operating losses continue, largely because of rent control, higher taxes in Cambridge, and increasing operating costs. In 1972-73, the estimated value in the investment portfolio of the Institute's commitment in the debentures of Northgate was reduced to \$1,997,000 (in contrast to \$2,995,000 on a cost basis), and in 1973-74 to zero, to reflect the further operating losses and the lack of a market under current credit and local real estate conditions for the remaining properties owned by Northgate. The realized capital losses on the Northgate properties liquidated to date were minimal, but the continuing operating losses and the consequent probable future loss

in value of the Northgate debentures were not reflected in the Institute's net realized gain and loss on investments on June 30, 1974.

Retirement Funds

The retirement plan investments in the following table are not part of the financial assets of M. I. T.

	June 30, 1974		June 30, 1973	
	Book	Market	Book	Market
Pension Association	\$ 75,599,000	\$ 68,649,000	\$ 67,162,000	\$ 69,559,000
Supplementary Retirement Plan -- Fixed Benefit	40,360,000	35,041,000	35,316,000	34,067,000
Supplementary Retirement Plan -- Variable Benefit	21,334,000	19,703,000	19,165,000	20,179,000
Retirement Plan for Employees	41,123,000	34,990,000	34,520,000	31,931,000
Total	\$178,416,000	\$158,383,000	\$156,163,000	\$155,736,000

The retirement plan investments are supplemented by reserves of approximately \$6.5 million held by a life insurance company to provide specified benefits under the Retirement Plan for Employees. M. I. T. pension contributions in the amount of \$7,529,000 were part of Institute operating expenses in 1973-74, and \$9,120,000 of these expenses were included in 1972-73. On June 30, 1974, unfunded past service costs of \$4,770,000 of the Retirement Plan for Employees were amortized over 13 years.

Personnel of the Draper Laboratory who were previously associated with M. I. T. continued as contributing members in the Retirement Plan for Employees until June 30, 1974, and their accumulated benefits will become available to them at the time of their retirement from the Charles Stark Draper Laboratory. To recognize the advance funding of certain benefits beyond July 1, 1974, under the level funding program of the Retirement Plan for Employees, the Institute and the separately organized Laboratory entered into an agreement providing for annual payments over a limited number of years to a retirement trust set up for the benefit of members of the Charles Stark Draper Laboratory.

The aggregate market value of the investments of the retirement funds was \$158,383,000 on June 30, 1974, compared to the book value of \$178,416,000.

The investments of the Pension Association and the Supplementary Retirement Plan -- Fixed, taken together at market values on June 30, 1974, were 10 percent in short-term investments, 58 percent in fixed income securities, and 32 percent in equities. The Retirement Plan for Employees was 19 percent in short-term investments, 50 percent in fixed income securities, and 31 percent in equities. The Supplementary Retirement Plan -- Variable fund was invested 9 percent in short-term fixed-rate investments and 91 percent in equities on June 30, 1974.

General

The invested funds of the Institute were well maintained in 1973-74, relative to the level of recent years, although it was necessary to draw on funds accumulated in earlier years to meet the requirement for unrestricted resources for operations, for student aid, and for

Vice President and Treasurer

special charges. Building the capital of the funds is a major financial goal for the Institute. Further growth in the funds will serve to strengthen M. I. T. and to assure the continued adequate funding of the programs in education and research for the future.

STUART H. COWEN
JOSEPH J. SNYDER

Sources of Revenues and Funds Used to Meet Expenses of Current Operations

for the years ended June 30, 1974 and 1973

Schedule A

	<u>1974</u>	<u>1973</u>
OPERATING EXPENSES		
Instruction and unsponsored research	\$ 33,711,000	\$ 29,449,000
Sponsored research (Note A):		
Direct costs:		
Departmental and interdepartmental	59,436,000	58,704,000
Lincoln Laboratory	70,775,000	76,444,000
Draper Laboratory (Note F).	6,214,000	53,169,000
Research vacation expense	3,555,000	4,532,000
Research administration and general expenses.	<u>1,410,000</u>	<u>1,470,000</u>
Total expenses directly attributable to instruction and research	\$175,101,000	\$223,768,000
Costs applicable to both instruction and research:		
Libraries	2,648,000	2,677,000
Medical	2,519,000	2,423,000
Plant operation and maintenance	13,505,000	12,656,000
Administration	3,193,000	3,236,000
Fiscal, personnel, and other Institute-wide services.	7,816,000	7,842,000
General expenses.	2,868,000	2,764,000
Other instruction and research support activities	1,775,000	1,915,000
Student services	5,125,000	4,400,000
Auxiliary activities	<u>9,272,000</u>	<u>7,935,000</u>
	\$223,822,000	\$269,616,000
REVENUES AND FUNDS USED		
Tuition and other income	\$ 26,474,000	\$ 24,571,000
Research revenues:		
Departmental and interdepartmental	77,887,000	72,294,000
Lincoln Laboratory.	78,637,000	83,248,000
Draper Laboratory (Note F).	5,848,000	63,905,000
Appropriation of indirect expense allowance for use of facilities	(1,334,000)	(1,324,000)
Auxiliary activities	9,272,000	7,935,000
Endowment investment income (Note B):		
Total income received from investments	19,099,000	18,321,000
Distributed to building and other invested funds	(3,793,000)	(3,748,000)
Distributed to endowment funds	<u>15,306,000</u>	<u>14,573,000</u>
Used for scholarships and fellowships	(2,187,000)	(2,329,000)
Added to unexpended balances and transferred to other funds	(3,438,000)	(2,451,000)
Used for operations	<u>9,681,000</u>	<u>9,793,000</u>
Gifts, investment income, and other receipts for designated purposes	12,048,000	8,437,000
Unrestricted funds used to meet operating expenses:		
Research Reserve	2,781,000	----
Special Items (Schedule E).	<u>2,528,000</u>	<u>757,000</u>
	\$223,822,000	\$269,616,000
	(Schedule E)	(Schedule E)

The accompanying notes are an integral part of the financial statements.

Balance Sheets June 30, 1974 and 1973

Schedule B

Assets

	<u>1974</u>	<u>1973</u>
CURRENT FUND ASSETS		
Cash:		
General purposes	\$ 189,000	\$ 903,000
Restricted, principally to research activities	8,042,000	5,607,000
Accounts receivable:		
U.S. Government	4,512,000	5,232,000
Other	6,039,000	5,970,000
Contracts in progress, principally U.S. Government	12,798,000	23,741,000
Deferred charges, inventories, and other assets	14,587,000	11,122,000
Due from invested funds (short-term)	4,052,000	5,295,000
	<u>\$ 50,219,000</u>	<u>\$ 57,870,000</u>
INVESTMENTS (Note B)		
General investments, at cost:		
Fixed income	\$151,863,000	\$153,445,000
Equities	107,169,000	104,509,000
Real estate (including \$12,990,000 -- 1974, and \$13,253,000 -- 1973, for present or future Institute use)	41,853,000	41,636,000
Due from Educational Plant Funds	5,628,000	5,250,000
	<u>\$306,513,000</u>	<u>\$304,840,000</u>
Investments of separately invested funds, at cost (including \$0 -- 1974, and \$2,578,000 -- 1973, due from Educational Plant Funds)	17,436,000	18,923,000
Students' notes receivable	<u>16,917,000</u>	<u>15,570,000</u>
Total investments	\$340,866,000	\$339,333,000
Cash held for investment	1,546,000	941,000
Receivables (Payables) arising from investment transactions	(2,127,000)	881,000
Due (to) current funds	<u>(4,052,000)</u>	<u>(5,295,000)</u>
	<u>\$336,233,000</u>	<u>\$335,860,000</u>
EDUCATIONAL PLANT (Note A)		
Land, buildings, and equipment, at cost	\$168,899,000	\$167,352,000
Construction in progress	14,209,000	2,620,000
Temporary investments and cash	<u>6,921,000</u>	<u>12,091,000</u>
	<u>\$190,029,000</u>	<u>\$182,063,000</u>
	<u>\$576,481,000</u>	<u>\$575,793,000</u>

The accompanying notes are an integral part of the financial statements.

Schedule B (continued)
Liabilities and Fund Balances

	<u>1974</u>	<u>1973</u>
CURRENT FUNDS		
Accounts payable and accruals	\$ 17,712,000	\$ 18,328,000
Withholdings, deposits, and other credits	4,976,000	5,788,000
Advances by the U. S. Government for certain research contracts and grants	16,912,000	22,122,000
Unexpended grants for sponsored research from private sources	959,000	2,705,000
Gifts and other receipts available for current expenses . .	9,660,000	8,927,000
	<u>\$ 50,219,000</u>	<u>\$ 57,870,000</u>
INVESTED FUNDS		
Endowment funds (Note B):		
Income for general purposes.	\$ 76,067,000	\$ 75,773,000
Income for designated purposes	117,832,000	113,658,000
Net realized gain from investments	40,652,000	39,896,000
Student loan funds (Note C)	14,802,000	13,958,000
Building funds	5,980,000	7,140,000
Other expendable funds:		
General purposes.	---	1,101,000
Designated purposes	46,224,000	49,510,000
Unexpended endowment income for designated purposes	4,267,000	4,007,000
Agency funds	796,000	674,000
Funds subject to life interests in income	6,359,000	6,266,000
Investment income for distribution to funds	21,325,000	21,148,000
	<u>\$334,304,000</u>	<u>\$333,131,000</u>
Notes payable -- student loans (Note D)	600,000	1,232,000
-- investment real estate (Note D)	1,032,000	1,291,000
Notes payable -- N. D. E. A. (Note D)	297,000	206,000
	<u>\$336,233,000</u>	<u>\$335,860,000</u>
EDUCATIONAL PLANT FUNDS		
Mortgage bonds and notes payable (Note D)	\$ 27,440,000	\$ 28,053,000
Due to invested funds	5,628,000	7,828,000
Funds used for educational plant.	156,961,000	146,182,000
	<u>\$190,029,000</u>	<u>\$182,063,000</u>
	<u>\$576,481,000</u>	<u>\$575,793,000</u>

Statement of Changes in Fund Balances

for the year ended June 30, 1974

Schedule C

	Balance June 30, 1973	Gifts and Other Receipts
Endowment funds (Note B):		
Income for general purposes	\$ 75,773,000	\$ 157,000
Income for designated purposes	113,658,000	4,061,000
Net realized gain from investments	39,896,000	756,000
Student loan funds (Note C)	13,958,000	1,177,000
Building funds.	7,140,000	8,576,000
Other expendable funds:		
General purposes.	1,101,000	1,990,000
Designated purposes	49,510,000	4,792,000
Unexpended endowment income for designated purposes	4,007,000	.....
Agency funds	674,000	138,000
Funds subject to life interests in income	6,266,000	79,000
Investment income for distribution to funds.	21,148,000	.....
Current year's general investment income . . . . .	.....	.....
Total invested funds	<u>\$333,131,000</u>	<u>\$ 21,726,000</u>
Gifts and other receipts available for current expenses	<u>8,927,000</u>	<u>11,537,000</u>
	\$342,058,000	\$ 33,263,000
Gifts and bequests received during the year added to funds (Note A)		\$ 19,475,000
Royalties received net of related costs		953,000
Receipts from foundations and agencies for student aid		4,321,000
Net gain on sales of investments		712,000
Appropriations from research contract allowances		1,426,000
Government student loan support		946,000
Government construction grants		3,024,000
Fees, services, and other receipts		<u>2,406,000</u>
		\$ 33,263,000
Endowment investment income used to meet expenses of current operation		
Gifts, investment income, and other receipts used to meet expenses of current operation		
Scholarship and fellowship awards for tuition and stipends		
Expenditures for buildings added to educational plant		
Expenditures of service activities and other charges to funds not representing operating expenses		
Operating expenses recorded in direct expenses of the Division of Sponsored Research		

The accompanying notes are an integral part of the financial statements.

Schedule C (continued)

Investment Income (Note B)	Transfers In-(Out)	Expenses	Other Charges	Balance June 30, 1974
\$ 6,146,000	\$ 50,000	\$ 6,059,000	.....	\$ 76,067,000
*	113,000	.....	.....	117,832,000
577,000	(577,000)	.....	.....	40,652,000
10,000	(55,000)	249,000	\$ 39,000	14,802,000
381,000	139,000	562,000	9,694,000	5,980,000
82,000	3,068,000	5,309,000	932,000	.....
2,819,000	(6,118,000)	1,679,000	3,100,000	46,224,000
8,583,000	(2,556,000)	3,621,000	2,146,000	4,267,000
38,000	(17,000)	.....	37,000	796,000
296,000	(4,000)	.....	278,000	6,359,000
{(18,954,000)}	{17,983,000}	.....	271,000	21,325,000
{ 1,138,000 }	{ 281,000 }	.....	.....	.....
17,983,000	(17,983,000)	.....	.....	.....
<u>\$19,099,000</u>	<u>\$ (5,676,000)</u>	<u>\$17,479,000</u>	<u>\$16,497,000</u>	<u>\$334,304,000</u>
.....	5,676,000	9,559,000	6,921,000	9,660,000
\$19,099,000	.....	\$27,038,000	\$23,418,000	\$343,964,000

.....	\$ 9,681,000
.....	<u>17,357,000</u>
.....	<u>\$27,038,000</u>
.....	\$ 7,711,000
.....	10,129,000
.....	4,595,000
.....	<u>983,000</u>
.....	<u>\$23,418,000</u>

* Investment income on endowment funds for designated purposes is included under the caption "Unexpended endowment income for designated purposes."

Summary of Changes in Invested Fund Balances

for the ten years ended June 30, 1974

(In thousands of dollars)

Schedule D

	<u>1974</u>	<u>1973</u>	<u>1972</u>
Fund balances at beginning of year	\$342,058	\$335,318	\$328,247
Sources of funds:			
Gifts and bequests (Note A)	\$ 19,475	\$ 18,407	\$ 18,440
Investment income (Note B)	19,099	18,321	16,942
Net gain on sales or exchanges of investments	712	2,429	1,931
Royalties received net of related costs	953	1,310	978
Receipts from foundations and agencies for student aid	4,321	3,999	4,280
Appropriations from research contract allowances	1,426	1,457	1,383
Government construction grants	3,024	651	776
Government grant for student loans	946	816	923
Fees, services, and other receipts	<u>2,406</u>	<u>2,490</u>	<u>2,778</u>
	\$ 52,362	\$ 49,880	\$ 48,431
Use of funds:			
Used to meet expenses of current operation:			
Endowment investment income (Note B)	\$ 9,681	\$ 9,794	\$ 9,602
Gifts, investment income, and other receipts	17,357	9,193	9,471
Scholarship and fellowship awards for tuition and stipends	7,711	7,965	8,162
Additions to educational plant	10,129	11,969	9,151
Operating expenses recorded in direct expenses of the Division of Sponsored Research	983	1,640	2,246
Other charges to funds not related to current operation	4,595	2,579	2,728
	<u>50,456</u>	<u>43,140</u>	<u>41,360</u>
Net increase in funds	<u>1,906</u>	<u>6,740</u>	<u>7,071</u>
Fund balances at end of year	343,964	342,058	335,318
Less gifts and other receipts available for current expenses	<u>9,660</u>	<u>8,927</u>	<u>7,680</u>
Total invested funds	\$334,304	\$333,131	\$327,638

The accompanying notes are an integral part of the financial statements.

Schedule D (continued)

<u>1971</u>	<u>1970</u>	<u>1969</u>	<u>1968</u>	<u>1967</u>	<u>1966</u>	<u>1965</u>
\$302,901	\$290,598	\$259,882	\$239,902	\$229,119	\$190,722	\$173,910
\$ 35,591	\$ 15,878	\$ 25,069	\$ 22,147	\$ 16,019	\$ 39,186	\$ 21,690
15,498	15,523	14,579	13,502	12,788	10,455	9,482
7,598	6,768	14,068	9,221	3,008	5,153	3,155
1,058	963	1,772	698	709	519	1,234
4,787	4,441	4,624	4,698	4,881	4,821	4,207
1,209	1,698	1,405	1,627	1,921	1,571	1,471
.....	92	2,188	2,028	1,793	1,294	3,148
874	556	639	699	677	850	686
<u>2,781</u>	<u>3,141</u>	<u>2,921</u>	<u>3,007</u>	<u>1,276</u>	<u>1,078</u>	<u>875</u>
\$ 69,396	\$ 49,060	\$ 67,265	\$ 57,627	\$ 43,072	\$ 64,927	\$ 45,948
\$ 8,435	\$ 7,354	\$ 7,351	\$ 6,865	\$ 4,859	\$ 4,490	\$ 2,810
14,529	13,704	10,344	11,113	9,970	8,242	6,833
7,999	7,533	7,279	7,566	6,879	5,703	4,673
6,513	4,283	7,067	10,076	8,509	6,815	13,096
2,869	2,627	1,957	1,062	1,241	72	261
<u>3,705</u>	<u>1,256</u>	<u>2,551</u>	<u>965</u>	<u>831</u>	<u>1,208</u>	<u>1,463</u>
<u>44,050</u>	<u>36,757</u>	<u>36,549</u>	<u>37,647</u>	<u>32,289</u>	<u>26,530</u>	<u>29,136</u>
<u>25,346</u>	<u>12,303</u>	<u>30,716</u>	<u>19,980</u>	<u>10,783</u>	<u>38,397</u>	<u>16,812</u>
328,247	302,901	290,598	259,882	239,902	229,119	190,722
<u>6,893</u>	<u>8,900</u>	<u>7,775</u>	<u>6,441</u>	<u>6,939</u>	<u>7,064</u>	<u>5,880</u>
\$321,354	\$294,001	\$282,823	\$253,441	\$232,963	\$222,055	\$184,842

Statement of Source and Application of Funds
for the year ended June 30, 1974

(in thousands of dollars)

Schedule E

	Current Funds			Invested Funds				Educational Plant		
	Unrestricted	Unex- pend- ment Income	Unex- pend- ed Gifts and Grants	Student Loans	Endow- ment	Desig- nated Purpose	Annu- ity and Life Income	Unex- pend- ed Funds	Used for Educa- tional Plant	Total 1974
Balances at Beginning of Year	\$ 1,101	\$ 4,007	\$ 11,631	\$ 15,190	\$ 230,619	\$ 70,658	\$ 6,940	\$ 7,140	\$ 174,235	\$ 521,521
New Resources:										
Tuition and Other Income	\$ 26,474	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 26,474
Research Revenues:										
Departmental & Interdepartmental	18,451	-	59,436	-	-	-	-	-	-	77,887
Lincoln Laboratory	7,862	-	70,775	-	-	-	-	-	-	78,637
Draper Laboratory	(366)	-	6,214	-	-	-	-	-	-	5,848
Educational Plant Funded from Operations	-	-	-	-	-	-	-	-	648	648**
Auxiliary Activities	-	-	9,272	-	-	-	-	-	-	9,272
Grants-in-Aid	-	-	3,191	-	-	-	-	-	-	3,191
Grants-in-Aid used in Sponsored Research	-	-	(4,937)	-	-	-	-	-	-	(4,937)
Gifts and Bequests Received Added to Funds	1,040	-	6,165	12	3,904	2,507	294	5,553	-	19,475
Patent Royalties Received Net of Cost . . .	948	-	5	-	-	-	-	-	-	953
Receipts from Foundations & Agencies for Student Aid	-	-	4,062	2	-	257	-	-	-	4,321
Net Gain or (Loss) on Sale of Investments.	-	-	-	-	769	49	(106)	-	-	712
Funds Used for Research Contract Allowances	-	-	64	-	-	27	-	-	-	91
Government Student Loan Support	-	-	-	946	-	-	-	-	-	946
Government Construction Grants	-	-	-	-	-	-	-	3,024	-	3,024
Fees, Service, and Other Receipts	2	-	1,240	217	300	619	28	-	-	2,406
Investment Income	6,228	8,583	-	10	-	3,563	334	381	-	19,099
Real Estate Investment Income Supplemented From Funds	(220)*	-	-	-	-	-	-	-	-	(220)
Subtotal New Resources	\$ 60,419	\$ 8,583	\$ 155,487	\$ 1,187	\$ 4,973	\$ 7,022	\$ 550	\$ 8,958	\$ 648	\$ 247,827

STATEMENT OF SOURCE AND APPLICATION OF FUNDS continued

	Current Funds		Invested Funds			Educational Plant	
	Unrestricted	Restricted	Endowment	Designated Purpose	Annuitiy and Life Income	Unexpended Funds	Used for Educational Plant
Retirement of Debt:							
Reduction of Debt for Educational Plant	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 613
Reduction of Debt for Student Aid	-	-	1,232	-	-	-	1,232
Reduction of Debt for Investment R.E.	-	-	-	260	-	-	260
Total Resources Applied	\$ 5,767	\$ 160,265	\$ 1,520	\$ 4,118	\$ 315	\$ 577	\$ 613
Balance Before Transfers and Appropriations	\$ 6,823	\$ 6,853	\$ 15,754	\$ 73,562	\$ 7,175	\$ 15,521	\$ 174,270
Transfers and Appropriations Among Funds:							
Patent Royalty Revenues Transferred to Patent Resource Fund	\$ (948)	\$ -	\$ -	\$ 948	\$ -	\$ -	\$ -
Patent Resources Transferred to Unrestricted	931	-	-	(931)	-	-	-
Research Revenues Appropriated to Use of Facilities Fund	(1,334)	-	-	1,334	-	-	-
Use of Facilities Funds Transferred to Unrestricted	1,202	-	-	(1,202)	-	-	-
Unexpended Endowment Income to Current Funds	(1,234)	1,234	-	-	-	-	-
Sloan Basic Research Funds to Current Funds	-	1,180	-	(1,180)	-	-	-
Endowment Income Added to Principal	(87)	-	87	-	-	-	-
Appropriations for Buildings Added to Educational Plant	-	(10)	-	(491)	-	(9,629)	10,130
Other Transfers & Appropriations	4,278	1,362	(55)	(4,491)	(22)	88	-
Total Transfers and Appropriations \$ 4,042	\$ (2,556)	\$ 3,766	\$ (55)	\$ (6,013)	\$ (22)	\$ (9,541)	\$ 10,130
Balance at June 30, 1974	\$ 4,267	\$ 10,619	\$ 15,699	\$ 67,549	\$ 7,153	\$ 5,980	\$ 184,400
							\$ 531,248

*Sum of Additional Appropriations and Unrestricted Funds used for Operations, Students and Other Charges is \$8,636.
 **Also included in Operating Revenues under New Resources.
 The accompanying notes are an integral part of the financial statements.

Notes to Financial Statements

A -- ACCOUNTING POLICIES

Basis of Presentation

The accompanying financial statements, which have been prepared on the accrual basis, include the accounts of Lincoln Laboratory in 1974 and 1973, and the Charles Stark Draper Laboratory in 1973 (as described in Note F). In order to ensure the 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, 1973, which is subject to final negotiation after Government audit. As a result of the divestment of the Charles Stark Draper Laboratory, indirect costs for the year ended June 30, 1974, have been recorded at agreed upon rates (see Note F).

Educational Plant

Educational Plant, representing land, buildings, and equipment, is shown at cost. As is customary for educational institutions, depreciation has not been recorded on educational plant. Costs associated with the construction of new educational plant 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 include short-term advances of \$3,094,000, as well as \$2,534,000 of borrowings from invested funds (at 5 + 6 percent interest) related to the temporary funding of certain buildings.

B -- INVESTMENTS AND INVESTED FUNDS

Total market value of investments approximated \$388,176,000 and \$440,924,000 at June 30, 1974 and 1973, 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.

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 funds and the income thereon in accordance with the restrictions designated by the donor or by the Corporation. At June 30, 1974, the Institute had reserved \$21,325,000 (captioned "investment income for distribution to funds") representing endowment fund income in excess of amounts distributed to funds in 1974 and prior years. The excess of amounts earned over amounts distributed was \$177,000 and

\$582,000 in 1974 and 1973, respectively. 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 its completion.

C -- STUDENT LOAN FUNDS

National Direct Student Loan Funds of \$7,839,000 and \$6,893,000 at June 30, 1974 and 1973, respectively, are ultimately refundable to the United States Government.

D -- MORTGAGE BONDS AND NOTES PAYABLE

Mortgage Bonds and Notes Payable consist of the following at June 30, 1974 and 1973:

	1974	1973
M.I.T. Construction and Consolidation Bonds of 1968:		
Series A, 3 1/2%, due 1974-2003	\$ 5,073,000	\$ 5,178,000
Series B, 3 3/4%, due 1974-2015	3,776,000	3,816,000
Series C, 3%, due 1974-2018	1,625,000	1,640,000
	<u>\$ 10,474,000</u>	<u>\$ 10,634,000</u>
Dining facilities bonds, 3 1/8%, due 1974-1999	319,000	327,000
Mortgage notes payable, 5 1/4%, due 1974-1978	482,000	576,000
Mortgage notes payable, 5 1/4%, due 1974-1981	527,000	602,000
Residential facility lease purchase obligation (note E)	5,373,000**	5,514,000**
Mortgage notes payable, 5-6 1/2%, due 1974-2003 (note E)	10,265,000	10,400,000
Total related to educational plant	<u>\$ 27,440,000*</u>	<u>\$ 28,053,000*</u>
Notes payable, 6%, due 1974-1976	186,000	279,000
Notes payable, 6%, due 1974-1978	699,000	816,000
Notes payable, non-interest-bearing, due 1974-1977	147,000	196,000
Total related to investment real estate	<u>\$ 1,032,000</u>	<u>\$ 1,291,000</u>
Notes payable to bank, 10 1/4%, due 1974, for student loans	\$ 600,000	\$ 1,232,000
Notes payable to U.S. Government, 6 1/8-7 5/8%, due 1974-1989, for student loans	\$ 297,000	\$ 206,000

*At June 30, 1974, the Institute had pledged securities with a market value of \$4,351,000, 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.

E -- COMMITMENTS

1. During 1970, the Massachusetts Health and Educational Facilities Authority agreed to construct a residence facility and provide additions to heating and chilled water plant for lease to the Institute, with title passing to the Institute upon expiration of the leases. Construction costs of \$10,500,000 were met by an issue of Authority Bonds, with the Institute paying the additional costs required to complete the residence facility. Construction costs of the residence facility incurred to date, recorded as educational plant, amount to \$7,520,000, of which \$5,373,000 represents the associated liability to the Authority. Annual payments under the 30-year lease purchase obligation approximate \$350,000.

Annual rentals for the utility facilities, which are being leased for their estimated 25-year useful lives, approximate \$400,000, and are being charged to plant operations as incurred.

2. During 1973, the Massachusetts Health and Educational Facilities Authority financed the retirement of advances previously made by the Institute in connection with existing dormitory

facilities, and in part, construction of the Chemical Engineering facility and renovation of a dormitory facility. Project costs of approximately \$17,478,000 have been met, in part, by an issue of Authority Bonds of \$10,400,000, which are supported by mortgages given by the Institute on certain of the project facilities.

Costs of the project incurred to June 30, 1974, recorded as educational plant, amount to \$11,802,000, of which \$10,265,000 represents an associated liability to the Authority.

3. The Institute is committed under real estate leases to a gross annual payment of \$815,000 in 1975, and approximately \$100,000 annually thereafter through 1978. Such amounts will be reduced by subleases approximating \$100,000 per year. Certain leases expiring in 1975 are subject to renewal or may be renewed.

F -- CHARLES STARK DRAPER LABORATORY

Effective July 1, 1973, the Charles Stark Draper Laboratory was formally divested from the Institute and organized and operated in a separate corporate status.

During 1974, \$2,781,000 of unrestricted funds was used to provide for the nonrecurring under-recovery of certain indirect costs, as a result of the negotiated fixed rate for fiscal 1974 and the loss of revenue associated with the divestment. The divestment also created a demand for additional unrestricted funds in 1974 which may continue in future years.

G -- RETIREMENT FUNDS

The Institute's retirement plans, which cover nearly 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 are being funded over approximately 13 years. Pension expense charged to operations was \$7,626,000 and \$9,465,000 in fiscal 1974 and 1973, respectively, the reduction in expense being primarily attributable to the divestment of Draper Laboratory.

Auditor's Report

TO THE AUDITING COMMITTEE OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY:

We have examined the following financial statements of Massachusetts Institute of Technology:

Schedule A -- Sources of Revenues and Funds Used to Meet Expenses of Current Operations for the Years Ended June 30, 1974 and 1973.

Schedule B -- Balance Sheets as of June 30, 1974 and 1973.

Schedule C -- Statement of Changes in Fund Balances for the Year Ended June 30, 1974.

Schedule D -- Summary of Changes in Invested Fund Balances for the Ten Years Ended June 30, 1974.

Schedule E -- Statement of Source and Application of Funds for the Year Ended June 30, 1974.

Our examinations were 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.

In our opinion, the aforementioned financial statements present fairly the financial position of Massachusetts Institute of Technology at June 30, 1974 and 1973, and the sources of revenues and funds used to meet expenses of current operations for the years then ended, changes in fund balances and the source and application of funds for the year ended June 30, 1974, and

Vice President and Treasurer

the summarized changes in invested fund balances for the ten years then ended, in conformity with generally accepted accounting principles applied on a consistent basis.

COOPERS & LYBRAND

Boston, Massachusetts, September 10, 1974

Vice President, Operations

The most significant effort in the operational area during academic year 1973-74 involved adjusting to, and compensating for, the changed supply and cost of energy. As described in the following section on physical plant operations, all elements of the M.I.T. community were enlisted in this effort, with primary leadership coming from the able and hardworking team in the Department of Physical Plant. Initial dimensions of the crisis involved the question of whether or not the Institute could reduce consumption to the extent of its diminished oil allotment, so that it could continue to carry out its educational and research functions without shutting down for periods of time or otherwise modifying its academic calendar. In the end, oil and electricity usage were curtailed quickly enough and significantly enough to allow Institute programs and calendar to continue. This was a result of: 1) prior planning and experimentation on energy conservation, prompted by budget cutting considerations; and 2) the intelligent cooperation of the Institute community. Although by midwinter it appeared that the Institute could cope with the limited supply, the effort became even more important as the costs of energy continued to rise and the major increase in Institute expense for purchased energy had to be blunted rapidly and significantly.

In December, 1973, an unusual and imaginative type of grant was made to the Institute by the Union Pacific Foundation. It covered the initial salaries and expense for M.I.T. to add an environmental engineer to its physical plant staff, to further and enhance a constructive program of energy conservation. This was done, and the program is in operation. It was the feeling of the Foundation that this initial investment in management at the Institute would be returned many times over through good operation and savings in expense. A reading of the Department of Physical Plant section of this report will demonstrate how sound this concept was.

In the spring, Richard A. Sorenson, Executive Assistant to the Vice President, Operations, was accepted for the Alfred P. Sloan Fellows Program of M.I.T.'s Sloan School of Management. In June, 1974, he began a year's leave of absence to participate in this Program. This is continuing evidence of the growing interest in, and support for, the further development of M.I.T.'s younger administrators.

PHILIP A. STODDARD

Physical Plant

Operations

Energy conservation, an important aspect of all plant activities in recent years, became the principle concern of the Department of Physical Plant during academic year 1973-74. An allocation of heating fuel supply less than 80 percent of the previous year's fuel consumption was imposed on M.I.T. during the November, 1973, energy crisis. This restriction forced the entire Institute community to participate in drastic reductions in the consumption of heat

and electricity.

Immediately after the announcement of the reduced allocation, an Energy Conservation Committee was formed to deal with the problem. Initially, daily meetings were held in which ideas were discussed and ultimate plans conceived to respond to the crisis. Concurrently with the formation of the Committee, an energy conservation hotline, ENCON, was installed within the office of the director to receive any and all suggestions or complaints from the community. A publicity campaign was developed, with the cooperation of the Institute news media, whereby pertinent energy conservation matters could reach the community. The financial impact of rising utility costs was described, and specific actions that might be taken by employees to conserve energy were discussed.

Among the energy conservation techniques employed by the Institute with the cooperation of the community were the following: 1) reduction of winter operating temperatures and a corresponding increase in summer temperatures; 2) a cutback in air conditioning for other than experimental and computer use; 3) a decrease in domestic hot water temperatures for lavatory supply; 4) ventilation changes to save heating and cooling costs and to limit the operation of high-horsepower fans; and 5) the rescheduling of classrooms and lecture halls to concentrate evening activities in low-energy-consumption buildings.

The cutback in heating and ventilating power use resulted in a dramatic reduction of the Institute's power consumption. This reduction supplemented other direct electric conservation measures which included: a reduction of overall corridor lighting levels; the elimination of decorative lighting and outdoor architectural lighting; and a reduction in office, laboratory, and classroom lighting levels to a task lighting standard of from 50 to 70 foot-candles. These levels were obtained by removing lamps from existing lighting fixtures, where possible, and by disconnecting entire fixtures, where necessary. In addition, the use of incandescent lighting has been curtailed drastically, by replacing these fixtures with fluorescent or other high-efficiency sources.

The reduction in consumption of heat energy and electricity resulting from energy conservation activities has been estimated for fiscal year 1974. The data indicates that the Institute's conservation activities resulted in a gross reduction of 18 percent in heat consumption and 13 percent in electric consumption for the year. Recognizing that the conservation activities were concentrated in the latter seven months of the fiscal year, the effective annual savings will approximate 30 percent for heat and 24 percent for electricity. In response to a 200 percent increase in the cost of heating oil and a 60 percent increase in the cost of electricity, the savings attributed to energy conservation efforts currently are approaching \$1,000,000 annually.

In March, 1974, the new position in the Department of Environmental Engineer was staffed. The addition of Carl W. Hagge in this position reflects the growing importance of energy conservation and environmental concerns as long-range elements of the Institute's total plant activity. The Environmental Engineer has assumed general responsibility for the energy conservation activity on campus, with the advisory support of the Department's Energy Conservation Committee. He also has assumed responsibility for the Department's compliance activities with regard to local and national air and water quality regulations.

As a result of a planning and design effort carried out in fiscal year 1974, prompted in large part by the need for energy conservation, the Department's centralized building monitoring and control capability will be augmented greatly this fall by the addition of a computer controlled power management system. This system will oversee the operation of the major mechanical systems in eight of the Institute's newer energy-intensive buildings. It is planned that the system will expand in an orderly way into a campus-wide central monitoring and control system (CMCS), which represents the best opportunity presently envisioned to manage

Physical Plant

the significant cost of operating and maintaining the complex building mechanical systems with which the Department of Physical Plant must cope in future years.

During the past year, the Institute completed its compliance filings for the air quality and water quality requirements established for M. I. T. by state and Federal agencies. In all filings to date, the Institute has been found to be in satisfactory compliance. Final state and Federal permits sanctioning and regulating M. I. T. 's present use of the Charles River for cooling water purposes were granted in fiscal year 1974, after several years of negotiation.

A substantial electrical renovation was completed in the central plant during the year. The work included the realigning of primary circuits within the plant switching station and the addition of two new unit substations to supply the plant equipment power needs. This is the first major electrical renovation in the central plant since 1938; it serves to make the plant self-sufficient for electric power. It also provides up-to-date equipment and a sound electrical base for the projected future growth of the normal and emergency power systems on campus.

Fiscal year 1974 was the first year in recent history in which substantial decreases in the demands on the central plant for steam heat and electric power were recorded; this occurred despite an increase in the area of facilities served. As noted earlier, overall demand on the steam boilers during the coldest weather decreased by 30 percent from the previous year, and electric peak demand on the local utility system was reduced by more than 10 percent. An interesting parallel, opposite development to this achievement is the fact that the plant anticipates an increase of 30 percent in the demand on the central chiller in the summer of 1974. This increase reflects many minor tie-ons to the chilled water mains, plus the addition to the central plant of the (previously independently operated) major chiller systems in Buildings 56 and 13. The assumption of these loads by the central plant steam driven chillers, accompanied by the mothballing of the electrically driven local chiller units, has resulted in a reduction of the total energy consumption, and as a result, is generating substantial cost savings in the utilities budget. A portion of these savings is being transferred to a utility system capital fund, as seed money to finance future economy based system alterations.

With the actual increase in chilled water demand and in anticipation of the additional load of the new Chemical Engineering Building (currently under construction), the scheduling of Refrigeration Machine #4 becomes critical. Refrigeration Machine #4 is the final stage of currently planned development of the central plant. This 4,000-ton unit brings the total plant capacity to 10,500 tons, the maximum contemplated for the present building. During the year, the chiller unit for the machine, a long-delivery item, was prepurchased by the Institute, and the engineering design for the construction package was begun. An in-service date of mid-1975 is contemplated.

Telecommunications

The major activities of the Telecommunications Office included: the introduction of a general facsimile transmission service for the M. I. T. community; an experiment with WATS (Wide Area Telephone Service) within the Commonwealth of Massachusetts to determine its feasibility and acceptance, with an associated plan to implement WATS with a new toll recording system; and the acquisition of 600 lines of telephone equipment from the American Optical Company, to be used by the dormitory telephone system. In addition, an order was placed for a customer dialed account recording system with the telephone company, to supplant the present method of placing outgoing toll calls via credit cards. The anticipated in-service date for the new system is September, 1975.

Activity within the Telecommunications Office continued at a high level, surpassing the previous year's orders by approximately 10 percent. Approximately 2,000 orders were issued during the year. Finally, a four-day workweek was initiated for telephone operators on a permanent basis, after a two-month trial period proved an overwhelming success.

Building Services

The demands on the Building Services operation have increased steadily over the past few years, due to a reduction in personnel, growth of the physical facilities at M.I.T., and the increased number and diversity of special events taking place. In order to meet these demands and to staff the operation with supervisors and employees 24 hours per day, seven days per week, various steps have been taken. Nonessential services have been eliminated or curtailed. A job analysis of hourly personnel has been conducted to effect the best utilization of existing manpower. A program has been organized to acquaint all employees with cleaning techniques and products, through the use of audio-visual aids and practical demonstrations, in order to achieve programmed standards. Additional mechanization of the cleaning force to reduce manpower costs and to improve the general quality of cleaning has been undertaken. Finally, a pilot program has been developed to investigate the possibility of "team" floor polishing, in order to specialize the tasks involved.

The Grounds section of the Support Services group received special recognition when the Massachusetts Horticultural Society, probably the most prestigious American horticultural organization, presented a Special Award of Merit to M.I.T. honoring the Institute "for the use of trees and plants around a great university." The citation constituted a singular honor for M.I.T., in that it is the first entire university campus to receive this merit award.

Construction

In the construction area, the renovation of the west wing of Ashdown House was completed in the fall of 1973, and students moved into the new spaces in December. Renovations began immediately on the east wing, and this work is scheduled for completion in the fall of 1974. Construction continued during the year on the Chemical Engineering Building. The two basement foundations were completed in the spring of 1974, and work was started on the building's superstructure.

The fifth floor of the Seeley G. Mudd Building was completed in December, 1973, just nine months after the start of construction; the Center for Cancer Research staff moved in immediately and initiated their research programs, while construction continued on the remaining floors. The Arteriosclerosis Center on the fourth floor was completed and occupied in May, 1974, and the Center for Cancer Research headquarters on the first floor were completed in June. The remainder of the building, including the Cell Culture Facility, is scheduled to be completed in the summer of 1974.

Major projects initiated during the year were the West Campus Undergraduate House, and the Geophysical Underground Laboratory in Westford, Massachusetts. The West Campus Undergraduate House, a 300-student facility to be constructed of reinforced concrete with brick exterior, will be located on Memorial Drive adjacent to MacGregor House. Foundation work began in April, 1974, with occupancy scheduled for the fall of 1975.

The Geophysical Laboratory, located near the Wallace Astrophysical Observatory in Westford, Massachusetts, will be devoted to seismic research. Research instrumentation will be installed in an accessible concrete underground vault founded on granitic bedrock and covered with 12 feet of earth.

Major space change renovation projects during the year involved the Career Planning and Placement Office, the office of the Vice President for Resource Development, the Department of Psychology's experimental animal quarters, the Laser Laboratory of the Department of Physics, the Department of Architecture, and the Planning Office.

HOWARD F. MILLER

Housing and Food Services

Housing

The Housing section has expanded in scope and personnel during the past year with the transfer of certain functions from the Institute Real Estate Office (I. R. E. O.). Specifically, these functions are the community housing service, visitors' furnished apartments, and faculty housing in Eastgate. This transfer permitted the closer integration of these activities with on-campus apartment house operations (Eastgate, Westgate, and Tang Residence Hall), providing a more effective, total service to the community of users.

There have been several changes in central management personnel and their responsibilities during the past year. In July, 1973, Arthur Beals was promoted to associate director, and Joseph Lynch was promoted to assistant director with primary responsibility for the undergraduate dormitory operations. Dexter Kamilewicz was appointed assistant director in November, 1973, with primary responsibility for the apartment house operations and those functions transferred from the I. R. E. O. Other promotions, due to the combining or redistribution of responsibilities, were Cecil Saunders and Norma Mele to house managers of MacGregor House and McCormick Hall respectively. Donald Hubbard was promoted to house manager of Baker House.

The renovation of the west wing of Ashdown House, which was started in January, 1973, was completed, and the wing was occupied by students in late November. The east wing is expected to be complete and ready for occupancy by the start of the fall term in 1974.

Two major projects involving changes or modification in dormitory spaces were completed this year. Senior House now functions separately from the East Campus Houses, with the building of an office and desk area on the first floor of Ware entry. This has had a positive effect on the residents, in that they now feel the House is an entity and not an adjunct to East Campus. The second project was the renovation of the west lounge on the fourth floor of Baker House. The new lounge incorporates new furnishings, lighting, and carpeting. It has been well received by the residents of the House.

Members of the Housing office, Planning Office, and Department of Physical Plant presently are studying the physical plant in Baker House. They will generate a report which will be the first step in developing a program of its renovation.

A new undergraduate dormitory is now under construction on the site just west of MacGregor House. Actual construction began in early April, 1974, and barring any major difficulties, occupancy is expected in the fall of 1975. Total occupancy for this house is expected to be about 300 residents. The program and building design permit the house to be divided into entries which will facilitate smaller, more cohesive units than an entire house. The plant itself is designed to present six distinct units.

Food Service

This has been a very active year for the Food Service section, with an extensive evaluation conducted by the operations personnel and an outside consultant. It focused primarily on the areas of service and concept of operations. The end result of this analysis was the decision to assume all management responsibility and to terminate the Institute's relationship with Stouffer Management Food Service, effective June 30, 1974. This decision was based not on any single area of concern, but on the system as a whole. It was felt that with total responsibility in Institute hands, the system can be tested better for the future and be more responsive to modification and change where desired.

This decision has affected the personnel structure. Many of the key management and food production positions were filled by Stouffer personnel, with the exception of the unit manager positions. The first task was to locate a general manager. Edward Leonard comes to the Food Service section with ten years of experience in this field and ten years prior experience in the commercial area of food service. He and others from Food Services are in the process of effecting the necessary organizational changes.

The coming academic year will begin with the basic structure of the system and the service it provides unchanged. Parts will be changed and modified as necessary throughout the year. The major change to date is that of providing more than one option for the board contract to the residents. This fall, the 15-meal plan will continue to be offered, along with a 19-meal plan, and a plan providing for 25 of each of the three meals, to be taken any time during the term. There will be other, more subtle changes, but many of these will not be readily apparent to the community.

In summary, there is a challenge ahead for the Institute's Food Services, which each employee has accepted cheerfully. It is generally felt that the system, as a whole, will grow in excellence and will provide the M. I. T. community with the service and quality that it deserves.

HARMON E. BRAMMER

Campus Patrol

The Campus Patrol continues to meet the challenges of an open campus with a coordinated effort that seeks to provide a high standard of service to an alert and informed community.

The trials of previous difficult years have provided valuable experience to those who have dedicated their future to campus law enforcement.

Campus Patrol officers can contribute significantly to the health and welfare of the M. I. T. community by conducting themselves with the highest ethical standards of the law enforcement profession. In accordance with these goals, this year the Patrol was fortunate to obtain the services of an exceptional educator in the law enforcement field as supervisor of training, to further its development on a continuous basis through in-service training programs. The results of this effort have been extremely rewarding.

In the area of Medical Department support, recently enacted legislation relative to the transportation of sick or injured persons requires the Patrol to upgrade the type of vehicle used for this purpose, as well as to provide additional training in emergency medical service for all personnel.

Campus Patrol

In 1973, Cambridge was marked by a period of serious crimes which caused widespread concern. This led to the development of various crime committees and closer cooperation with city agencies in an effort to develop programs to combat this type of activity. M. I. T. participated in these efforts while continuing to amplify its own preventative patrol procedures. The campus did not reflect the serious external rise of criminal activity.

The following recorded statistics cover some of the major areas of activity.

	<u>1972</u>	<u>1973</u>
Number of Recorded Complaints	1,421	1,713
Medical or Emergency Service	715	850
Assaults, Armed Robbery, etc.	28	29
Reported Rape	2 (Attempts)	0
Auto Theft*	136	130
Bicycle Theft	119	107
Institute Property Loss	\$33,449	\$20,979
Personal Property Loss	\$16,618	\$13,337
Arrests	60	78

* Includes surrounding Cambridge streets.

Various crime prevention programs currently in use continue to assist the efforts of the Patrol: "Operation Identification," the equipment bolt-down program, increased patrol escort services, informative warning bulletins in problem areas, and additional foot patrols are a few. The Patrol added the services of a female officer in 1973, which was welcome news to the Institute's female population.

Through the voluntary efforts and initiative of four Campus Patrol officers, a community relations program known as the M. I. T. Junior Beavers was instituted. This involves work with Cambridge youths in the neighborhood, providing supervised access to M. I. T. facilities as well as interesting field trips. The program has the enthusiastic support of everyone; it provides a new alternative for Cambridge youngsters accustomed to becoming "minor offenders" for confusing M. I. T. with free playground space. M. I. T. officers also have been attending police-community relations meetings with nearby neighborhood groups, and have been well received by them.

JAMES OLIVIERI

Safety Office

After 25 years of service to the Institute, Mark Dondero has resigned as head of the Safety Office. Recognized nationally as a leader of the college safety movement, the Office is fortunate that he has accepted an assignment as consultant in the areas of long-range planning, special projects, and organizational planning. His guidance (characterized by his knowledge of the Institute and his sense of professionalism) is sought by all, and particularly by new personnel, in safety matters. During the year John Fresina was promoted to director and Raymond Diffley to associate director.

The Occupational Safety and Health Administration (OSHA) inspection program of the entire campus and off-campus sites is nearly complete. All areas of the Institute have been inspected by the Safety Office staff and/or a departmental safety coordinator or representative. Reports on violations have been sent to department heads or laboratory directors, and remedial action on violations by them and by the Department of Physical Plant have been very good.

The second phase of the program, involving the transition from the OSHA-type inspection to an ongoing departmental in-house safety program, is in the planning stages and will be implemented this coming year. The goal is to have the departmental safety coordinators assume more responsibility in the safety area. Hopefully, this will involve them in long-range safety planning, as well as day-to-day safety concerns. The key areas of involvement for the coordinators are: the annual safety inspection, with a report to the department head and the Safety Office; employee and student safety problems and accident investigation; and a review of contract research proposals for safety.

The impact of the OSHA compliance inspection at M. I. T. still is being felt, as requests for information continue to come in. This year found members of the Safety Office participating in many conferences throughout the country. All the professional staff have participated to some degree in relating their experience with OSHA compliance to various college associations. Among these were the National Association of Educational Buyers; College and University Personnel Association; Campus Safety Association; Campus Insurance Managers; Campus Radiation Safety Association; and the Research and Development Section of the National Safety Council. In addition, members of the Office have increased their interest and participation in state and Federal legislative matters as they pertain to safety legislation which might affect universities (i. e., the Committee on Government Activities [COGA], the State Hearing on Waste Disposal, the Massachusetts Occupational Safety and Health Act [MOSHA], the National Fire Protection Association [NFPA], and so on).

Considerable effort has been devoted to the indoctrination and education of the two new members of the safety staff. This has included both formal safety training in continuing education programs in local schools and on-the-job safety training which is task oriented. Their addition to the Safety Office has enhanced its quality of performance. Senior staff members also have participated in Administrative Development Program (ADP) I and II and have become highly qualified in first aid training. New relationships have been formed with certain groups in the Institute, and older relationships have expanded and become firmer. In general, the response to OSHA and the additions to the staff have produced more awareness of safety and a new atmosphere of cooperativeness at the Institute.

Draper Laboratory officially divested itself from the Institute, and the Office participated in the smooth turnover of the safety function to the new Safety Engineer. Members of its staff met with Draper personnel well before and after the turnover to plan and effect the transition smoothly.

Increased involvement of the Safety Office with fraternities has occurred, due to its inclusion on the physical facilities survey team of the Department of Physical Plant. The office of the Dean for Student Affairs has asked that all fraternity houses be contacted over the next two years.

The program of automatic sprinkler installation continues, with emphasis on protecting living group areas. Currently, the Office is working on or has completed installation in Eastgate; Ford Building computer areas; Westgate high-rise; Bexley Hall; Senior House; Francis Bitter National Magnet Laboratory; the Student Center; and smaller laboratory areas. In addition, sprinklers have been added in many areas affected by space change requests.

A review of the entire fire protection system for the main group of buildings has been undertaken by Factory Mutual Liability Insurance Co. of America, to evaluate and make recommendations regarding the reliability and adequacy of the water supply. It has been determined already that the water reservoir under Building 43 is not required, as public and private water supplies are reliable. The desirability of replacing the manual steam fire pumps with automatic starting electric pumps still is being evaluated.

The number of fires during the year decreased to 29, from the 45 reported in 1972-73. Fire damage was slight in each case, with no fire loss approaching the deductible amount on the Institute's policy. Only two sprinkler actuations were recorded. This decrease is due largely to the discontinuation of burning waste in dormitory incinerators.

The volume of hazardous chemical waste continues to increase, and the problem of ultimate disposal persists. Faced with a complete ban on ocean dumping effective January 1, 1975, the Office continues to search for approved disposal contractors who will handle the Institute's wastes. Due to the wide variety and small quantities of waste generated, most commercial disposal contractors who recycle on a large scale are not interested in doing business with M. I. T. If this waste is not disposed of commercially during the next year, the Office will have to turn inward for solutions.

Joseph Kuchta has been appointed by the American National Red Cross to serve as a trainer of Red Cross instructors. This is a noteworthy achievement and of extreme value to the Institute, as Mr. Kuchta has responsibility for first aid training in its safety program. Mr. Kuchta also has been elected to the Board of Directors of the M. I. T. chapter of the Alpha Pi Omega service fraternity.

A new dimension has been added to safety review of new construction. At the request of the Department of Physical Plant, neither the Fairchild Building nor the Seeley Mudd Building was occupied until all mechanical and machine rooms complied with OSHA standards.

First aid training continues, with the following participation: Department of Mechanical Engineering, standard first aid course -- 16 persons; Bitter National Magnet Laboratory, multimedia course -- 31 persons; and Cardiac Pulmonary Resuscitation -- 9 persons.

JOHN M. FRESINA

Graphic Arts Service

Revenue and work orders continued to increase, after a two- to three-year period of decline and instability. This occurred despite the fact that departmental budgets again were reduced. Graphic Arts has increased its share of the Institute's printing, and has been able to fill the requirements of the Institute community, since prices have remained relatively stable. An increased awareness of Graphic Arts' capabilities and functions, along with improved methods

and procedures which have contributed to a better, faster service, account for this success. Total dollar volume was up approximately 15 percent.

The quick copy centers showed the largest increase of all Graphic Arts departments, with a rise in revenue of 30 percent despite large price reductions from the previous year. This reflects a continuing desire on the part of various M. I. T. departments for lower costs through the use of lower-quality reproduction. To handle this large increase, additional and more efficient machinery was acquired, bringing to 12 the number of duplicators and copiers now operating at full capacity in the three copy centers. In addition, a nearly 100 percent increase in floor space was acquired for the central copy center, thereby solving a long-standing problem.

The five other departments (offset printing, illustration, photographic, mailing, and audio-visual) showed smaller increases.

The typesetting service, which was initiated in 1972 as a part of the illustration department, continued to be a success. New equipment was purchased and new typefaces became available as the service expanded. Further expansion with more sophisticated equipment may be necessary to meet the future needs of the community.

The student picture and identification card program remains a function of Graphic Arts Service. New equipment has been purchased to implement a faster method of producing the identification cards.

JAMES W. COLEMAN

Endicott House

The first part of the year 1973-74 appeared somewhat disappointing in terms of use of the House, but as the months went on, activity increased markedly, and the year's end found the overall pattern quite gratifying and comparable to the previous year. Endicott House again was open 12 months of the year, although the use pattern was light in the months of July, December, and January.

An indication of the significant use made of this beautiful facility can be seen in the following statistics. The House was used a total of 248 days during the year, including 188 nights by resident groups. Twenty-three resident conferences were held at the House. Overnight stays totaled 4,792, an average of over 25 guests per night. Seventy-eight nonresident groups involved a total of 5,725 guests, which was an increase in this type of activity over previous years.

Due to the staggering increase in costs, particularly for electricity, fuel oil, and food, it was necessary to increase the rates in January, 1974. By the latter part of the academic year, it was evident that a further increase would be required in July.

Several major capital and maintenance projects were accomplished during the year. These included interior and exterior painting, rug replacements, and resurfacing of the tennis court. A comprehensive physical facilities and furnishings survey was completed in February, 1974, which provided an update on a long-range program for maintenance and improvements.

Vice President, Operations Philip A. Stoddard assumed the chairmanship of the Board of Governors again at the beginning of the year. Grateful appreciation is extended to his predecessor, Secretary of the Institute Vincent A. Fulmer, for his leadership.

MIMI PIERSON

Vice President

This report consists of a general overview of the Institute's several housing programs, a brief discussion of important current concerns of the Medical Department and Environmental Medical Service, comments on studies related to the academic calendar, and some notes concerning developments of some importance in the Registrar's area. Additional information regarding housing is contained in the annual reports of the Dean for Student Affairs and the Vice President, Operations. Dr. Albert O. Seeler's report on the Medical Department, including the Environmental Medical Service, and Warren D. Wells's report of the Registrar follow.

Undergraduate Housing

Construction of a major new addition to the Institute's undergraduate housing capacity was begun during the year. The new building will house 300 undergraduates in six individual, self-contained entries which are interconnected by an enclosed passageway at ground level. Accommodations for a housemaster and family as well as for resident tutors are part of the program.

The site of this new house is that of the former Joyce Chen Restaurant on Memorial Drive, just west of MacGregor House. An enclosed walkway will be constructed between the new house and MacGregor, to permit residents of the new building to share the commons facilities in MacGregor with the undergraduate residents of MacGregor House.

Construction began on part of the site on April 1, 1974; the entire site was available for work by June 17. The construction schedule calls for occupancy of about 150 beds in time for registration day, September, 1975, with the remaining 150 beds to become available shortly thereafter. This project is a first for the Institute's residence program in that it has been undertaken on a modified "fast-track, design-build" scheme. The architectural firm of Sert, Jackson, and Associates and the Turner Construction Company joined forces as the West Campus Associates to work with M. I. T. staff to design and build this new house as economically and as rapidly as possible. Although many economies were made throughout the effort, beginning with the initial program and following through the architectural design and construction cost analysis, the project cost (above land) will be slightly over \$20,000 per student housed -- a cost which reflects the difficulties to be faced in finding ways to provide even more housing to respond to student demand.

The new house, when fully occupied sometime after September, 1975, will bring the total capacity of the undergraduate Institute Houses to 2,215. Projections for future new construction requirements have been made under the following assumptions:

1. The Institute's housing policy will continue to be that of seeking to provide up to eight continuous terms of residence in Institute Houses for those undergraduates who desire them.
2. The Institute's fraternity system and the M. I. T. Student House will continue to provide housing for about 1,300 undergraduates.

3. The Institute will continue to require all first-year students to live in an Institute house, a recognized fraternity, or the Student House, and the fraction of upperclass students who opt to remain in the Institute House will remain constant. Inflation has forced the Institute to announce very large increases in room and board rates for 1974-75. Since Cambridge and Boston rental markets are under rent control, it is possible that more upperclassmen will opt to move off-campus. At this writing, however, early data for September, 1974, gives no indication that current upperclassmen are choosing to leave the Institute Houses in greater numbers than their predecessors.
4. Bexley Hall will be discontinued as a student residence as soon as new replacement accommodations are available. Bexley is an old apartment house which was turned into undergraduate housing as a "temporary" measure several years ago. The condition of the building is such that it requires major renovation, and studies indicate that the cost involved is so high that any such capital investment would be utilized more effectively for new construction.

With these assumptions, future needs for new construction have been predicted for two levels of undergraduate admissions rates. For an annual steady-state freshman admissions rate of 1,000 and a college transfer rate of 100, one additional new house with a capacity of approximately 250 is required. If each of these admissions rates is increased by 20 percent in 1976 and held steady from that time on, additional accommodations for approximately 700 -- probably two houses of about 350 each -- will be required.

Aside from the need for new construction, three undergraduate Institute Houses are in need of significant renovation and modernization. These are Senior House, East Campus, and Baker House. At the present time, studies are being undertaken to determine the level of renovation required, and the associated costs, for each of the houses.

Student rental income cannot cover all or even a large fraction of the debt service of new residences or major renovations at current and projected construction costs -- even at the most favorable lending rates, which are currently Massachusetts Health and Educational Facilities Authority (MHEFA) bond issues. It is clear, therefore, that there would be significant economic dividends to the residence program if further increases in the size of the undergraduate body were accompanied by better utilization of existing housing stock, such as the adoption of some form of year-round academic calendar. The complex matters of increasing the size of the undergraduate body and changing to a year-round academic calendar are currently under discussion in several areas of the Institute.

For educational and philosophical reasons, the Institute long has supported its independent residences -- 29 fraternities and the cooperative M. I. T. Student House. The preceding discussion of costs associated with meeting the demand for undergraduate housing in Institute Houses is indicative of the additional, very pragmatic reason why it hopes to keep the independent residences strong and healthy: they provide housing for some 1,300 undergraduates. If the Institute were to lose these resources, the financial dilemma associated with new Institute housing construction would be compounded several times.

Student interest in fraternities has remained strong; the percentage of incoming freshmen male students who joined fraternities in September, 1973, was a record high. Nevertheless, the physical plants of many of the houses have deteriorated seriously. Some are located in uncongenial Back Bay neighborhoods which have declined significantly in recent years. Many, in an effort to keep house bills at the lowest levels, have provided neither adequate maintenance nor built up cash reserves which would permit major remodeling or new construction

without massive new financial inputs.

The undergraduate Interfraternity Conference (I. F. C.) and the Alumni Interfraternity Council (A. I. F. C.) worked hard at these problems during the 1960s. The Independent Residence Development Fund (I. R. D. F.) of the Alumni Fund was one of the most significant developments of this period. However, the unrest of the late 1960s and early 1970s took its toll in the vitality of the I. F. C. and A. I. F. C. , both of which became largely inactive. Fortunately, this past academic year has seen a new surge in both groups, and it is hoped that they will contribute once again to finding solutions to the very real and urgent problems faced by a significant number of the houses.

This renewal of interest is in part the result of the strong impetus provided by the opening of the new Alpha Tau Omega and Kappa Sigma houses on Memorial Drive, just east of Burton-Conner House. These houses are the culmination of a collaborative fraternity effort begun in the mid-1960s, made possible by the dedicated leadership of several fraternity alumni, most notably James H. Eacker (Alpha Tau Omega, 1955). Also, the houses have received very favorable long-term, low-interest financing from the I. R. D. F. and a long lease at practically no cost on a choice piece of Institute owned land fronting on the river.

These new houses and their neighbor, Phi Beta Epsilon, which was renovated extensively and expanded a few years ago with the aid of I. R. D. F. funding, played host to a number of alumni during a recent Alumni Weekend. This social event was intended as a forerunner of a large A. I. F. C. "renewal and hard work" meeting currently planned for fall, 1974. It also served as a preliminary to the kick-off in the fall of a second major fund drive by the Alumni Fund on behalf of the I. R. D. F.

Currently, Delta Psi (The Number 6 Club) has begun a renovation similar to the earlier renovation undertaken by Phi Beta Epsilon. Also, a new collaborative effort of several Beacon Street, Boston houses is getting under way. Both of these projects will require I. R. D. F. financing as well as significant fund-raising efforts by the individual houses to make them financially viable. A recent study places the probable demand for I. R. D. F. funds for these and several other anticipated projects in the range of 10 to 12 million "1974 dollars." Clearly, significant new development efforts will be needed on behalf of the fraternity system.

Graduate Housing

Current predictions suggest that the population of regular graduate students will not decrease in the near future. Instead, a modest growth of one or two percent per year is expected. Accordingly, graduate housing plans are being developed on a projection of modest growth.

The second and final phase of the massive renovation of Ashdown House is scheduled for completion in September, 1974. Some 60 new undergraduates will be housed in Ashdown until the scheduled opening of the new undergraduate house in September, 1975. Following that time, Ashdown's accommodations will be available only to single graduate students.

The combined capacity of Ashdown House and the Tang residence, the new apartment structure for single graduate students, is approximately 800 -- or nearly one-half of the total population of single regular graduate students. This fraction was established some time ago as a target for on-campus housing capacity for single graduate students, but it appears now that student demand for on-campus housing still is far from being satisfied. Although Ashdown House rentals have been increased, to reflect both inflation and the slight decrease in capacity resulting from the renovation, and although Tang rental levels reflect the high cost of the recent construction of that building, the number of applications for these facilities currently is far in excess of space available. It is estimated that the excess demand (the

number of students who request accommodations but whose requests cannot be met) for September, 1974, will be in the range of 200 to 240.

The excess demand for married student accommodations in Eastgate and Westgate is even greater. For several years the number on the waiting list typically has been about equal to the total number of apartment units -- approximately 400 -- and the turnover each year has been approximately one-third.

Although the earlier target was to have available on-campus married student accommodations for approximately one-half of the married student population (predominantly graduate students), currently there are only approximately 400 units for a married graduate student population of nearly 1,600. The problems of high construction costs have made the development of married student housing even more difficult than the development of single student housing. Current above-ground project costs for modest-size apartments on campus are estimated to be in the range of \$40,000 per dwelling unit. The monthly debt service for amortization of total project costs of this magnitude would be at least \$225 to \$250 per unit; consequently, the total rentals appear to be beyond the reach of most students.

The commercial rental market in the Cambridge-Boston area appears to become more unattractive each year. Although apartment rentals are "artificially depressed" by rent control, its imposition has made the problem of locating satisfactory rental housing even more difficult than before, particularly for "transient" students. New construction for the rental market virtually has ceased. Older buildings of any quality rapidly are being turned into condominiums. Owners of the lower-quality rental buildings are not maintaining them adequately, and they also find ways to add other charges to the base controlled rents, which make for high total monthly costs. Finally, the turnover for rent controlled units is low. The total impact is such that the new transient student finds fewer accommodations available, and those available are at very high cost.

A recent survey purported to establish the cost of living in the Boston area as higher than any other continental United States city. If the cost is high for permanent residents, it is even higher for transients. The Institute is redoubling its efforts in seeking ways to build student housing at lower cost, and in searching for financing mechanisms which would bring rental levels within reach of students' ability (or willingness) to pay. The current outlook, however, is gloomy at best.

Staff Housing

The problems which students face in the local rental markets are shared, at least in part, by faculty and staff, particularly by younger members who have little or no equity on which to base the purchase of residential property.

Presently, the Institute is passing through a transition phase in its programs designed to assist faculty and staff in finding satisfactory housing. Four such programs were established in the mid-1960s as efforts to have more faculty living close to campus, in hopes that they might complement and interact with the largely residential student body. The Institute also hoped to assist faculty and staff in coping with the highly competitive local rental and real estate market.

Under the faculty housing program, the Institute was to acquire an inventory of nearby residences for sale to incoming faculty members under buy-back agreements. The housing crisis which came to the fore in Cambridge in the late 1960s resulted in the adoption of a policy of acquiring no additional residential properties in Cambridge. Furthermore, experience showed that it was not possible to develop a sufficiently large inventory of homes to appeal to a spectrum of tastes and desires. Finally, those who purchased houses under this program found the restrictions associated with the Institute's repurchase rights

somewhat onerous, as they undertook remodeling and so on. Accordingly, this program has been disbanded; purchasers have been released from the repurchase agreements.

Upon the completion of the Eastgate apartment tower for married students, about one-fifth of these apartments were assigned for rental to younger faculty members. In general, the hoped-for student-faculty interaction has not lived up to expectations. The number of apartments assigned to faculty has been reduced by attrition, as faculty have left and these apartments have been turned to married student use. The future of this program is currently under study.

The Northgate Community Corporation was established as a nonprofit but real estate tax-paying subsidiary of the Institute. The objectives of the Corporation were to construct new housing in Cambridge (primarily but not exclusively for M.I.T. personnel); to finance this construction through commercial financing at generally favorable rates; and to operate the properties on a no-gain, no-loss basis -- thereby providing good value and hopefully making for some stabilization in the local market.

As inflation (particularly in the construction fields) and rent control impacted, Northgate never really "got off the ground." Although some land was purchased for the construction of new residential properties, these projects were not carried through. Several older apartments and multifamily residences were purchased, and several blanket leases on older apartments and on new buildings as they opened were taken by Northgate. The tenant population was made up of M.I.T. persons (a large fraction of whom were students, since the quality and/or location of most Northgate buildings did not meet faculty needs), and persons from the community -- "indigenous" residents who had resided in the buildings prior to Northgate's purchase, and leased-housing tenants.

For several years, Northgate functioned as a successful housing resource, even though it was unable to mount new construction. Tenants appeared to be satisfied with the rental levels and general operation; M.I.T.'s community housing service found Northgate a very valuable resource in satisfying the needs of incoming students and younger staff who could not be accommodated or did not wish to live on campus. The imposition of rent control in Cambridge and the impact of accelerating inflation struck Northgate simultaneous blows approximately three years ago. Northgate succeeded in establishing those units rented to M.I.T. persons as "excepted" from rent control. However, the actions, or lack thereof, of the rent control administrator and Rent Control Board, with respect to Northgate, other landlords, and tenants' lawsuits (including those initiated by M.I.T. students), coupled with rapid cost increases, turned Northgate from an Institute housing resource into an Institute problem.

Reluctantly, Northgate has decided that the current and foreseeable residential rental markets in Cambridge are such that it cannot hope to meet the objectives for which it originally was established -- at least not on the basis of its current holdings. Accordingly, a nonforced process of divestment has been undertaken. As of this writing, Northgate has reduced its holdings to about one-half of the total number of dwelling units which were under its control at the time rent control was adopted in Cambridge.

The Faculty Second Mortgage Program was established to assist faculty members in the purchase of their first personal residence within "reasonable" distance of the Institute. The rates typically are based upon a ten-year pay-back, and their interest is at one-quarter of a percentage point above the first mortgage, which the faculty member is expected to arrange through normal commercial channels. The experience with this program has been good. Through careful preliminary study and discussion, the mortgage recipient is discouraged from overextending himself or herself, and the Institute is protected from the occasional person who wishes to take advantage of this program for purely investment purposes.

There have been no defaults, and since most of the applicants are in the younger age bracket and can look forward to significant annual increases in income, the ten-year pay-back time has not proved to be a burden.

However, the program is a small one. At the present time, some 22 individual second mortgages, totaling about \$120,000, are outstanding. A total pool of \$200,000 from the investment portfolio had been earmarked. It is felt that the program is not generally well-known or understood around the Institute.

Of all the mechanisms studied (or attempted) through which the Institute has sought to assist its nonstudent personnel in finding satisfactory residences, the Second Mortgage Program seems to have the greatest advantages. Among these are:

1. It does not place the Institute in a tenant-landlord relationship, to which Institute ownership of rental housing inevitably seems to lead.
2. It makes possible a constructive response to a wide range of personal choice in residential styles, location, and so forth. In particular, it enables a person to undertake condominium ownership at a time when condominiums rapidly are replacing rental units on the local markets.
3. It assists younger staff members in building equity in what appears to be one of the best anti-inflation hedges -- personal residential real estate -- and in taking advantage of the associated tax benefits.
4. It encourages stability, both for the staff member's family and in his or her relationship with the Institute.

For these reasons, this program is being reassessed to determine whether the benefits should be extended beyond the present relatively small eligible faculty group, and whether the permissible levels should be increased. Any significant extension, of course, will require considerable additions to the rotating capital fund and also a reevaluation of the validity of using any significant amount of investment funds for this purpose. A specially identified investment fund, similar to the I.R.D.F., has been proposed. Alternately, an employee benefits approach might prove fruitful.

Inevitably, when matters related to nearby faculty and staff housing are discussed, progress in developing housing on the Simplex "Northwest Area" site is questioned. Although construction of housing continues to appear a desirable use for a portion of this site, the project continues to face the twin dilemmas of high costs and poor physical environment. Thus, the Vice President's office continues to seek a compatible commercial development of sufficient scale to provide for a significant change in the environment and to make feasible the initiation of one or more housing programs of modest scale. Without such an initial commercial development, any residential program which is undertaken would have to be on a sufficiently large scale to impact on the environment. Today's residential market and construction and financing costs discourage the undertaking of such a large risk.

Medical Department

In the report which follows, Dr. Albert O. Seeler provides some statistical data on the first year of pilot operation of the new M. I. T. Health Plan, a form of health maintenance organization (HMO). He also comments on the generally favorable reception this comprehensive prepaid group practice approach has received from M. I. T. personnel, and on the equally good effects to date of the Plan within the Medical Department.

At the time the decision to mount this limited-enrollment pilot operation was made, a three-year period for evaluation was established. It was intended, at the conclusion of that evaluation time, either to discontinue the Plan or to expand it and make it available on an optional basis to all M. I. T. staff and employees. In establishing the three-year evaluation period, the Institute did not foresee accurately enough how rapidly new health care developments would emerge, particularly through congressional action.

Congress enacted, and the President signed into law in December, 1973, the so-called HMO (health maintenance organization) Bill, the content of which has had a marked impact on the Institute's planning. One of the more important provisions of this legislation will require M. I. T. to offer to all of its employees -- as options to their present Blue Cross/Blue Shield Master Medical Plan -- health insurance options in one of each of the two forms of health maintenance programs eligible for "qualification" under the law, provided that these options are available in the Cambridge area. One such form is already available locally through the Harvard Community Health Plan (which is expected to be able to "qualify"), and it is likely that the second form also may evolve, under the auspices of the Middlesex Medical Foundation. Thus, during the coming year, M. I. T. could be required to offer as many as four health care options in addition to the M. I. T. Health Plan. These could be: no coverage (as at present); Blue Cross/Blue Shield Master Medical (as at present); the Harvard Community Health Plan (almost certainly a new legal requirement); and a Middlesex Foundation plan (a possible new legal requirement).

It is generally felt that, in addition to complications in the administration of employee benefits which could be encountered, the health care of certain individual employees and their dependents could suffer from lack of continuity, should these employees switch back and forth among the several options at the (legally required) annual enrollment periods.

In view of these developments and because the experience with the M. I. T. Health Plan has been encouraging, the decision was made to advance its evaluation time from three years to one, and to assemble and assess the relevant data during the summer of 1974. Hopefully, this will permit a formal decision to be made on the future of the Plan by the Institute's senior administration and the Corporation early in the fall of 1974. If the decision is made to continue and to expand the Plan to accommodate all of those employees and their dependents who choose it, it is hoped that the Institute then could "qualify" the Plan under Federal legislation -- thus satisfying through the Plan the requirement that M. I. T. offer its employees qualified HMO options.

As parts of the data currently being assembled for this evaluation, financial and personnel implications for the Medical Department ambulatory units and the Infirmary, as well as the outside hospitalization experience, are being analyzed. With the assistance of the M. I. T. Planning Office, estimates also have been made of the scale and costs of the new physical plant which would be required, of possible sites for such a facility, and of the temporary space arrangements which would be necessary during the interim period of growth, until the transition from the present to new facilities could be accomplished. In cooperation with Professor Glen Urban of the Sloan School of Management, the Medical Department also is participating in a pilot study of M. I. T. personnel which is aimed at finding reliable mechanisms to determine consumer health care preferences. Although Professor Urban's primary interest is to design procedures for application in many diverse settings, his findings should be of value in terms of better understanding the M. I. T. population's desire and in planning its health care programs.

Other regulatory-legislative developments, particularly in Massachusetts, have stimulated a review of the Institute's medical administrative and governance procedures. The following three significant changes were made.

1. The By-Laws of the Medical Staff -- last revised in 1967 -- were brought up to date and approved by the Executive Committee of the Corporation during the past year.
2. The Executive Committee at the same time approved the establishment of a new entity, the Medical Administrative Board. This Board is intended to accommodate the roles of the M. I. T. administration and the M. I. T. Corporation to legislative requirements developed primarily for hospitallike organizations, wherein the trustees relate more directly to the medical staff and the administrative role is quite different. The Medical Administrative Board is a "manageable-size" vehicle through which the trustees may discharge their governing body functions in cooperation with the administration and with consumer representatives. The Board will be made up of three Members of the Corporation (preferably those who reside in this area); three members of the administration; the chairman of the newly formalized, presidentially appointed Medical Advisory Committee; two appointments from the M. I. T. faculty and staff; and the director of the Medical Department, ex officio.
3. The Medical Advisory Board was formalized as a presidentially appointed committee of the Institute. It was established two years ago on an ad hoc basis by Dr. Seeler to provide consumer oriented advice and criticism to the Department. Since the Board is representative of the different categories of students, staff, and employees at the Institute, its several members serve as effective ombudspersons for medically related issues within these several constituencies.

The Medical Administrative Board and Medical Advisory Board are not intended to replace the role and function of the long-standing Corporation Visiting Committee to the Medical Department, although some possibility of overlap is foreseen. However, the dual responsibilities and roles of several members will permit effective and efficient conduct of business.

In their reports to Dr. Seeler on the Environmental Medical Service (E. M. S.), Dr. Franklin D. Aldrich and his associates briefly describe the magnitude and complexity of the problems M. I. T. faces as it seeks to comply with the many additional and more stringent "institutional health" regulations promulgated by the government relating to radioactive substances, animal care, and carcinogenic chemicals, as well as environmental control. The problems are compounded further as the Institute's research and academic programs expand rapidly into new areas of life sciences and biomedical engineering.

The Medical Department, primarily through E. M. S., is charged with the responsibility for maintaining healthy working conditions. However, the Institute is a decentralized organization, one in which the freedoms of academic process are valued highly. Thus, the staff of the E. M. S. in discharging their very significant responsibilities cannot rely upon directive modes suitable to a tightly organized, relatively authoritarian structure. Instead, they must rely upon mutually cooperative, persuasive, educational techniques. Such methods are time-consuming, but hopefully in the end more productive -- and certainly more suitable to teaching and research efforts in which there are rapid turnovers in student personnel.

Decentralization of most of the facilities in which hazardous teaching and research are conducted is also inevitable in this relatively large and diverse institution. Nevertheless, it is recognized that certain functions must be centralized. Further, the very high costs of providing the plant and equipment required for certain particularly hazardous work makes unwise the duplication of such investment in several locations around the Institute.

Accordingly, staff members of the E. M. S. and the Institute Planning Office have been engaged for some time in developing a program for upgrading the present facilities, for a new

central facility for animal care and controlled environmental laboratories in which biologically hazardous chemicals may be utilized with safety. It is anticipated that this study will be completed in the very near future. Hopefully, a phased program of appropriate upgrading of the several decentralized animal care spaces and associated laboratories will be begun, along with the construction of a new central animal care-controlled environments laboratory facility.

Academic Calendar

Considerations of possible changes to the academic calendar beyond the present, quite new, Independent Activities Period (I. A. P.) calendar have continued this year, but at a relatively low level.

Commencement

Minor modifications to the end-of-term schedule for the spring term of 1974 were approved by the faculty. These were made to provide more time between the end of the examination period and commencement, for the processing of student grades and faculty committees' evaluations of academic performance. These modifications resulted in a far less hectic preparation for commencement than in the recent past -- with essentially no complications in the traditional award to each graduating student of his or her individual diploma.

Another new innovation in commencement format was a widely applauded success. Since student and parent attendance at the traditional commencement luncheon had been dropping off in recent years, the luncheon was replaced by simultaneous receptions immediately following commencement and organized by each of the five Schools for its students, parents, faculty, and administration. Attendance was large, and the general spirit appeared to be very high. It is anticipated that this format will be followed in 1975.

The faculty, administration, Corporation, and Alumni Association also joined together this year to approve a change in Commencement and Alumni Day dates, effective with the coming academic year, 1974-75. Commencement and the associated meeting of the M. I. T. Corporation will take place on the Monday following the traditional Friday date. Alumni Day, which traditionally has taken place on the Monday following Friday commencement, will be moved to the following Friday. The time thus added between end-of-term and commencement should make for a superior faculty review of student performance. Fortunately, the Alumni Association has hoped for some time to build alumni events around an all-Alumni Day on a Friday.

Year-round Calendar

For the most part, studies of the potential for changing the academic calendar to some form of year-round operation have been confined to analytical analyses of the financial implications of such a change.

The results of these analyses necessarily are dependent upon many assumptions which must be made concerning student-faculty ratios for the associated increased student throughput, research patterns for the added faculty, financial aid policy, and so on. Nevertheless, the results are encouraging from the financial viewpoint. They clearly indicate that, given some internal discipline in adapting to the new calendar, there is good reason to believe that the Institute could realize significant sources of new net income which would assist it in coping with projected financial problems.

Such a massive calendar change can be successful only if it is supported widely by faculty and students for providing benefits to their academic and research interests. Some new programs which clearly would benefit from a year-round calendar are currently under active discussion, such as a new School-wide cooperative program for undergraduates in engineering.

At the present time, the future size of the undergraduate body is under active study by the Provost's office and the academic deans. Questions concerning housing policy and academic calendar changes are interwoven closely. Hopefully, considerable progress will be made next year in the understanding of these and related issues so that planning may be accelerated.

Registrar

During this past year, the Registrar's staff and the Office of Administrative Information Systems (O.A.I.S.) devoted extraordinary efforts to the development of a new computer based system of "academic bookkeeping" for student records, to replace the current outmoded and somewhat unreliable processes. The Systems Computer Technology Corporation of Philadelphia has been the contractor for the software development.

This process has not taken place without trial and tribulation. In most respects, it served as a first pilot effort for a new systems development approach, involving both the Registrar and O.A.I.S. as a "client team" working on behalf of the Institute in directing, monitoring, and evaluating the work of an outside vendor of services. Some confusion in role, considerable turnover of O.A.I.S. personnel, and other factors made this effort more difficult than succeeding projects are expected to be.

The several modules which together make up the new system are completed as of this writing. There is little doubt now that the old system will be shut down during the summer of 1974, and that the new system will be operative for the end of the summer term and the beginning of the fall term in September.

Still to be accomplished is the design of a companion system, which will provide for direct on-line access to students' records from the several offices and academic departments of the Institute which have daily need for up-to-date information. The current schedule calls for the development of this companion program during 1974-75.

The schedules section of the Registrar's office is responsible for the complex task of minimizing conflict in the set of variables of student schedules, teacher schedules, and available teaching space equipped with appropriate facilities for each subject. Visitors from other educational institutions often express admiration for the rapid pace at which satisfactory resolutions of these matters are accomplished at the Institute.

One cost of minimizing conflicts is the relatively low utilization of M.I.T.'s teaching spaces. It follows that, given budgetary stringencies, the monies which can be made available for the upgrading of teaching space usually is judged inadequate by those who occupy the spaces. As curricula seem to become inevitably more flexible, and as teaching styles and modes seem to evolve continuously, the traditional lecture-recitation section format becomes less common. These changes have clear implications, both with respect to short-range and long-range programs, for teaching space maintenance, modification, and construction.

Currently, members of the Registrar's staff, the Planning Office staff, and others are engaged in trying to understand teaching space scheduling and maintenance needs better -- with the hope of developing both greater efficiency and higher-quality spaces.

KENNETH R. WADLEIGH

Medical Department

This was the first year of the M. I. T. Health Plan. The Medical Department began offering care to members of the Plan on July 1, 1973, with some apprehension about what unanticipated problems might be encountered. It is a great pleasure to report that the Plan has operated remarkably smoothly. It began with approximately 750 subscribers, and within two months not only had completed its quota of 1,000 subscribers, but had a waiting list of about 100. Because of problems related to the divestiture of the Draper Laboratory, the Department has had to delay offering membership in the Plan to Laboratory employees, but it now has the approval of Blue Cross-Blue Shield, and is in the process of enrolling members of the Laboratory for Health Plan care beginning August 1, 1974.

At present, 1,043 employees are enrolled, and with their dependents, there are 2,676 members of the Health Plan. It was expected that the program would appeal mainly to employees with families, but one-third of the subscribers are single. From studies of the M. I. T. community, an average family size for the Plan of 3.3 had been predicted, and this figure proved to be correct. The age distribution of the subscribers parallels that of the M. I. T. community. Thirty-one percent of the subscribers are under 30, and another 33 percent are between 30 and 40, while only 4 percent are over 60. More than two-thirds of the subscribers are members of the faculty and staff; 15 percent are secretarial and clerical employees, and 7 percent are hourly. Although the Medical Department had anticipated a predominance of faculty and staff among the initial subscribers, it believes that if the Plan is permitted to expand, the proportion of nonstaff membership will increase. As might be expected, the majority of subscribers live comparatively close to M. I. T., though some live more than 20 miles away. Eighteen percent of the members live in Cambridge. The subscribers represent a reasonably good cross-section of the M. I. T. community, which was a goal for this pilot program.

The only new program introduced to meet the demands of the Health Plan is the Obstetrical Service. This service was much busier than had been anticipated; based on experience of other comprehensive health plans, the Medical Department had expected about 70 deliveries. There were, however, about 100 deliveries from among the 1,000 families. The Pediatric Service increased its activity from 862 clinic visits to 2,641, as a result of the Health Plan. Previously, it had provided care only for the children of students.

Although the advent of the M. I. T. Health Plan has made the year unique for the Medical Department, services to members of the Health Plan accounted for less than 15 percent of the total visits. The Medical Department already had been serving most of the subscribers, since they are employees.

There was a surge in demand for gynecological care, with an 86 percent increase in number of visits to this service. Less than one-third of the increase was due to Health Plan members; most of the demand came from students and young M. I. T. employees. This sharp increase in requests for gynecological evaluation is not a local M. I. T. phenomenon, but is common to the entire Boston area and probably to the nation as a whole. The Department has not been able to offer nonurgent gynecology visits without several weeks' delay, although urgent problems are taken care of promptly by the generous cooperation of two part-time gynecologists. The Department is anxious to increase its gynecological staff, but as yet this has not been possible. It hopes to improve its facilities in the coming year by adding examining rooms, and also to relieve the gynecologists of routine examinations by adding a specially trained nurse-clinician to the staff.

As the Medical Department reported last year, its computer program, which recorded the number and type of clinical services supplied, collapsed. As a consequence, the Department's statistical data had to be estimated. This year, the Department was fortunate in obtaining the services of Andrew M. Thomson, who is developing a program which will serve its administrative requirements very well. This program has become operational only within the past few months; consequently, overall data for the year can only be approximate. There was an increase of approximately 10 percent in visits to the Medical Department during the year, to a total of approximately 98,000, including the Lincoln Laboratory satellite clinic and the off-hours clinic in the M. I. T. Infirmary.

Space continues to be the Medical Department's major problem. Although it has added a small amount of space during the past year, it is still far below generally accepted minimum requirements for ambulatory health care services. Consequently, the Department loses a great deal in efficiency, not to speak of patient and physician convenience and comfort. Many of the Department's part-time physicians frequently have to wait because the office to which they are assigned still is occupied by a physician running behind schedule. Most of the Department's physicians do not have separate offices and consulting rooms. Regardless of the future of the Health Plan, the steady increase in utilization of the Department's services by the M. I. T. community makes the need for additional space urgent.

An increasing problem for the Medical Department is the time required of professional and support staff to conform with the increasingly detailed and inflexible Federal and state regulations. Various committees of the medical staff now are mandated, whether the medical unit is a 1,000-bed hospital or M. I. T.'s 28-bed infirmary. These committees must meet regularly, and their minutes are reviewed periodically by government inspectors. The recent Professional Standards Review Organizations (PSRO) legislation will make matters even more complicated. The burgeoning regulatory activities related to the Occupational Safety and Health Administration (OSHA) and to the Atomic Energy Commission (AEC) have increased the burden on the Environmental Medical Service tremendously during the year. The demands on the Committee on the Use of Humans as Experimental Subjects, chaired by Dr. Warren Point, are steadily increasing as the Federal requirements become more detailed and the human oriented research activities of the Institute expand.

Personnel

Staff appointments during the year were as follows: H. Arthur Bird, Consultant in Pathology; Ching-piao Chien, Psychiatrist; Louise A. Dierker, Psychiatrist; Valentine Donahue, Obstetrician-Gynecologist; Karen C. Holmes, Assistant for Consumer Information; James L. Jones, Assistant Radiation Protection Officer; Gail A. Magenis, Assistant Radiation Protection Officer; Peter R. Maggs, Surgeon; Janice M. McDonough, Supervisor of Nurses, Outpatient Clinics; Mary O'Hara Morse, Dermatologist; Stephen L. Nigro, Animal Handler; Joseph Perkell, Assistant Dentist; Joel Umlas, Consultant in Pathology; and Paul I. Winig, Obstetrician-Gynecologist. Pauline R. Jones was promoted to Director of Nurses. Resignations during the year included: Theodore Barton, Gynecologist; Thomas Cottle, Research Sociologist; Edvardas Kaminskas, Physician; Dudley Merrill, Physician; and Don Palmer, Psychiatrist.

The Department is sorry to report the deaths of Drs. John W. Chamberlain and Myron H. Matz. Dr. Chamberlain served the Medical Department devotedly for 34 years as surgeon, surgeon-in-chief, and finally consultant in surgery. Dr. Matz, a very able dermatologist, had been with the Department for ten years.

Health Surveys

During the past year, approximately 1,200 complete medical examinations for faculty and staff members were performed. This program has been in existence for many years, and the percentage of those eligible who request an examination has increased steadily. While these health surveys are in great demand, they are very costly in physician time. The Department is continuing to experiment with health survey procedures designed to find treatable early disease, minimize physician time, and be acceptable to the patient. The computer based medical history system mentioned in last year's report has not proved to be satisfactory for the Department's needs, because it is not sufficiently flexible.

Employee Health Program

Dr. Melvin H. Rodman reports that this area of activity is in transition, moving toward standardization of examination procedures and conservation of physician time. Examinations in this category include the evaluation of: applicants for employment; workers in certain hazardous occupations; those who have reached retirement age; and employees invited periodically to have health surveys. During the past year, many examinations were conducted in all of these groups, utilizing a combination of tests and other observations and a minimum of physician time. Experience indicates not only the feasibility of conducting the program in this fashion, but also the possibility of extending this program so as to include all health surveys conducted by the Department.

Unfortunately, statistics are not available for the entire year. The numbers available indicate the same level of activity in the previous year. During the past year, nine applicants for employment were found to have health problems which would interfere with their capability to perform the job for which they were applying. This figure is much higher than in the recent past, but still comprises less than 1 percent of all applicants. The reasons for this abrupt increase are unclear. When possible, Department policy offers the applicant the opportunity to be seen again after the health problem has been corrected or brought under control. If a job within his or her capabilities is available at that time, he or she may apply for it. One of the nine who were rejected for medical reasons subsequently was hired under this arrangement.

In addition, 14 applicants were hired despite health problems which, although significant, would not interfere with the performance of their job.

Twenty-four deaths were recorded in the Institute community this past year. Heart disease (13) and cancer (seven) accounted for the great majority.

Dental Service

Except for emergency dentistry for the entire Institute community, the Service confines its care to M. I. T. students and their dependents, because facilities are not large enough to offer total dental care to a larger group. There was an increase of 18 percent in the number of visits this past year, as a result of more efficient scheduling and the addition of a part-time dentist. The Dental Service has been frustrated in its hope of extending the use of dental assistants, because of a rigidly conservative attitude on the part of state dental authorities.

Psychiatric Service

Data on the activity of the Service is given in Table 1. Much of the following information was provided by Dr. Merton J. Kahne, Psychiatrist-in-Chief.

Amid the chaos of political, economic, and administrative confusion in the medical world last year, the Psychiatric Service, in conjunction with the Medical Department, began to experiment with a prepaid health plan. Tailoring the program to the needs of the M. I. T. community has been a challenging and rewarding opportunity to bring into play the considerable talents and understanding of the psychiatric staff. Through the determined efforts of Drs. Rochelle R. Friedman and Alfred J. Koumans, the group and family programs now are becoming an integral part of the Service. Stirred by their efforts, other members of the Service have begun to make time for an expanded group therapy program, which, hopefully by the end of the next academic year, will be able to accommodate all of the group therapy needs. Dr. Loumans has undertaken an Institute survey to evaluate the feasibility of an alcoholism program, the outlines of which are beginning to take shape. The Service has attempted to meet the emergency needs of the community, but it is apparent now that there is sufficient community interest and administrative support to develop a deeper and fuller program. Hopefully, it will extend beyond the particular problems of alcoholism to meeting the many social needs of hourly workers as well.

Myra Rodrigues and Charlotte G. Schwartz have widened the scope of their work with student wives. In addition, they have developed a sufficient presence in that area to have enlisted the volunteer services of members of the graduate community to help foreign students, other members of the student community, and their families. The Service is initiating a program of self-help which eventually should improve the interpersonal relations of many on the M. I. T. campus.

There were several staff changes. Dr. Don Palmer, who had been associated with the Service for over five years, left to assume clinical responsibilities for a major program in Detroit. His decision to leave occasioned much sorrow among those who had worked closely with him. Drs. Louise A. Dierker and Ching-piao Chien, who joined the Service this year, are providing much-needed clinical assistance. The restructuring of the Service to meet enlarged responsibilities both in the Health Plan area and for the Institute in general, provided a vehicle for the much-deserved promotions of Drs. Joseph H. Brenner and Peter B. Jenney to the positions of associate psychiatrists-in-chief. Dr. Brenner will assume responsibilities for the clinical programs, and Dr. Jenney will take responsibility for the further development of various Institute programs. Ann Wiggins, who joined the Service recently, brings to it a considerable knowledge of the Institute and its administrative intricacies, in addition to her secretarial skills.

The first year's experience with the Health Plan has demonstrated clearly the importance of paying close attention to the particular needs of the M. I. T. community. The Service anticipates few difficulties in providing clinical services. The number of Health Plan visits has equaled the estimates made in the planning stage. There has been a noticeably increasing need for psychological testing and evaluation of very young people. The rise in the number of employees using the Service is significant, and there has been a steady expansion of the group therapy program. It also is apparent that if the Psychiatric Service is to continue to maintain contact with various hospitals and physicians on whose services it calls, more sophisticated methods of liaison will be needed to allow a steady response to patients' needs.

Social Work Service

Data on the activity of the Social Work Service is presented in Table 2. The following information was provided by Jacqueline A. Buck, Chief Social Worker.

During this past year, there have been 1,597 visits to the Social Work Service, 305 more visits than in the previous year. Ninety-nine of these visits were made by Health Plan

members. There also has been increased use of the Service in this period by faculty members, foreign student wives, and employees.

An intensified effort has been undertaken, jointly with the Psychiatric Service, to focus on the special needs of foreign students and their families. Mrs. Rodrigues, together with Mrs. Schwartz and the Office of the Advisor to Foreign Students, staffed an open house during Residence/Orientation week in September, 1973, for newly arrived foreign students, their wives, and other foreign visitors. Eighty people attended, and this outreach has continued since October with a series of group meetings held twice monthly with foreign student wives. The meetings have been very effective in helping this group to use the resources of the community more creatively, to allay anxiety, and to promote a sense of comfort with a new environment.

Social workers, for the first time, have been invited to attend some regular Personnel Office staff meetings in order to consider important problems of mutual concern.

Mrs. Rodrigues and Mrs. Buck have tried to concentrate their efforts on those areas of M. I. T. and with those groups that can utilize their particular skills and expertise as social workers to the greatest degree. They are involved with other M. I. T. staff in the establishment and operation of a larger and expanded child care service, which presently is serving the needs of more than 125 M. I. T. families. Some of these are student families, and others are one-parent employee families, the heads of which could not continue to work without such a service. In addition to a nursery school, there is now a day-care center serving 25 children, as well as a very successful family day-care program caring for 35 children. Child care is provided largely by foreign student wives who otherwise would be unable to work to supplement their family income. The Service offers consultation to the nursery school and day-care staff and families, and Mrs. Rodrigues has supervised the family day-care coordinator on a regular basis. The Service continues to be concerned about and to work with blind and handicapped students in the community. Pregnant women and newly delivered mothers have been followed closely in conjunction with the obstetrical staff. As a result of concentrating on this group in a preventive way, many potentially serious problems, either during pregnancy or in the time immediately following delivery, were forestalled and diffused.

Mrs. Rodrigues served on a panel for the orientation of house-masters and house tutors in the dormitory system, and as a resource person for the Black Science and Technology Conference.

It is generally felt that if the workload of direct service continues at its present pace, if requests for participation with other members of the Institute in attempts to cope with the larger issues confronting the M. I. T. community continue to increase, and if more Health Plan members turn to the Service for assistance, it may be necessary to consider seriously the possibility of adding an additional worker.

Infirmary

The Infirmary statistics are given in Table 3. Health Plan members accounted for 45 admissions (9 percent) and 196 patient days during the year. Since moving the Infirmary to the former Sancta Maria Hospital, its use by the M. I. T. community as a whole has been encouraged, and last year one-third of the admissions were nonstudents. All major surgery is performed in a general hospital, usually the Mount Auburn Hospital, but whenever it is possible, patients are transferred to the Infirmary for convalescence. During the past year, 453 minor surgical operations were performed in the Infirmary, an increase of 7 percent over the previous year. Most of these procedures were excision of skin lesions or suture of lacerations, but 20 vasectomies were performed.

The off-hours clinic operates on the first floor of the Infirmary and is very busy. There were 6,157 visits, representing an increase of 17 percent over the previous year. There are two nurse-clinicians on duty in this clinic, and there are always an internist, an obstetrician-gynecologist, a pediatrician, and a psychiatrist on call.

Food services have been a recurrent problem, since the small size of the Infirmary does not justify the maintenance of an independent kitchen, and the M. I. T. Food Services are not designed to meet its special needs. Currently, equipment is being installed which will permit the handling of prepackaged frozen meals on those occasions when the M. I. T. Food Service is closed, and also meet the need for special diets, which are now available as frozen packages.

Clinical Laboratory, Electrocardiography, X-ray

Because of the need for a broad variety of sophisticated laboratory tests available during nights, weekends, and holidays, arrangements were made to have the work performed by the superbly staffed and equipped laboratories of the Mount Auburn Hospital. This proved to be a satisfactory arrangement. Approximately 49,000 laboratory tests were performed during the year. This was a much larger number than the year before, but the data are not completely comparable, since the new laboratory classifies tests differently.

Approximately 2,500 electrocardiograms were taken during the year, a dramatic increase of 53 percent over the previous year. While some of this increase is attributable to the Health Plan, there is no doubt that many of M. I. T.'s older employees with serious chronic heart disease are coming to the Department as their former physicians retire.

This was a very expensive year for the X-ray Department, as the old machine in the Infirmary had to be replaced. The number of X rays taken increased by 8 percent to 10,177; the majority were chest X rays.

Sanitation

Routine bacteriological monitoring of the M. I. T. Food Services and swimming pool continues to be handled by the Massachusetts Dairy Laboratories. Fred E. Smith, Consultant Sanitary Engineer, reviews the bacteriological results and inspects the facilities regularly. He was pleased to report that everything seemed to be in good order during the year. The installation of a new automatic chlorine and pH controller in the swimming pool eliminated the problems that had been encountered in the previous year.

Environmental Medical Service

During the past year, this Service, under the direction of Dr. Franklin D. Aldrich, has seen a marked increase in its overall responsibilities to the Institute community. This has been caused in large part by the mounting complexity and stringency of government regulations which deal with occupational health and safety. A second major problem, certainly not unique to the Environmental Medical Service, is remarkable inflation in costs of materials and services necessary for discharging its obligations within the myriad Federal regulations pertaining to radioactive waste disposal, environmental monitoring and control, and medical surveillance of employees.

In February, 1974, the Occupational Safety and Health Administration (OSHA) promulgated regulations controlling employee exposure to 14 carcinogenic chemicals. A campus-wide inventory of the regulated carcinogens was prepared, in compliance with the new law, and 10 of the 14 substances were identified as stored or in use in various laboratories. Special high-hazard laboratories currently are planned for Buildings 18 and E18 to accommodate

scientists who must use one or more of the controlled substances. The law requires employers to provide periodic medical surveillance of employees who work with the regulated carcinogens. Although the Institute has been monitoring the health status of a small group of aflatoxin researchers for several years, and had begun in 1972 to examine the hematologic, renal, and hepatic status of 13 additional personnel handling other chemical carcinogens, the new law has brought the total number of monitored personnel to 53. Future increase in their number is likely. No laboratory abnormalities suggesting malignancy have been identified in the present group. By fortunate coincidence, however, one employee with a probable thalassemia trait and two others with mild liver injury due to carbon tetrachloride were found.

The E. M. S. acquired administrative responsibility for laboratory animal care during the year 1973-74. An average daily census of 4,500 experimental animals on campus requires the ministrations of an animal care supervisor, a veterinarian's assistant, and a corps of eight animal caretakers, plus one veterinarian. A major goal in the past year was recruiting a qualified full-time veterinarian to replace Dr. Kenneth Goddard, who resigned one year ago. Dr. James G. Fox recently was appointed to the post of Institute Veterinarian, and he will assume his duties on July 1, 1974. The Service is especially grateful to Dr. David M. Smith for serving most ably as consulting veterinarian while completing his doctoral degree requirements. Presently under way is the initial planning of a new animal care facility, including a high-hazard experimental area. This is a phased program which will undertake immediately to modify and upgrade existing animal areas, in order to bring them up to accreditation standards. Further phases involve the expansion of existing spaces and the ultimate construction of a centralized animal receiving, quarantine, and holding facility, including a veterinary clinic and laboratories. Target date for final completion is 1978.

In mid-May, 1974, routine annual ophthalmologic examinations of a Lincoln Laboratory technician revealed lenticular vacuolation which was thought to be caused by inadvertent exposure to a low-point infrared laser. If this finding is confirmed, it will mark the first recorded instance at M. I. T. of a laser induced eye injury. The Institute's laser safety program is in need of expansion. Limitations in time and personnel have delayed its complete development.

Radiation Protection Office

The demands for regular radiation protection services on campus and at the Bates Linear Accelerator (LINAC) in Middleton resulted in a significantly increased work load for the Radiation Protection Office (R. P. O.) during this reporting period.

In addition, a number of special projects and problems required major attention, some of which are summarized in the following list.

1. On-campus radiation protection
 - a. Extensive participation in the submission of license renewal applications and associated negotiation with the Atomic Energy Commission (AEC) relative to M. I. T. 's broad-coverage by-product material licenses, which are necessary for most of the research activities at M. I. T. involving the use of radioactive material
 - b. Planning and implementing radiation protection program modifications necessary for compliance with new AEC regulations, and associated license conditions
 - c. Evaluation of the radiation protection aspects, and submission of an AEC license application, for the proposed installation of a Gammacell-40 irradiation unit (containing 3600 curies of Cesium-137) in the Center for Cancer Research
 - d. Implementation of a stack-sampling program for measuring effluent-air discharge concentrations of radioactive iodine

2. Reactor radiation protection
 - a. R. P. O. services were provided for various Reactor repair and maintenance projects
 - b. R. P. O. services were provided during preliminary work projects associated with the Reactor modification (i. e. the Reactor core change)
 - c. The Reactor was shut down on May 24, 1974, and R. P. O. services currently are being provided during the initial stages of its dismantling
3. LINAC radiation protection
 - a. Radiation protection services were provided for LINAC operation of 400 MeV, successful long runs at lesser energies, and delivery of the first electron beam for research use
 - b. The advent of initial operation of the electron-beam spectrometer has led to the requirements for additional shielding around the end-station, expansion of the search-and-secure electronic systems, and the development of an additional beam-interlock system

Each of the above items involved extensive participation by members of the LINAC radiation protection group. Statistics pertaining to the activities of the Radiation Protection Office will be found in Table 4.

Industrial Hygiene Office

During this past year, several changes or new trends became necessary in the normal Industrial Hygiene Office (I. H. O.) activities. The impetus for these changes was the increasing number of rules and regulations imposed under the Occupational Safety and Health Act, and in particular the OSHA standards for carcinogens.

The laboratory hood surveillance program, for example, which has been a basic service provided by I. H. O. for many years, now is required by law in many new areas. The number and type of such surveys, the qualification of personnel performing the tests, effluent air cleaning requirements, as well as actual airflows, now are specified. With the exception of the airflows, which are 50 percent higher than those recommended by it in the past, I. H. O. is essentially in agreement with the requirements.

Compliance with the carcinogen standard also will require special laboratory facilities in several departments. A typical "regulated area" laboratory has been designed for the Department of Chemistry, and construction bids have been received. A second facility currently is being studied for the Department of Nutrition and Food Science. It is expected that such minimum satellite facilities will be needed, even though central facilities may be available in the future. Construction of these two laboratories, which must be completed as soon as possible, will require close supervision by I. H. O. personnel.

In anticipation of the requirement for in-place filter testing, Thomas M. Lynch and Hugh G. Pilgrim have been trained in the accepted Dioctyl-phthalate testing procedures. These tests will be done after each filter change. The equipment necessary should be available by the middle of the summer of 1974. There are over 50 systems, now that the Center for Cancer Research is in operation, where in-space tests need to be performed.

It is expected that government involvement will increase, and that a more formal approach will be required. Documentation of exposures, including negative data, will be required.

To assure acceptance of laboratory data, laboratory accreditation also will be a future requirement, and ground rules for this already are embodied in the OSHA Regulations. No

problem is anticipated in obtaining accreditation, and application for it has been made.

ALBERT O. SEELER, M. D.

Arteriosclerosis Center

The academic year 1973-74 was the first in which the Arteriosclerosis Center (A. S. C.) operated in its new headquarters, as an interdisciplinary center for research in atherosclerotic diseases under the aegis of the Medical Department. The Center was established in 1971, to take advantage of the engineering skills of M. I. T. and the clinical resources of the Massachusetts General Hospital (MGH); it houses physicians, biological scientists, and engineers at both institutions.

During the spring of 1974, the Center's facilities in the newly renovated Seeley G. Mudd Building were completed, and its administrative staff, including its director and clinical director, Drs. Robert S. Lees and Gordon S. Myers, moved into the new complex of offices and laboratories. This move has facilitated coordination of the many aspects of the Center's activities.

Progress has been made during the academic year in a number of directions. A patient characterization has been developed for describing patients at risk for arteriosclerosis, so that they may be followed over long periods of time. This characterization includes medical history, physical findings, and clinical laboratory tests, as well as radiological and noninvasive methods of cardiovascular assessment. This is realized through a computer data bank in which data is stored and manipulated.

Much of the work of the Center is directed at understanding the processes of atherogenesis and thrombosis in terms of quantitative physiology and basic engineering processes. In the past year, major progress has been made in quantifying the penetration of the fat-carrying proteins of blood (the lipoproteins) into the arterial wall. Professors Clark K. Colton and Kenneth A. Smith of the A. S. C. and the Department of Chemical Engineering and their colleagues have established the characteristics of the entry of the major cholesterol carrier of blood, β -lipoprotein, into the arterial wall.

Drs. Angelina Carvalho and Robert W. Colman of the Center and the MGH have shown that patients with high blood levels of β -lipoproteins have an unusual tendency to thrombosis. This defect, which lies in the blood platelets, not only helps to explain the high incidence of heart attacks in such people, but also provides a rational basis for preventive treatment.

Other projects in progress include methods for outlining blood vessels noninvasively with the use of pulsed Doppler ultrasound, and a large clinical trial of methods for the medical treatment of atherosclerotic disease.

The A. S. C. is funded through a grant from the National Heart and Lung Institute and through the kindness of the Ambrose Monell and Unger G. Vetlesen Foundations.

ROBERT S. LEES

TABLE 1 PSYCHIATRIC SERVICE

June 1, 1973 - May 31, 1974

Total individuals seen		1276 (HP 139)*
Total number of visits		5209 (HP 628)**
<u>Analysis of caseload</u>	<u>Size of class</u>	<u>Number of individuals seen</u>
Freshman	895	47
Sophomore	1130	106
Junior	1024	108
Senior	1064	121
Special		7
Undesignated		25
Graduates	3358	195
Spouses		88
Faculty		60
Staff		141
Employees		202
Other		106
Alumni		70
Number of individuals hospitalized***		9 (HP 1)
Number of individuals referred to:		
clinics		73 (HP 20)
private facilities		53 (HP 40)
Number of individuals hospitalized at Infirmary		46 (HP 6)
Number of days of occupancy at Infirmary		602 (HP 92)
Group therapy -- number of individuals participating in weekly group sessions throughout the year.		18

*HP represents Health Plan member

** Excluding group therapy

*** At hospitals other than M. I. T. Infirmary

TABLE 2 SOCIAL WORK SERVICE

June 1, 1973 - May 31, 1974

	<u>New Cases</u>	<u>Total Visits</u>
Faculty	20	48
Staff	44	191
Student		
Undergraduate	26	83
Graduate	31	143
Student Wife		
Undergraduate	2	10
Graduate	10	67
Foreign Student		
Undergraduate	6	30
Graduate	40	142
Foreign Student Wife		
Undergraduate	-	6
Graduate	32	116
Employee	65	475
Other	44	183
Clinical Research Center	-	4
Health Plan	<u>13</u>	<u>99</u>
TOTAL	333	1,597
	<u>New Referrals</u>	<u>Total Referrals</u>
Medical	31	83
Psychiatry	30	109
Self	124	322
Other Department	138	266
Personnel	<u>10</u>	<u>23</u>
TOTAL	333	803

TABLE 3 INFIRMARY

June 1, 1973 - May 31, 1974

Number of patients admitted to Infirmary	569
Number of patients remaining from May, 1973	<u>6</u>
Total number of patients	575
Number of patients discharged	550
Number of patients transferred	22
Patients remaining after May 31, 1974	<u>3</u>
Total number of patients	575

Admissions

<u>Number of Patients</u>		<u>Days in Infirmary</u>	
Faculty	28	Faculty	180
Staff	36	Staff	200
Employee	93	Employee	635
Graduate Student	107	Graduate Student	437
Undergraduate Student	264	Undergraduate Student	963
Student Spouse	16	Student Spouse	76
Other	<u>25</u>	Other	<u>322</u>
	569		2,814

Nature of Admissions

Medical	365
Surgical	161
Psychiatric	<u>43</u>
	569

TABLE 4 RADIATION PROTECTION OFFICE

June 1, 1973 - May 31, 1974

	<u>1972-73</u> [*]	<u>1973-74</u> [*]
Number of currently registered radiation workers	1140	1370 ^{**}
Number of workers currently issued film badges	600	550
Number of radioisotope laboratories	280	270
Number of radioisotope surveys		
Routine surveys	4260	4040
Special surveys	190	230
Authorization for use of radioisotopes		
Current approved authorizations	190	210 ^{**}
Reviews of authorizations and amendment requests	70	80 ^{**}
Sample analyses in R. P. O. Counting Room in Building 20		
Number of persons measured with <u>in-vivo</u> counting system	70	100
Air samples analyzed	1940	2340
Wipe-test samples analyzed	10580	13320
Samples counted by liquid scintillation counter system	2070	2450
Use of Room 6-017 by M. I. T. departments, in man-hours	550	880
Radioactive Waste Program		
Gallons of liquid waste processed	1250	1230
Containers of solid waste processed	950	1310
Volume in cubic feet of solid waste shipped to burial site (including Reactor waste)	2610	2000
Total solid waste activity shipped in millicuries	4240	3700

* Figures are rounded off to nearest 10.

** Totals for on campus, Reactor, Lincoln Laboratory, and Bates Linear Accelerator.

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	1902-03	1,608	1938-39	3,093
1866-67	137	1903-04	1,528	1939-40	3,100
1867-68	167	1904-05	1,561	1940-41	3,138
1868-69	172	1905-06	1,466	1941-42	3,055
1869-70	206	1906-07	1,397	1942-43	3,048
1870-71	224	1907-08	1,415	1943-44	1,579
1871-72	261	1908-09	1,461	1944-45	1,198
1872-73	348	1909-10	1,479	1945-46	1,538
1873-74	276	1910-11	1,506	1946-47	5,172
1874-75	248	1911-12	1,559	1947-48	5,662
1875-76	255	1912-13	1,611	1948-49	5,433
1876-77	215	1913-14	1,685	1949-50	5,458
1877-78	194	1914-15	1,816	1950-51	5,171
1878-79	188	1915-16	1,900	1951-52	4,874
1879-80	203	1916-17	1,957	1952-53	5,074
1880-81	253	1917-18	1,698	1953-54	5,183
1881-82	302	1918-19	1,819	1954-55	5,348
1882-83	368	1919-20	3,078	1955-56	5,648
1883-84	443	1920-21	3,436	1956-57	6,000
1884-85	579	1921-22	3,505	1957-58	6,179
1885-86	609	1922-23	3,180	1958-59	6,259
1886-87	637	1923-24	2,949	1959-60	6,270
1887-88	720	1924-25	2,938	1960-61	6,289
1888-89	827	1925-26	2,813	1961-62	6,454
1889-90	909	1926-27	2,671	1962-63	6,695
1890-91	937	1927-28	2,712	1963-64	6,925
1891-92	1,011	1928-29	2,868	1964-65	7,151
1892-93	1,060	1929-30	3,066	1965-66	7,408
1893-94	1,157	1930-31	3,209	1966-67	7,567
1894-95	1,183	1931-32	3,188	1967-68	7,730
1895-96	1,187	1932-33	2,831	1968-69	7,764
1896-97	1,198	1933-34	2,606	1969-70	8,024
1897-98	1,198	1934-35	2,507	1970-71	7,799
1898-99	1,171	1935-36	2,540	1971-72	7,717
1899-00	1,178	1936-37	2,793	1972-73	7,850
1900-01	1,277	1937-38	2,966	1973-74	7,888
1901-02	1,415				

* From 1943 to 1946, Army and Navy students are omitted (see Table 3-B in reports for 1943-46).

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	-	1961	1,668	1,412
1949	1,875	171	1962	1,748	1,763
1950	1,852	259	1963	1,808	1,397
1951	1,861	813	1964	1,882	1,492
1952	1,689	832	1965	2,090	1,568
1953	1,672	1,289	1966	2,054	1,787
1954	1,675	1,398	1967	2,218	1,829
1955	1,619	1,653	1968	2,490	1,739
1956	1,553	2,497	1969	2,241	1,719
1957	1,548	1,757	1970	2,185	1,666
1958	1,650	1,752	1971	2,197	1,109
1959	1,635	1,510	1972	2,121	1,235
1960	1,600	1,696	1973	2,205	1,367

* 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 Profess- ors Emeriti--	Part Time	Associate Professors	Assistant Professors	Senior Lecturers & Professors Emeriti	Senior Lecturers	Lecturers	Senior Research Scientists	Instructors	Technical Instructors	Research Associates	Technical Assistants	Research Assistants	Research Assistants	Teaching Assistants	Instructor	Grad	Total	Visiting Professors	Others ¹
Institute Professors	9	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	3	-
SCHOOL OF ARCHITECTURE AND PLANNING																						
Architecture	11	1	-	10	10	2	2	-	2	-	5	3	1	2	6	10	10	-	-	63	6	5
Urban Studies and Planning School Professors	7	2	-	14	10	-	-	-	9	-	-	-	2	-	10	24	8	-	-	86	5	21
	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Total	19	3	-	24	20	2	2	-	11	-	5	3	3	2	16	34	8	8	150	11	26	
SCHOOL OF ENGINEERING																						
Aeronautics and Astronautics	23	1	-	12	5	1	1	-	11	-	-	2	7	-	87	2	-	-	151	2	5	
Chemical Engineering	9	1	-	4	8	1	1	-	1	-	2	2	5	-	32	29	2	-	96	3	6	
Civil Engineering	17	1	-	16	9	1	3	1	1	-	-	1	15	-	107	18	3	-	192	3	13	
Electrical Engineering	47	4	-	26	20	3	3	-	16	-	-	-	19	-	155	100	14	-	404	7	22	
Mechanical Engineering	25	2	-	15	9	2	2	3	8	-	1	2	10	-	145	5	4	-	231	3	14	
Metallurgy and Materials Science	16	1	-	5	5	2	2	-	1	-	-	3	3	-	70	25	-	-	131	-	14	
Nuclear Engineering	11	1	-	4	3	-	-	-	-	-	-	-	4	-	26	15	-	-	64	1	4	
Ocean Engineering	10	2	-	6	4	-	-	-	1	-	-	-	6	-	24	10	-	-	63	3	10	
School Professors	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	
Total	163	13	-	88	63	10	10	6	39	-	3	10	69	-	646	204	23	23	1,337	22	88	
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE																						
Economics	11	1	-	5	5	-	-	-	-	-	-	-	-	-	12	16	1	-	51	3	6	
Foreign Literatures and Linguistics	10	2	-	2	3	-	-	-	3	-	6	-	-	-	8	1	-	-	35	-	9	
Humanities	18	1	-	10	24	3	3	-	8	-	6	1	-	8	-	-	-	-	79	1	13	
Philosophy	6	1	-	3	5	-	-	-	-	-	5	-	-	-	1	4	1	-	26	-	-	
Political Science	13	2	-	6	4	-	-	-	1	-	2	-	2	-	20	8	-	-	58	-	7	
Psychology	6	1	-	2	2	-	-	-	1	-	2	2	11	1	1	3	-	-	32	-	4	
School Professors	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	
Total	65	8	-	28	43	3	3	-	13	-	21	3	13	9	42	32	2	2	282	4	39	
ALFRED P. SLOAN SCHOOL OF MANAGEMENT																						
Management	18	3	-	18	15	3	3	11	2	-	2	-	4	-	30	38	7	7	151	10	16	

Table II continued

SCHOOL OF SCIENCE																		
Biology	15	4	-	10	9	-	-	1	-	1	58	45	19	18	-	180	2	45
Chemistry	18	3	-	5	6	-	1	1	2	1	50	6	66	64	-	223	3	32
Earth and Planetary Sciences	9	1	-	8	6	2	-	1	1	-	12	-	48	12	-	100	-	8
Mathematics	36	2	-	6	11	1	-	7	-	28	1	1	12	50	-	155	3	4
Meteorology	7	2	-	1	1	2	-	-	-	-	4	-	36	2	-	55	3	4
Nutrition and Food Science	10	2	-	8	11	-	1	8	2	-	34	11	35	3	-	125	4	15
Physics	45	4	-	16	22	2	-	7	6	5	2	1	123	45	-	278	4	12
Total	140	18	-	54	66	7	1	16	12	37	7	161	64	339	194	1,116	19	120
MISCELLANEOUS																		
Administration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19
Aerospace Studies	-	-	-	-	-	-	-	-	1	5	-	-	-	-	-	6	1	-
Athletic	-	1	-	5	7	-	-	-	5	-	-	-	-	-	-	18	-	17
Center for Advanced Engineering Study	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	2
Center for Advanced Visual Studies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12
Center for International Studies	-	-	-	-	-	-	-	-	1	-	9	-	-	-	-	10	-	5
Center for Policy Alternatives	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	4	-	2
Center for Space Research	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Clinical Research Center	-	-	-	-	-	-	-	-	-	-	2	3	-	-	-	5	-	-
Division for Study and Research in Education	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	2	2	1
Electronic Systems Laboratory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Energy Laboratory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Harvard-M.I.T. Health Sciences and Technology Laboratory for Nuclear Science	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2	-	-
Libraries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
Medical	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	57
Military Science	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	4	1	2
Naval Science	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	8	1	-
National Magnet Laboratory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Operations Research	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Project MAC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Research Laboratory of Electronics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
Sea Grant Program	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Student Activities	-	-	-	-	-	-	-	-	2	-	2	4	-	-	-	8	-	1
Urban Systems Laboratory	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	2	-	9
Total	2	2	-	5	7	3	-	-	2	8	17	19	8	-	-	73	5	309
Grand Total	416 ²	47 ²	8 ²	217 ²	214 ²	28 ²	18 ²	81 ²	14	76 ²	40 ²	269	83	1,073	502 ²	40 ²	3,126	374 ² 598 ³
Faculty ex-officio	39																	
																	3,165	

Footnotes for Table III

The total faculty is 969.

¹Includes Guests, visiting Engineers, visiting Lecturers, visiting Instructors, visiting Scientists, visiting Social Scientists, Research Affiliates, Postdoctoral Associates, Fellows, Administrative Officers, Administrative Assistants, visiting Architects, Executive Officers, Consulting Professors, Special Assistants, visiting Scholars, Coaches, Editors, Librarians, and Medical Doctors.

²Total teaching staff is 1,687.

³Not included in preceding total.

⁴Visiting Professors include 46 Professors, 21 Associate Professors, and 7 Assistant Professors.

TABLE III CLASSIFICATION OF STUDENTS SINCE 1971

Course	1971-72			1972-73			1973-74			Total					
	2	3	4	Total	2	3	4	Total	2		3	4	Total		
SCHOOL OF ARCHITECTURE AND PLANNING															
Architecture (IV)	37	59	51	141	288	29	51	54	149	283	43	42	51	144	280
Architecture (IV-B)	-	1	4	-	5	1	1	1	-	3	-	2	3	-	5
Urban Studies and Planning (XI)	11	12	26	149	198	14	18	18	140	190	10	23	23	147	203
Total	48	72	81	290	491	44	70	73	289	476	53	67	77	291	488
SCHOOL OF ENGINEERING															
Aeronautics and Astronautics (XVI)	16	15	39	189	259	26	13	12	165	216	19	23	16	152	210
Aeronautics and Astronautics (XVI-B)(Cooperative)	-	1	5	-	6	1	-	2	-	3	-	2	-	-	2
Chemical Engineering (X)	38	32	31	141	242	29	41	30	141	241	29	34	33	148	244
Chemical Engineering (X-C)	3	6	5	-	14	1	4	9	-	14	2	3	6	-	11
Civil Engineering (I)	27	29	43	227	326	27	52	28	199	306	37	48	48	244	377
Electrical Engineering (VI-1)	113	114	141	463	1,046	123	90	115	527	1,119	130	122	97	464	1,101
Electrical Engineering (VI-3) (Computer Science)	73	70	72	-	-	98	78	93	-	-	85	109	94	-	-
Electrical Engineering (VI-A)(Cooperative)	-	27	31	51	109	-	38	34	-	72	2	35	36	27	100
Mechanical Engineering (II)	30	35	41	210	316	49	40	45	210	344	61	54	38	237	390
Mechanical Engineering (II-A)	4	6	17	-	27	6	7	15	-	28	8	6	12	-	26
Mechanical Engineering (II-B) (Cooperative)	-	-	-	-	-	-	2	-	-	2	1	-	1	-	2
Mechanical Engineering (II-T)	-	-	-	11	11	-	-	-	8	8	-	-	-	6	6
Metallurgy and Materials Science (III)	17	6	20	133	176	8	16	8	129	161	9	10	16	130	165
Metallurgy and Materials Science (III-A)	-	-	3	-	3	1	3	6	-	10	-	-	1	-	1
Nuclear Engineering (XXII)	-	-	-	120	120	-	-	-	117	117	-	-	-	129	129
Ocean Engineering (XIII)	10	9	5	71	95	9	12	10	87	118	16	11	10	97	134
Ocean Engineering (XIII-C)	-	-	-	-	-	-	-	-	-	-	3	2	-	-	5
Ocean Engineering (XIII-W)(Woods Hole)	-	-	-	11	11	-	-	-	11	11	-	-	-	9	9
Naval Construction and Engineering (XIII-A)	-	-	-	60	60	-	-	-	60	60	-	-	-	59	59
Shipping and Shipbuilding Management (XIII-B)	-	-	-	2	2	-	-	-	2	2	-	-	-	2	2
Center for Advanced Engineering Study (EN)	-	-	-	25	25	-	-	-	26	26	-	-	-	47	47
Total	332	353	456	1,714	2,855	372	393	404	1,682	2,851	402	459	408	1,751	3,020

Table III continued

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE																		
Economics (XIV)	6	25	39	107	177	12	17	29	112	170	15	20	28	121	184			
Foreign Literatures and Linguistics (XXIII)	-	-	-	40	40	-	-	-	37	37	-	-	-	37	37			
Humanities and Engineering (XXI-A)	-	5	10	-	15	-	2	8	-	10	-	1	5	-	6			
Humanities and Science (XXI-B)	20	30	68	-	118	8	27	44	-	79	8	14	39	-	61			
Philosophy (XXIV)	1	6	5	27	39	2	2	8	29	41	4	3	2	20	29			
Political Science (XVII)	10	14	24	74	122	4	19	14	90	127	6	7	22	99	134			
Psychology (IX)	-	-	-	30	30	-	-	-	27	27	-	-	-	28	28			
Total	37	80	146	278	541	26	67	103	295	491	33	45	96	305	479			
ALFRED P. SLOAN SCHOOL OF MANAGEMENT																		
Management (XV)	16	49	80	346	491	25	48	63	383	519	12	46	67	386	511			
SCHOOL OF SCIENCE																		
Biology (VII)	94	96	87	105	382	82	112	102	123	419	72	110	105	143	430			
Biology (VII-A)	8	11	11	-	30	6	17	24	-	44	4	12	28	-	44			
Biology (VII-B)	-	-	-	-	-	4	8	11	-	23	9	15	14	-	38			
Biology (VII-W)(Woods Hole)	-	-	-	7	7	-	-	-	8	8	-	-	-	10	10			
Chemistry (V)	42	47	43	214	346	72	45	42	192	351	62	56	41	186	345			
Earth and Planetary Sciences (XII)	12	22	21	71	126	24	21	22	82	149	19	25	25	88	157			
Earth and Planetary Sciences (XII-A)	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-			
Earth and Planetary Sciences (XII-W)(Woods Hole)	-	-	-	26	26	-	-	-	30	30	-	-	-	29	29			
Interdisciplinary Science Program (XXV)	-	-	-	-	-	12	8	9	-	29	2	5	10	-	17			
Mathematics (XVIII)	87	113	84	123	407	94	108	116	121	439	74	95	114	112	395			
Meteorology (XIX)	-	-	-	49	49	-	-	-	48	48	-	-	-	39	39			
Meteorology (XIX-W)(Woods Hole)	-	-	-	11	11	-	-	-	13	13	-	-	-	17	17			
Nutrition and Food Science (XX)	-	-	-	102	102	-	-	-	114	114	-	-	-	124	124			
Physics (VIII)	87	97	113	242	539	79	89	95	249	512	108	89	79	248	524			
Health Sciences and Technology (HST)	-	-	-	-	-	-	-	-	38	38	-	-	-	46	46			
Total	332	394	379	952	2,057	373	408	418	1,018	2,217	350	407	416	1,042	2,215			
Undesignated	282				282	250				250	280				280			
First Year	1,000				1,000	1,046				1,046	895				895			
Grand Total	1,000	1,047	948 ¹	1,142 ¹	3,580	7,717	1046	1,090	986 ²	1,061 ²	3,667	7,850	895	1,130 ³	1,024	1,064 ³	3,775	7,888

(Not included in above figures)

Non-Institute Students from Harvard	1	2	23	218	244	-	10	14	188	212	2	4	10	190	206
Non-Institute Students from Wellesley	56	71	135	-	262	2	45	56	91	194	53	51	100	-	204
Non-Institute Students from Boston University	-	-	-	-	-	-	-	-	1	1	-	-	-	1	1

1 These totals include 14 students in third year and 2 in fourth year on foreign study; 2 in third year and 1 in fourth year on domestic study.
 2 These totals include 1 student in second year and 8 in third year on foreign study; 5 in third year and 2 in fourth year on domestic study.
 3 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.

TABLE III-A WOMEN STUDENTS BY SCHOOLS, COURSES, AND YEARS, 1973-74¹

Course	Year			G	Total
	2	3	4		
SCHOOL OF ARCHITECTURE AND PLANNING					
Architecture (IV)	8	7	5	49	69
Urban Studies and Planning (XI)	1	9	3	38	51
Total	9	16	8	87	120
SCHOOL OF ENGINEERING					
Aeronautics and Astronautics (XVI)	3	2	-	2	7
Chemical Engineering (X)	4	5	4	6	19
Civil Engineering (I)	7	6	7	12	32
Electrical Engineering (VI)	-	-	-	19	19
Electrical Engineering (VI-1)	5	2	6	-	13
Electrical Engineering (VI-3)	7	8	2	-	17
Mechanical Engineering (II)	7	5	-	4	16
Mechanical Engineering (II-A)	2	1	-	-	3
Metallurgy and Materials Science (III)	1	1	4	4	10
Ocean Engineering (XIII)	2	1	-	1	4
Ocean Engineering (XIII-W)(Woods Hole)	-	-	-	1	1
Nuclear Engineering (XXII)	-	-	-	1	1
Center for Advanced Engineering Study (EN)	-	-	-	4	4
Total	38	31	23	54	146
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE					
Economics (XIV)	1	4	4	8	17
Foreign Literatures and Linguistics (XXIII)	-	-	-	13	13
Humanities and Engineering (XXI-A)	-	1	-	-	1
Humanities and Science (XXI-B)	3	-	4	-	7
Philosophy (XXIV)	-	-	-	2	2
Political Science (XVII)	-	2	1	23	26
Psychology (IX)	-	-	-	9	9
Total	4	7	9	55	75
ALFRED P. SLOAN SCHOOL OF MANAGEMENT					
Management (XV)	1	6	4	40	51
SCHOOL OF SCIENCE					
Biology (VII)	13	26	16	50	105
Biology (VII-A)	-	1	3	-	4
Biology (VII-B)	3	5	4	-	12
Biology (VII-W)(Woods Hole)	-	-	-	4	4
Chemistry (V)	7	8	8	26	49
Earth and Planetary Sciences (XII)	4	7	3	6	20
Earth and Planetary Sciences (XII-W) (Woods Hole)	-	-	-	2	2
Interdisciplinary Science Program (XXV)	1	1	3	-	5
Mathematics (XVIII)	14	23	18	7	62
Meteorology (XIX)	-	-	-	3	3

TABLE III-A continued

SCHOOL OF SCIENCE (continued)						
Meteorology (XIX-W)(Woods Hole)	-	-	-	2		2
Nutrition and Food Science (XX)	-	-	-	39		39
Physics (VIII)	8	7	6	13		34
Health Sciences and Technology (HST)	-	-	-	10		10
Total	50	78	61	162		351
Undesignated	56					56
First Year Students	122					122
Grand Total	122	158	138	105	398	921

¹Included also in Table III.

39 special undergraduate students are included, 35 of whom are registered as second year undesignated.

TABLE III-B SPECIAL STUDENTS BY SCHOOLS, COURSES, AND YEARS, 1973-74¹

Course	Year				Total	
	2	3	4	G		
SCHOOL OF ARCHITECTURE AND PLANNING						
Architecture (IV)	-	-	-	16	16	
Urban Studies and Planning (XI)	-	-	-	36	36	
Total	-	-	-	52	52	
SCHOOL OF ENGINEERING						
Aeronautics and Astronautics (XVI)	-	-	1	17	18	
Chemical Engineering (X)	-	1	1	2	4	
Civil Engineering (I)	-	1	-	42	43	
Electrical Engineering (VI, VI-1, VI-3)	1	3	2	64	70	
Mechanical Engineering (II, II-A)	-	1	1	10	12	
Metallurgy and Materials Science (III)	-	-	-	5	5	
Nuclear Engineering (XXII)	-	-	-	2	2	
Ocean Engineering (XIII)	-	-	-	6	6	
Center for Advanced Engineering Study (EN)	-	-	-	47	47	
Total	1	6	5	195	207	
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE						
Economics (XIV)	-	-	-	7	7	
Foreign Literatures and Linguistics (XXIII)	-	-	-	4	4	
Humanities and Engineering or Science (XXI-B)	1	-	1	-	2	
Philosophy (XXIV)	-	-	-	-	-	
Political Science (XVII)	-	-	-	12	12	
Psychology (IX)	-	-	-	2	2	
Total	1	-	1	25	27	
ALFRED P. SLOAN SCHOOL OF MANAGEMENT						
Management (XV)	-	1	1	37	39	
SCHOOL OF SCIENCE						
Biology (VII)	-	2	-	25	27	
Chemistry (V)	-	1	-	1	2	
Earth and Planetary Sciences (XII)	-	-	-	6	6	
Interdisciplinary Science Program (XXV)	-	-	1	-	1	
Mathematics (XVIII)	1	1	1	5	8	
Meteorology (XIX)	-	-	-	1	1	
Nutrition and Food Science (XX)	-	-	-	11	11	
Physics (VIII)	2	2	-	13	17	
Health Science and Technology (HST)	-	-	-	46	46	
Total	3	6	2	108	119	
Undesignated	68				68	
First Year	-				-	
Grand Total	-	73	13	9	417	512

¹Included also in Table III.

TABLE IV CONTINUED, FORMER, AND NEW STUDENTS

	1969-70	1970-71	1971-72	1972-73	1973-74
Continued Students					
Undergraduate and graduate students registered at the end of the last academic year (including special students)	5,471	5,474	5,332	5,337	5,426
Noncontinued Students					
Former undergraduate and graduate students who previously attended the Institute but were not registered at the end of the last academic year (including special students)	308	304	291	273	306
Undergraduate students who enrolled for the first time since secondary school (excluding special students)	956	942	979	1,041	893
Undergraduate students who enrolled for the first time at the Institute and who transferred from another collegiate institution (excluding special students)	98	102	90	104	85
Graduate students who enrolled for the first time at the Institute (excluding special students)	883	759	786	883	884
Special undergraduate and graduate students with no previous Institute registration	308	218	239	212	294
Total	8,024	7,799	7,717	7,850	7,888

TABLE V REGULAR STUDENTS FROM OTHER COLLEGES AND GRADUATES OF M. I. T.
CLASSIFIED BY SCHOOLS AND COURSES, 1973-74

	Entered with no previous degree	Entered with bachelor's degree from other colleges	Entered Graduate School with bache- lor's degree from M. I. T.
SCHOOL OF ARCHITECTURE AND PLANNING			
Architecture (IV, IV-B)	14	97	31
Urban Studies and Planning (XI)	5	100	11
Total	19	197	42
SCHOOL OF ENGINEERING			
Aeronautics and Astronautics (XVI)	5	100	35
Chemical Engineering (X, X-C)	11	112	34
Civil Engineering (I)	12	157	45
Electrical Engineering (VI, VI-1, VI-3, VI-A)	63	235	192
Mechanical Engineering (II, II-A, II-T)	17	165	68
Metallurgy and Materials Science (III)	2	88	37
Naval Construction and Engineering (XIII-A)	-	59	-
Nuclear Engineering (XXII)	-	110	17
Ocean Engineering (XIII, XIII-C, XIII-W)	7	86	14
Shipping and Shipbuilding Management (XIII-B)	-	2	-
Total	117	1,114	442
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE			
Economics (XIV)	10	106	8
Foreign Literature and Linguistics (XXIII)	-	31	2
Humanities and Engineering or Science (XXI-A, XXI-B)	6	-	-
Philosophy (XXIV)	1	18	2
Political Science (XVII)	-	79	8
Psychology (IX)	-	20	6
Total	17	254	26
ALFRED P. SLOAN SCHOOL OF MANAGEMENT			
Management (XV)	5	283	66
SCHOOL OF SCIENCE			
Biology (VII, VII-A, VII-B, VII-W)	14	110	18
Chemistry (V)	11	182	3
Earth and Planetary Sciences (XII, XII-W)	3	92	19
Interdisciplinary Science Program (XXV)	2	-	-
Mathematics (XVIII)	30	91	16
Meteorology (XIX, XIX-W)	-	47	8
Nutrition and Food Science (XX)	-	94	19
Physics (VIII)	23	148	87
Total	83	764	170
Undesignated	2	-	-
Grand Total	243	2,612	746

TABLE VI LIST OF COLLEGES AND UNIVERSITIES WITH NUMBER OF GRADUATES
ENTERING THE INSTITUTE AS REGULAR STUDENTS, 1973-74

<u>United States</u>			
Adelphi University	1	Duke University	4
Air Force Institute of Technology	1	Emory University	2
Akron, University of	1	Fairleigh Dickinson University	1
Amherst College	3	Federal City College	1
Antioch College	1	Fiske University	1
Arizona State University	2	Florida Agricultural and Mechanical University	2
Arkansas, University of, Monticello	1	Florida State University	1
Auburn University	2	Franklin and Marshall University	1
Bates College	1	General Motors Institute	3
Belknap College	1	George Mason College	1
Beloit College	1	George Washington University	1
Bemidji State College	1	Georgia Institute of Technology	4
Boston College	1	Grinnell College	1
Boston University	7	Hamilton College	1
Brandeis University	4	Hampden-Sydney College	1
Brigham Young University	2	Harvard University	24
Brooklyn College	2	Haverford College	2
Brown University	15	Hawaii, University of	2
California, University of, Berkeley	20	Holy Cross College	1
California, University of, Davis	2	Hope College	1
California, University of, Los Angeles	4	Idaho State University	1
California, University of, Riverside	3	Illinois, University of	6
California, University of, San Diego	2	Illinois, University of, Urbana-Champaign	2
California, University of, Santa Barbara	2	Illinois Institute of Technology	4
California, University of, Santa Cruz	2	Indiana Institute of Technology	4
California Institute of Technology	5	Indiana University	3
California State University, Fresno	1	Iowa State University of Science and Technology	2
California State University, Longbeach	1	John Carroll University	1
California State University, Northridge	1	Johns Hopkins University	4
Carnegie-Mellon University	2	Kalamazoo College	1
Case Western Reserve University	2	Kansas, University of	1
Catholic University of America	3	Kansas State College of Pittsburg	1
Chicago, University of	4	Kent State University	1
Cincinnati, University of	4	Lafayette College	4
City College, The	9	Lake Forest College	1
Clark University	2	Lehigh University	5
Clarkson College of Technology	2	Louisiana State University	1
Clemson University	1	Lowell Technological Institute	8
Cleveland State University	1	Loyola, University of, New Orleans	1
Colby College	1	Luther College	1
Colorado, University of	4	Maine, University of	1
Colorado College	1	Manhattan College	4
Colorado School of Mines	1	Maryland, University of	7
Columbia University	8	Maryland Institute, College of Art	1
Concordia College	1	Massachusetts, University of, Amherst	6
Connecticut, University of	3	Massachusetts, University of, Boston	1
Cooper Union, The	4	Massachusetts Institute of Technology	179
Cornell University	19		
Cranfield Institute of Technology	2		
Dartmouth College	5		
Dayton, University of	1		
Delaware, University of	7		
Detroit, University of	3		
Drexel University	1		

¹ Graduates of 210 colleges and universities in the United States and 147 foreign colleges entered the Institute.

TABLE VI continued

Merrimack College	3	Richmond, University of	1
Miami, University of, Florida	2	Rochester, University of	4
Miami University, Ohio	1	Rochester Institute of Technology	1
Michigan, University of	13	Rutgers, The State University	3
Michigan State University	2		
Michigan Technological University	2	St. Johns University, New York	1
Minnesota, University of	4	St. Joseph's College, Pennsylvania	1
Missouri, University of, Rolla	1	Santa Clara, University of	1
Montana College of Mineral Science and Technology	1	Simmons College	2
Mount Holyoke College	3	Smith College	1
		South Dakota School of Mines and Technology	2
Nebraska, University of	4	Southeastern Massachusetts University	1
New Hampshire, University of	2	Southern Methodist University	1
New Mexico, University of	2	Southern Missionary College	2
New Mexico Institute of Mining and Technology	1	Stanford University	10
New York, State University of, Albany	1	Swarthmore College	3
New York, State University of, Buffalo	5	Syracuse University	3
New York, State University of, Maritime College	2		
New York, State University of, Oneonta	1	Tennessee, University of, Knoxville	6
New York, State University of, Stonybrook	4	Texas, University of, Arlington	1
New York City, University of	3	Texas, University of, Austin	5
New York University	9	Texas Christian University	1
Newark College of Engineering	1	Texas Technical University	1
North Carolina, University of, Chapel Hill	1	Trinity College, Connecticut	1
North Carolina Agricultural and Technical State University	1	Tufts University	12
North Carolina State University, Raleigh	5	Tulane University	3
North Dakota State University	1		
Northeastern University	19	Union College, New York	1
Northwestern University	1	Union Theological Seminary, New York	1
		U. S. Air Force Academy	3
Oberlin College	4	U. S. Coast Guard Academy	4
Occidental College	1	U. S. Merchant Marine Academy	1
Oregon, University of	2	U. S. Military Academy	4
Oregon State University	2	U. S. Naval Academy	16
		Upsala College	2
		Utah, University of	3
Pennsylvania, University of	9	Valparaiso University	1
Pennsylvania State University	5	Vanderbilt University	3
Pittsburgh, University of	1	Vassar College	2
Polytechnic Institute of Brooklyn	8	Villanova University	2
Pomona College	3	Virginia, University of	4
Pratt Institute	1	Virginia Polytechnic Institute	3
Princeton University	6		
Principia College	2	Wabash College	1
Purdue University	8	Wake Forest University	1
		Wartburg College	1
Queens College	2	Washington, University of	5
		Washington State University	1
Radcliffe College	1	Washington University, Missouri	2
Redlands, University of	1	Wayne State University	4
Reed College	3	Webb Institute of Naval Architecture	3
Rensselaer Polytechnic Institute	10	Wellesley College	5
Rhode Island, University of	3	Wesleyan University	1
Rice University	3	West Florida, University of	1
		West Virginia University	1

TABLE VI continued

Instituto Tecnológico Autonomo de Mexico (Mexico)	1	Santo Tomas, University of (Philippines)	1
Instituto Tecnológico y de Estudios Superiors de Monterrey (Mexico)	1	Saskatchewan, University of (Canada)	1
Institutul Polytechnic din Cluj (Rumania)	1	Seoul Dai Hak Kyo (Republic of China)	1
Jami'at Al-Riyalh (Arabia)	1	Seoul National University (Korea)	1
Karachi, University of (Pakistan)	2	Shanghai Institute of Technology (China)	1
Katholieke Universiteit te Leuven (Belgium)	2	Sogang Dai Hak (Korea)	1
Keio Gijuku Daigaku (Japan)	2	Staatliche Ingenieurschule (West Germany)	1
Kievskij Inzernerno-Slroitel 'nyz Institut (U. S. S. R.)	1	Surrey, University of (England)	2
Kings College, Newcastle-on-Tyne (England)	1	Taiwan Provincial Chung-Hsing University (Republic of China)	1
Kwame Nkrumah University of Science and Technology (Ghana)	1	Taiwan Provincial Maritime College (Republic of China)	1
Kyoto Daigaku (Japan)	2	Tatung Institute of Technology (Republic of China)	1
Kyushu Daigaku (Japan)	1	Technische, Universitat, Aachen (West Germany)	2
London, University of (England)	2	Technische Hochschule Darmstadt (West Germany)	1
Loughborough University of Technology (England)	1	Tokyo Daigaku (Japan)	10
Luanda University (West Africa)	1	Toronto, University of (Canada)	7
Manchester, University of (England)	1	Unite Pedagogique d'Architecture VI (France)	1
Manitoba, University of (Canada)	1	Universidad Central de Venezuela (Venezuela)	1
McGill University (Canada)	1	Universidad de Barcelona (Spain)	1
McMaster University (Canada)	1	Universidad de Chile (Chile)	4
Melbourne, University of (Australia)	1	Universidad de los Andes (Colombia)	2
Nairobi, University of (Kenya)	1	Universidade de Sao Paulo (Brazil)	5
National Taiwan University (Republic of China)	3	Universidad del Valle (Colombia)	1
National Tsing Hua University (Republic of China)	2	Universidad Nacional Autonoma de Mexico (Mexico)	1
Newark College of England (England)	1	Universidad Nacional de Ingenieria (Peru)	1
Nigeria, University of (Nigeria)	1	Universidad Complutense de Madrid (Spain)	1
Niigata University (Japan)	1	Universidade de do Estado da Guanabara (Brazil)	1
Norges Handshogskole (Norway)	1	Universidade Federal da Bahia (Brazil)	1
Norges Tekniske Hogskole (Norway)	1	Universidade Federal do Rio de Janeiro (Brazil)	1
Oska Gaikokugo Daigaku (Japan)	1	Universidade Mackenzie (Brazil)	1
Oxford University (England)	4	Universite Catholique de Louvain (Belgium)	1
Padagogische Hochschule Berlin (West Germany)	1	Universite de Dijon (France)	1
Philippines, University of The (Philippines)	1	Universite de Geneva (Switzerland)	1
Puerto Rico, University of, Mayaguez (Puerto Rico)	5	Universite de Grenoble (France)	1
Queen's University at Kingston (Canada)	3	Universite de L'etat de Liege (Belgium)	2
Rijksuniversiteit te Gent (Belgium)	1	Universite de Liege (Belgium)	2
Rijksuniversiteit te Groningen (Netherlands)	1	University de Nancy I (France)	1
Royal Military College (Canada)	1	Universite Degli Studi de Geneva (Switzerland)	2
		Universite Paris III (France)	1
		Universite Paris VII (France)	1
		Universitet I Oslo (Norway)	1
		Univerzitet u Beogradu (Yugoslavia)	2
		University College, Gallaway (Ireland)	1
		University of Buenos Aires (Argentina)	1
		University of Science and Technology (Ghana)	2

TABLE VI continued

Victoria, University of (England)	1
Waseda Daigaku (Japan)	3
West Indies, University of (West Indies)	1
Western Australia, University of (Australia)	1
Windsor, University of (Canada)	1
Yonsei University (Korea)	1
Yumaguchi Daigaku (Japan)	<u>1</u>
Total Foreign	224
Grand Total	1,063

TABLE VII GEOGRAPHIC DISTRIBUTION OF STUDENTS, 1973-74

<u>United States</u>	Undergraduate	Graduate		Undergraduate	Graduate
Alabama	25	15	Rhode Island	27	19
Alaska	6	1			
Arizona	27	9	South Carolina	16	14
Arkansas	9	4	South Dakota	5	2
California	167	171	Tennessee	26	16
Colorado	30	17	Texas	90	54
Connecticut	123	88	Utah	4	13
Delaware	16	13	Vermont	19	8
District of Columbia	27	23	Virginia	83	65
Florida	101	46	Washington	43	22
Georgia	24	14	West Virginia	6	9
Hawaii	27	9	Wisconsin	45	37
Idaho	10	2	Wyoming	2	2
Illinois	151	97	<u>U. S. Territories and</u>		
Indiana	34	29	<u>Dependencies:</u>		
Iowa	24	14	Puerto Rico	19	10
Kansas	30	12	U. S. Citizens		
Kentucky	18	7	Foreign Address	45	23
Louisiana	19	19	<u>Total U. S.</u>	<u>3,730</u>	<u>2,729</u>
Maine	27	17	<u>Foreign Countries</u> *		
Maryland	130	77	Afghanistan	-	2
Massachusetts	506	728	Algeria	-	1
Michigan	88	53	Argentina	7	7
Minnesota	33	26	Australia	2	6
Mississippi	6	4	Austria	-	1
Missouri	50	23	Bangladesh	-	2
Montana	11	1	Belgium	-	13
Nebraska	17	10	Bermuda	1	-
Nevada	5	-	Bolivia	1	1
New Hampshire	31	19	Brazil	3	49
New Jersey	259	134	Bulgaria	-	1
New Mexico	9	6	Burma	1	-
New York	794	467	Cambodia	1	-
North Carolina	30	19	Cameroon	1	1
North Dakota	2	-	Canada	55	79
Ohio	146	91	Ceylon	2	3
Oklahoma	17	10	Chile	-	17
Oregon	22	9	China, Republic of	24	85
Pennsylvania	249	151			

*Country of Citizenship

TABLE VII continued

Colombia	10	16	Netherlands	1	8
Costa Rica	1	1	New Zealand	2	2
Cuba	7	4	Niger	1	-
Curacao	1	-	Nigeria	2	16
Cyprus	2	3	Norway	4	13
Czechoslovakia	-	4			
			Pakistan	18	11
Denmark	1	8	Panama	1	1
			Peru	4	11
Ecuador	-	1	Philippines	1	9
El Salvador	1	-	Poland	1	6
England	13	40	Portugal	-	10
Ethiopia	1	3			
			Rumania	2	7
Finland	1	3			
France	2	49	Saudi Arabia	-	5
			Scotland	-	1
Germany	3	15	Singapore	2	4
Ghana	13	10	South Africa, Republic of	1	8
Greece	16	37	Spain	-	7
Guatemala	-	2	Sweden	3	3
Guyana	1	-	Switzerland	1	4
Honduras	-	1	Tanzania	4	1
Hong Kong	49	70	Thailand	7	15
Hungary	1	-	Trinidad	1	-
			Turkey	4	20
Iceland	-	2			
India	4	70	Uganda	-	1
Indonesia	2	1	United Arab Republic (Egypt)	-	8
Iran	13	31	United Kingdom	3	7
Iraq	-	3	Uruguay	1	2
Ireland	-	3			
Irish Republic	-	1	Venezuela	4	19
Israel	1	21	Vietnam	4	2
Italy	4	10			
Ivory Coast	-	1	Wales	-	1
Jamaica	4	6	Yugoslavia	1	7
Japan	13	71			
Jordan	-	3	Zambia	-	2
Kenya	1	3	Stateless	6	7
Korea	13	24			
Lebanon	2	11	Total Foreign	383	1,046
Libya	-	1			
Luxembourg	-	1	Grand Total	4,113	3,775
Malaysia	19	6			
Mexico	6	22			
Morocco	1	2			

TABLE VIII NUMBER OF DEGREES AWARDED IN SEPTEMBER, 1973, FEBRUARY, 1974, AND JUNE, 1974

	S. B.		S. M.		M. Arch. M. C. P.		M. Arch. A. S.		Engineer		Ph. D.		Sc. D.		Total	
	Sept.	June	Sept.	June	Sept.	June	Sept.	June	Sept.	June	Sept.	June	Sept.	June	Sept.	June
SCHOOL OF ARCHITECTURE AND PLANNING																
Architecture	-	-	-	-	2	2 15	1	4 10	-	-	-	-	-	-	3	6 25
Undesignated	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Art and Design	3	14 38	-	-	-	-	-	-	-	-	-	-	-	-	3	14 38
Urban Studies and Planning	-	5 12	-	-	6	4 14	-	-	-	-	1	3 3	-	-	7	12 29
Total	3	19 53	-	-	8	6 29	1	4 10	-	-	1	3 3	-	-	13	32 95
SCHOOL OF ENGINEERING																
Aeronautics and Astronautics	-	2 12	17	9 17	-	-	-	-	1	1 2	7	6 1	2	1 -	27	19 32
Ceramics	-	-	1	3 -	-	-	-	-	-	-	-	-	-	-	1	3 -
Chemical Engineering	5	4 24	7	3 10	-	-	-	-	1	1 6	1	1 4	4	5 1	18	14 45
Undesignated	-	1 4	-	-	-	-	-	-	-	-	-	-	-	-	-	1 4
Chemical Engineering Practice	-	-	-	14 29	-	-	-	-	-	-	-	-	-	-	-	14 29
Civil Engineering	2	7 45	18	20 26	-	-	-	-	3	1 -	5	2 2	-	3 1	28	33 74
Undesignated	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Electrical Engineering	37	38 152	47	28 51	-	-	-	-	8	7 25	14	5 12	4	2 5	110	80 245
Environmental Engineer	-	-	-	-	-	-	-	-	1	1 1	-	-	-	-	1	1 1
Mechanical Engineering	3	5 31	22	15 33	-	-	-	-	2	4 8	1	7 8	-	3 6	28	34 86
Undesignated	3	3 8	-	-	-	-	-	-	-	-	-	-	-	-	3	3 8
Materials Engineering	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2
Materials Science	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Metallurgy and Materials Science	1	5 9	4	1 6	-	-	-	-	1	1 -	8	4 2	1	2 2	16	12 22
Naval Architecture and Marine Engineering	1	1 5	2	2 16	-	-	-	-	-	-	-	-	-	-	3	3 21
Nuclear Engineering	-	-	10	10 13	-	-	-	-	1	1 3	-	4 1	2	1 -	13	16 17
Ocean Engineering	1	- 2	5	5 9	-	-	-	-	2	2 17	1	1 -	-	-	9	8 28
Shipping and Shipbuilding Management	-	-	2	1	-	-	-	-	-	-	-	-	-	-	2	1 1
Textile Technology	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1 1
Total	53	66 294	137	111 214	-	-	-	-	20	18 63	37	30 30	13	17 15	260	242 616

SCHOOL OF HUMANITIES
AND SOCIAL SCIENCE

Economics	2	7	16	-	-	-	-	-	-	-	-	8	5	6	-	-	10	12	24
Humanities and Engineering	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	4
Humanities and Science	-	7	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	23
Linguistics	-	-	-	-	-	-	-	-	-	-	-	2	3	1	-	-	2	3	1
Philosophy	-	1	3	1	-	-	-	-	-	-	-	3	2	2	-	-	4	1	5
Political Science	2	3	12	2	4	1	-	-	-	-	-	6	5	3	-	-	10	12	16
Psychology	-	-	-	2	-	1	-	-	-	-	-	2	1	-	-	-	4	1	1
Total	5	18	58	5	4	4	-	-	-	-	-	21	14	12	-	-	31	36	74

ALFRED P. SLOAN SCHOOL
OF MANAGEMENT

Management	4	11	45	19	19	152	-	-	-	-	-	7	1	3	-	-	30	31	200
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SCHOOL OF SCIENCE

Biochemical Engineering	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	1	2
Biochemistry	-	-	-	1	-	-	-	-	-	-	-	7	7	4	-	-	10	7	7
Biology	-	-	-	3	-	3	-	-	-	-	-	-	-	-	-	-	-	11	36
Undesignated	-	11	36	-	-	-	-	-	-	-	-	25	7	16	-	-	29	16	61
Chemistry	3	7	43	1	2	2	-	-	-	-	-	-	5	1	-	-	7	10	19
Earth and Planetary Sciences	1	3	16	6	2	2	-	-	-	-	-	-	-	-	-	-	1	1	2
Food Science and Technology	-	-	-	1	1	2	-	-	-	-	-	-	-	-	-	-	1	2	9
Interdisciplinary Science Program	1	2	9	-	-	-	-	-	-	-	-	-	-	-	-	-	4	23	77
Life Sciences	4	23	77	-	-	-	-	-	-	-	-	13	5	14	-	-	22	33	98
Mathematics	5	28	84	4	-	-	-	-	-	-	-	2	2	2	-	-	4	5	4
Meteorology	-	-	-	4	3	2	-	-	-	-	-	4	6	7	-	1	2	4	9
Nutrition and Food Science	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nutritional Biochemistry and Metabolism	-	-	-	6	1	3	-	-	-	-	-	-	-	-	-	-	6	1	3
Oceanography	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Physics	13	3	67	5	-	3	-	-	-	-	-	10	13	13	-	1	28	17	83
Total	27	77	332	31	12	19	-	-	-	-	-	59	45	57	-	2	117	136	410

Operations Research
Without Course Specification

Operations Research Without Course Specification	-	-	-	2	3	6	-	-	-	-	-	-	-	-	-	-	2	3	6
	-	-	-	15	8	13	-	-	-	-	-	-	-	-	-	-	15	8	13

AWARDED JOINTLY WITH
WOODS HOLE OCEANOGRAPHIC
INSTITUTION

Earth and Planetary Sciences	-	-	-	-	-	-	-	-	-	-	-	3	1	1	-	-	3	1	1
Meteorology	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Ocean Engineering	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-

Grand Total

Grand Total	92	191	782	209	157	408	8	6	29	1	4	10	21	18	63	13	20	17	472	490	1,415
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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 decades										Grand Total	Calendar year since 1970 (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-	1970	1971	1972	1973	1974*
SCHOOL OF ARCHITECTURE AND PLANNING¹																		
Architecture	-	12	24	162	188	223	233	23	-	-	-	-	-	-	-	-	-	
Undesignated	-	-	-	-	-	-	-	23	-	-	-	-	-	-	-	-	-	
Architectural Engineering ²	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Art and Design	-	-	-	-	-	108	64	-	-	2	10	-	-	-	6	1	3	
Urban Studies	-	-	-	-	-	-	-	-	-	26	192	218	14	46	43	51	52	
Undesignated	-	-	-	-	-	-	-	-	-	-	59	59	-	9	23	10	17	
Total	-	12	24	162	188	233	331	87	-	28	262	1,327	16	56	72	62	72	
SCHOOL OF ENGINEERING																		
Aeronautics and Astronautics ¹¹	-	-	-	-	-	-	68	287	526	395	556	113	1,945	57	39	47	13	14
Undesignated	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
Building Engineering and Construction	-	-	-	-	-	-	32	99	114	131	-	-	376	-	-	-	-	-
Chemical Engineering	-	-	-	91	123	372	571	434	740	726	421	96	3,574	26	22	20	26	28
Undesignated	-	-	-	-	-	-	-	-	-	-	3	24	27	3	1	8	10	5
Chemical Engineering Practice	-	-	-	-	-	-	99	90	95	108	1	-	393	-	-	-	-	-
Civil Engineering	12	84	86	256	407	504	653	284	272	457	252	145	3,412	16	25	35	33	52
Undesignated	-	-	-	-	-	-	-	-	-	-	7	17	24	6	8	4	3	2
Electrical Engineering (including VI-A)	-	-	72	335	349	468	1,000	719	1,218	1,518	1,941	844	8,464	189	209	221	224	190
Undesignated	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-
Electrochemical Engineering ³	-	-	-	-	28	84	133	56	-	-	-	-	301	-	-	-	-	-
General Engineering	-	-	-	-	-	6	226	222	230	133	-	-	817	-	-	-	-	-
Mechanical Engineering	5	40	147	329	502	623	797	602	1,164	1,049	563	155	5,976	44	43	39	37	36
Undesignated	-	-	-	-	-	-	-	-	-	-	12	56	68	10	18	13	14	11
Metallurgy and Materials Science ⁴	-	-	-	-	-	-	-	52	194	311	186	51	794	12	14	13	10	14
Undesignated	-	-	-	-	-	-	1	4	-	-	1	15	16	1	4	7	4	-
Military Engineering	-	-	-	-	-	-	174	137	-	-	-	-	5	-	-	-	-	-
Mining Engineering and Metallurgy	8	44	64	74	250	129	174	137	-	-	-	-	880	-	-	-	-	-
Naval Architecture and Marine Engineering	-	-	-	43	133	69 ⁺	100	173	234	139	69	19	979	3	5	3	5	6
Ocean Engineering	-	-	-	-	-	-	-	-	-	-	-	7	7	-	-	1	4	2
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	1,544	28,324	367	388	412	384	360

SCHOOL OF HUMANITIES
AND SOCIAL SCIENCE

Economics	-	-	-	-	-	-	-	-	-	129	110	239	28	23	40	24	23
Economics, Politics and Engineering or Science	-	-	-	-	-	61	152	100	-	313	-	-	-	-	-	-	-
Humanities and Engineering or Science ⁵	-	-	-	-	-	-	49	412	203	664	87	63	63	63	43	34	34
Philosophy	-	-	-	-	-	-	-	-	16	16	-	-	-	-	4	8	4
Political Science ⁹	-	-	-	-	-	-	-	114	72	186	27	24	17	16	16	15	15
Total	-	-	-	-	-	61	201	755	401	1,418	142	110	124	91	76	91	76

ALFRED P. SLOAN SCHOOL
OF MANAGEMENT⁶

Business and Engineering Administration	-	-	-	-	142	872	641	909	732	-	-	3,296	-	-	-	-	-
Management ¹⁰	-	-	-	-	-	-	-	-	172	565	270	1,007	76	75	74	65	56
Total	-	-	-	-	142	872	641	909	904	565	270	4,303	76	75	74	65	56

SCHOOL OF SCIENCE

Biology ⁷	-	3	11	25	27	49	57	129	74	116	16	-	507	-	-	-	-
Undesignated	-	-	-	-	-	-	-	-	-	-	-	140	140	13	39	41	47
Chemistry	2	27	80	154	151	111	141	166	232	207	307	177	1,755	25	37	45	50
Earth and Planetary Sciences ⁸	-	-	-	8	6	3	36	22	32	141	109	80	437	8	17	17	19
Undesignated	-	-	-	-	-	-	-	-	-	-	7	34	41	6	17	17	-
Food Technology and Biochemical Engineering	-	-	-	-	-	-	-	-	35	62	11	-	108	-	-	-	-
General Science or General Course	2	11	17	49	20	26	17	73	58	62	-	-	335	-	-	-	-
Interdisciplinary Science Program	-	-	-	-	-	-	-	-	-	-	-	25	25	-	3	11	11
Life Sciences	-	-	-	-	-	-	-	-	291	310	601	46	50	60	100	100	100
Mathematics	-	-	-	-	-	-	19	48	72	220	831	401	1,591	94	79	88	122
Meteorology	-	-	-	-	-	-	-	-	56	38	-	-	94	-	-	-	-
Physics	-	5	6	24	19	21	49	170	306	617	1,079	402	2,698	85	122	106	104
Total	4	46	114	260	223	210	319	608	865	1,463	2,651	1,569	8,332	264	335	375	450
Grand Total	29	226	507	1,579	2,257	2,963	5,410	4,515	6,626	7,535	8,011	4,046	43,704	865	964	1,057	1,052

*Includes only February and June degrees.

+Two received the degree in Naval Architecture, Course XIII-B, in 1916 and three in 1917.

¹See also Table XI.

²Prior to 1923, degrees were awarded in Architecture.

³Prior to 1909 this course was designated as Option 3 (Electrochemistry) or Physics.

⁴Prior to 1938 these degrees were included in Mining Engineering and Metallurgy; changed from Metallurgy to Metallurgy and Materials Science, January, 1968.

⁵Prior to 1958 these degrees were included in General Engineering and General Science or General Course.

⁶Changed to Alfred P. Sloan School of Management after 1963.

⁷Changed to Life Sciences beginning January, 1962.

⁸Changed from Geology and Geophysics to Earth Sciences in February, 1961. Changed from Earth Sciences to Earth and Planetary Sciences in February, 1970.

⁹Prior to September, 1965, these degrees were included in Economics, Politics, and Engineering or Science.

¹⁰Prior to 1959, Business and Engineering Administration; changed from Industrial Management to Management in February, 1967.

¹¹Prior to 1960, Aeronautical Engineering.

TABLE X NUMBER OF DEGREES OF MASTER OF SCIENCE AWARDED

	Total by decades										Grand Total	Calendar year since 1970 (included in decade total)				
	1886-90	1891-1900	1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-		1970	1971	1972	1973	1974*
SCHOOL OF ARCHITECTURE AND PLANNING¹																
Architecture	-	8	45	31	-	-	-	-	-	-	-	-	-	-	-	
Architectural Engineering ²	-	-	-	-	9	10	-	-	-	-	-	-	-	-	-	
Total	-	8	45	31	9	10	-	-	-	-	-	-	-	-	-	
SCHOOL OF ENGINEERING																
Aeronautics and Astronautics ¹²	-	-	-	17	59	76	307	375	645	179	1,658	71	51	52	50	26
Building Engineering and Construction	-	-	-	-	-	-	21	66	21	-	108	-	-	-	-	-
Ceramics	-	-	-	-	-	3	3	13	20	10	49	2	2	2	3	3
Chemical Engineering	-	3	2	18	69	152	275	467	398	91	1,475	26	29	29	20	13
Chemical Engineering Practice	-	-	-	-	245	284	241	256	102	100	1,228	13	18	14	25	43
Civil Engineering	-	1	4	27	53	179	194	350	548	215	1,571	46	46	67	56	46
Electrical Engineering (including VI-A)	-	-	7	43	462	474	546	1,164	1,530	424	4,650	138	94	128	123	79
Electrochemical Engineering	-	-	-	4	16	8	-	-	-	-	28	-	-	-	-	-
Fuel and Gas Engineering	-	-	-	-	15	11	-	-	-	-	26	-	-	-	-	-
Materials Engineering	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	2
Materials Science	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	2
Mechanical Engineering	-	1	8	22	100	175	357	525	690	260	2,138	72	77	71	64	48
Metallurgy	-	-	-	-	8	36	92	230	205	54	625	10	19	14	14	7
Mining Engineering	-	-	-	9	8	16	-	-	-	-	33	-	-	-	-	-
Naval Architecture and Marine Engineering	-	-	2	1	5	20	60	165	281	78	612	28	18	19	23	18
Naval Construction and Engineering	-	-	39	48	101	89	206	-	-	-	483	-	-	-	-	-
Nuclear Engineering ³	-	-	-	-	-	-	-	67	282	107	456	37	22	28	34	23
Ocean Engineering	-	-	-	-	-	-	-	-	3	47	50	3	6	5	22	14
Petroleum Engineering	-	-	-	-	-	5	-	-	-	-	5	-	-	-	-	-
Railroad Engineering	-	-	-	-	-	14	-	-	-	-	14	-	-	-	-	-
Sanitary Engineering	-	-	2	8	3	10	53	99	16	-	191	-	-	-	-	-
Shipping and Shipbuilding Management	-	-	-	-	-	-	-	4	15	10	29	1	2	3	4	1
Textile Technology	-	-	-	-	-	1	31	34	20	7	93	1	1	1	3	2
Total	-	5	64	197	1,144	1,553	2,386	3,815	4,776	1,586	15,526	448	385	433	443	325

SCHOOL OF HUMANITIES
AND SOCIAL SCIENCE

Economics ⁸	-	-	-	-	-	-	-	-	19	9	28	4	1	5	1	2
Economics, Politics, and Engineering or Science ¹¹	-	-	-	12	16	19	10	-	-	-	57	-	-	-	-	-
Linguistics	-	-	-	-	-	-	1	3	1	3	4	-	1	-	2	-
Philosophy	-	-	-	-	-	-	2	2	2	2	4	2	-	1	1	-
Political Science ⁸	-	-	-	-	-	-	-	25	24	24	49	9	9	2	8	5
Psychology ⁴	-	-	-	-	-	-	-	7	5	5	12	1	-	2	2	1
Total	-	-	-	12	16	19	64	43	64	43	154	16	11	10	14	8

ALFRED P. SLOAN SCHOOL
OF MANAGEMENT⁵

Management ⁹	-	-	-	4	60	122	581	1,274	686	2,727	159	176	144	195	171
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SCHOOL OF SCIENCE

Biology ¹³	-	1	1	10	1	19	25	34	21	24	136	4	4	6	11	3
Chemistry	2	3	7	22	32	51	53	46	97	27	340	11	12	6	5	4
Earth and Planetary Sciences ¹⁰	-	-	-	-	-	-	-	-	7	33	40	7	6	12	11	4
General Science	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Geology and Geophysics ¹⁰	-	-	2	5	21	15	17	48	71	-	179	-	-	-	-	-
Mathematics	-	-	-	2	9	25	45	96	73	21	271	12	8	6	7	-
Meteorology ⁷	-	-	-	-	-	35	99	118	87	33	372	6	5	9	14	5
Nutritional Biochemistry and Metabolism ⁶	-	-	-	-	-	-	12	51	125	50	238	10	9	15	16	10
Oceanography	-	-	-	-	-	-	-	-	28	13	41	1	6	4	1	2
Physics	-	3	2	2	16	40	50	121	138	55	427	22	22	11	19	3
Total	2	8	12	41	79	185	301	514	647	256	2,045	73	72	69	84	31
Operations Research Without Course Specification	-	-	-	-	-	308	263	123	357	300	1,518	44	56	48	37	21
Grand Total	2	21	121	274	1,544	2,083	2,948	5,286	7,061	2,764	22,104	740	708	713	778	565

* Includes only February and June degrees.

¹See also Table XI.

²Prior to 1923, degrees were awarded in Architecture.

³Prior to 1959, included in Chemical Engineering.

⁴Prior to September, 1964, included in Economics, Politics, and Engineering or Science.

⁵Considered Engineering until 1950.

⁶Includes degrees in Biochemical Engineering and in Food Science and Technology.

⁷Considered Engineering until 1956.

⁸Prior to September, 1965, these degrees were included in Economics, Politics, and Engineering or Science.

⁹Prior to February, 1967, Industrial Management.

¹⁰Changed to Earth and Planetary Sciences beginning February, 1970.

¹¹Includes six degrees in Political Science, awarded 1965.

¹²Prior to 1960, Aeronautics Engineering.

¹³Includes degrees in Biochemistry and Biophysics.

TABLE XI
 NUMBER OF DEGREES OF BACHELOR AND MASTER IN ARCHITECTURE
 AND BACHELOR AND MASTER IN CITY PLANNING AWARDED

	Total by decades						Calendar year since 1970 (included in decade total)				
	1921-30	1931-40	1941-50	1951-60	1961-70	1971- Grand Total	1970	1971	1972	1973	1974*
Bachelor in Architecture ²	-	146	126	257	211	25	16	21	4	-	-
Bachelor in City Planning ¹	-	14	13	4	-	-	31	-	-	-	-
Master in Architecture ³	63	81	78	191	214	21	648	20	1	-	-
Master of Architecture	-	-	-	-	-	62	62	-	22	23	17
Master of Architecture in Advanced Studies	-	-	-	-	-	54	54	-	22	18	14
Master in City Planning	-	18	82	114	152	96	462	24	25	29	18
Grand Total	63	259	299	566	577	258	2,022	49	74	70	49

*Includes only February and June degrees.

¹From 1935 to 1944, Bachelor of Architecture in City Planning.

²Degree of Bachelor in Architecture changed to degree of Master of Architecture in June, 1972.

³Degree 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 decades						Grand Total	Calendar year since 1970 (included in decade total)			
	1949-60	1961-70	1971-	1970	1971	1972		1973	1974*		
Engineer in Aeronautics and Astronautics ¹	35	58	12	105	3	4	3	2	3		
Building Engineer ³	5	2	-	7	-	-	-	-	-		
Chemical Engineer	17	31	31	79	2	6	6	12	7		
Civil Engineer	21	78	41	140	6	7	23	10	1		
Electrical Engineer	132	444	172	748	57	50	48	42	32		
Environmental Engineer	-	-	3	3	-	-	-	1	2		
Marine Mechanical Engineer	7	2	1	10	-	-	1	-	-		
Materials Engineer	-	7	1	8	-	-	1	-	-		
Mechanical Engineer	102	166	59	327	17	15	14	18	12		
Metallurgical Engineer	24	18	6	48	-	1	2	2	1		
Meteorologist ²	2	-	-	2	-	-	-	-	-		
Naval Architect	11	21	5	37	2	3	1	1	-		
Naval Engineer	334	246	19	599	27	19	-	-	-		
Nuclear Engineer	-	37	16	53	3	4	3	5	4		
Ocean Engineer	-	4	68	72	4	3	21	25	19		
Sanitary Engineer ³	9	3	-	12	-	-	-	-	-		
Total	699	1,117	434	2,250	121	112	123	118	81		
Awarded jointly with Woods Hole Oceanographic Institution											
Ocean Engineer	-	-	7	7	-	1	4	2	-		
Grand Total	699	1,117	441	2,257	121	113	127	120	81		

*Includes only February and June degrees.

¹Prior to 1960, Aeronautical Engineer.²Degree discontinued after 1955.³Degrees discontinued after 1964.

TABLE XIII NUMBER OF DEGREES OF DOCTOR OF PHILOSOPHY AWARDED

	Total by decades										Calendar year since 1970 (included in decade total)					
	1907-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-	Grand Total	1970	1971	1972	1973	1974*		
SCHOOL OF ARCHITECTURE AND PLANNING																
Urban Studies and Planning ⁶	-	-	-	-	-	-	24	20	44	4	3	5	6	6		
SCHOOL OF ENGINEERING																
Aeronautics and Astronautics ⁷	-	-	-	-	-	6	57	39	102	11	9	10	13	7		
Chemical Engineering	-	-	-	-	-	-	31	19	50	5	6	1	7	5		
Civil Engineering	-	-	-	-	1	9	72	49	122	25	14	15	16	4		
Electrical Engineering	-	-	-	-	1	9	248	138	396	39	49	32	40	17		
Mechanical Engineering	-	-	-	-	4	4	95	56	155	11	18	15	8	15		
Metallurgy and Materials Science ³	-	-	-	-	6	5	103	58	167	16	24	14	14	6		
Nuclear Engineering	-	-	-	-	5	90	90	30	125	11	8	10	7	5		
Ocean Engineering ⁸	-	-	-	-	-	-	15	12	27	6	3	5	3	1		
Sanitary Engineering	-	-	-	-	-	2	3	-	5	-	-	-	-	-		
Total	-	-	-	-	1	33	714	401	1,149	124	131	102	108	60		
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE																
Economics ¹	-	-	-	-	19	96	195	74	384	29	18	25	20	11		
Group Psychology	-	-	-	-	8	1	-	-	9	-	-	-	-	-		
Linguistics	-	-	-	-	-	-	35	24	59	7	5	9	6	4		
Philosophy	-	-	-	-	-	-	8	10	18	2	1	3	4	2		
Political Science	-	-	-	-	-	-	71	37	108	11	12	7	10	8		
Psychology	-	-	-	-	-	3 ⁺	24	14	41	7	2	6	5	1		
Total	-	-	-	-	27	100	333	159	619	56	38	50	45	26		

ALFRED P. SLOAN SCHOOL OF MANAGEMENT

Management ²	-	-	-	-	-	-	-	-	-	89	33	122	13	9	10	10	4	
SCHOOL OF SCIENCE																		
Biology	-	1	10	17	21	38	105	64	256	11	17	25	11	11	11	11	11	
Chemistry	7	19	59	146	180	342	427	188	1,368	50	58	55	52	23	23	23	23	
Earth and Planetary Sciences ⁴	1	7	10	22	20	71	84	28	243	9	11	8	3	6	6	6	6	
Mathematics	-	-	6	25	35	70	211	97	444	27	25	22	31	19	19	19	19	
Meteorology	-	-	-	-	-	14	45	17	76	9	7	5	1	4	4	4	4	
Nutrition and Food Science	-	-	-	-	4	28	66	47	145	11	9	7	18	13	13	13	13	
Oceanography ⁵	-	-	-	-	-	-	11	-	11	-	-	-	-	-	-	-	-	
Physics	-	2	6	48	159	283	390	161	1,049	48	54	43	38	26	26	26	26	
Total	8	29	91	258	419	846	1,339	602	3,592	165	181	165	154	102	102	102	102	

AWARDED JOINTLY WITH WOODS HOLE
OCEANOGRAPHIC INSTITUTION

Earth and Planetary Sciences	-	-	-	-	-	-	4	10	14	3	-	2	6	2	2	2	2
Meteorology	-	-	-	-	-	-	1	6	7	1	4	2	-	-	-	-	-
Grand Total	8	29	91	258	447	979	2,504	1,231	5,547	366	366	336	329	200	200	200	200

*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.

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.

TABLE XIV NUMBER OF DEGREES OF DOCTOR OF SCIENCE AWARDED

	Total by decades										Grand Total	Calendar year since 1970 (included in decade total)				
	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-	1970	1971	1972		1973	1974*			
SCHOOL OF ENGINEERING																
Aeronautics and Astronautics ¹	2	4	5	18	31	76	18	9	5	6	6	1				
Chemical Engineering	-	23	78	114	117	151	37	13	10	12	9	6				
Civil Engineering	-	2	12	23	46	75	21	7	8	6	3	4				
Electrical Engineering	3	12	30	34	141	124	33	9	6	13	7	7				
Electrochemical Engineering	-	1	1	-	-	-	-	-	-	-	-	-				
Mechanical Engineering	-	4	13	35	125	145	33	4	8	10	6	9				
Metallurgy and Materials Science ²	-	14	32	86	194	201	37	10	9	13	11	4				
Mineral Engineering	1	-	4	-	-	-	-	-	-	-	-	-				
Nuclear Engineering	-	-	-	-	9	55	22	10	4	11	6	1				
Ocean Engineering ⁵	-	1	-	-	2	6	4	-	2	2	-	-				
Petroleum Engineering	-	-	1	-	-	-	-	-	-	-	-	-				
Sanitary Engineering	-	-	2	3	18	2	-	-	-	-	-	-				
Total	6	61	178	313	683	835	205	62	52	73	48	32				
SCHOOL OF SCIENCE																
Biology	-	-	-	-	-	1	-	-	-	-	-	-				
Chemistry	-	2	5	4	3	1	1	1	1	-	-	-				
Earth and Planetary Sciences ³	1	2	4	5	2	3	2	2	-	2	-	-				
Mathematics	-	2	3	-	1	1	2	9	1	1	-	-				
Meteorology	-	-	6	25	17	6	1	55	3	1	-	-				
Nutrition and Food Science	-	-	-	3	10	17	13	2	5	2	3	3				
Oceanography ⁴	-	-	-	-	-	1	-	-	-	-	-	-				
Physics	-	5	18	14	7	6	4	-	2	-	1	1				
Total	1	11	36	51	40	36	23	8	9	6	4	4				
AWARDED JOINTLY WITH WOODS HOLE OCEANOGRAPHIC INSTITUTION																
Meteorology	-	-	-	-	-	-	4	-	1	1	1	1				
Grand Total	7	72	214	364	723	871	232	70	62	80	53	37				

*Includes only February and June degrees.
¹Prior to 1960, Aeronautical Engineering.
²Including Ceramics.
³Changed from Geology and Geophysics to Earth and Planetary Sciences, 1970.
⁴Beginning 1967-68, included in Earth and Planetary Sciences or Meteorology.
⁵Changed from Naval Architecture and Marine Engineering to Ocean Engineering in September, 1971.

TABLE XV SUMMARY OF DEGREES AWARDED
(1868-1974)

Bachelor of Science	43,704
Bachelor in Architecture (discontinued 1972)	765
Bachelor in City Planning (discontinued 1954)	31
Master of Science	22,104
Master in Architecture (discontinued 1972)	648
Master of Architecture	62
Master of Architecture in Advanced Studies	54
Master in City Planning	462
Master in Public Health (discontinued 1944)	104
Advanced Engineering	2,250
Advanced Engineering awarded jointly with Woods Hole Oceanographic Institution	7
Doctor of Philosophy	5,526
Doctor of Philosophy awarded jointly with Woods Hole Oceanographic Institution	21
Doctor of Science	2,479
Doctor of Science awarded jointly with Woods Hole Oceanographic Institution	4
Doctor of Public Health (discontinued 1944)*	9
Doctor of Engineering (discontinued 1918)*	4
	78,234

*See 1959 Report of the Registrar for details.

WARREN D. WELLS

Secretary of the Institute

The assignment of the Secretary to the Institute is to provide staff support to the Corporation and to the Committees of the Corporation. This report summarizes the work of the Institute's governing body under the chairmanship of Howard W. Johnson.

Corporation Membership

At the academic year's end there was a total of 88 Members of the Corporation -- 77 Active Members, two Life Members Emeriti, and one Member-Elect of the Corporation due to assume office at the October 4, 1974, Annual Meeting of the Corporation as a Representative from Recent Classes. During the year the Corporation regained (at the October 5, 1973, Annual Meeting) the membership of Laurence Storch, a student at the Harvard Law School, for a five-year term. Mr. Storch previously had served a one-year term.

On August 24, 1973, the Corporation lost through death its beloved Eugene McDermott, former president and founder of Texas Instruments, Inc.; on November 19, 1973, its distinguished Member, H. I. Romnes, former chairman and president of American Telephone and Telegraph Company; and on June 28, 1974, its former chairman, Dr. Vannevar Bush, Class of 1916.

Dr. Bush had served as a Life Member of the Corporation for the past 35 years. He was elected the third chairman of the Institute's governing body in 1957, and served until 1959. He was a former president of the Carnegie Institution of Washington, a former vice president and dean of the School of Engineering at M. I. T., and (during World War II) the famed director of the Office of Scientific Research and Development (OSRD). In his passing the nation lost a distinguished public servant and a revered spokesman for the scientific community. M. I. T. has lost one of its greatest leaders, a beloved alumnus and administrator.

At the time of his death, Mr. McDermott was an honorary lecturer in the Department of Earth and Planetary Sciences. He is memorialized at M. I. T. in McDermott Court and McDermott Hall -- both of which are associated with the Cecil and Ida Green Building -- and through the McDermott Scholarship Fund, the Institute's largest named scholarship fund.

At its March 1, 1974, Meeting, the Corporation elected the following to five-year terms effective July 1, 1974: Louis W. Cabot, Chairman, Cabot Corporation; Frank T. Cary, Chairman, International Business Machines Corporation; and Dr. Cecily C. Selby, Class of 1950, National Executive Director, Girl Scouts of America.

At its May 31, 1974, Meeting, the Corporation elected the following to five-year terms effective July 1, 1974: James A. Champy, Class of 1963, attorney-at-law; Thomas F. Creamer, Class of 1940, Executive Vice President, First National City Bank of New York; Dr. Edward E. David, Jr., Class of 1947, Executive Vice President, Gould Incorporated; Dr. Jerome H. Holland, former U.S. ambassador to Sweden; Breene M. Kerr, Class of 1951, Senior Partner, Howell-Kerr Enterprises; Carl M. Mueller, Class of 1941, Managing Partner, Loeb, Rhoades, and Company; Dr. Charles E. Reed, Class of 1937, Senior Vice

President, General Electric Company; and Jephtha H. Wade, Class of 1946, Partner, Choate, Hall, and Stewart. Gregory C. Chisholm, Class of 1973, a graduate student in mechanical engineering at M. I. T., was elected a Representative from Recent Classes, for five years, to assume office on October 4, 1974. In addition, Life Member Luis A. Ferré, Class of 1924, former governor of the Commonwealth of Puerto Rico, assumed the additional position of ex officio Member of the Corporation by virtue of his election as the 1974-75 president of the Alumni Association.

In a year marked by important changes in the bylaws and membership, Dr. Howard W. Johnson succeeded Dr. James R. Killian, Jr. as chairman of the Corporation Development Committee. Dr. Killian was elected honorary chairman of this 140-member Standing Committee of the Corporation. No amount of praise can do justice to Dr. Killian's monumental leadership of this crucial Committee and his role as the principal architect of the Institute's development for more than a quarter of a century. The growth of the Institute's resources over this period speaks eloquently for M. I. T.'s great fortune in having his continuing services.

Life Member Lloyd D. Brace, former chairman of the First National Bank of Boston, transferred to Life Member Emeritus status after more than 20 years of active service. Expiration of term membership has cost the Corporation the formal services of Elisha Gray II, Class of 1928, Chairman of the Finance Committee, Whirlpool Corporation; Dr. Christina H. Jansen, Class of 1963, Staff Member, Polaroid Corporation; and Harold E. Thayer, Class of 1934, Chairman and Chief Executive Officer, Mallinckrodt Chemical Corporation. Sir William Hawthorne resigned after serving for nearly five years to accept an appointment to the faculty of the School of Engineering. These retiring Corporation Members continue their association with the Corporation in important ways as members of various Corporation Committees, and, in Dr. Hawthorne's case, as a valued advisor and investigator in the Institute's energy program.

The Corporation held four meetings during the year. In a year when President Jerome B. Wiesner and Chancellor Paul E. Gray demanded an extra effort from all segments of the Institute community, the Corporation played a central role in communicating with students, faculty, alumni, and the general public on the range of questions and issues before M. I. T. Special thanks once again are due the Ad Hoc Committee on Shareholder Responsibility. Additional thanks are due the Corporation Screening Committee, under the chairmanship of Dr. Ralph M. Davison, and the staff of the Alumni Association for their efforts in conducting the expanded version of alumni elections and the special alumni election needed to fill a vacancy in the membership category, Representatives from Recent Classes.

Corporation Joint Advisory Committee on Institute-wide Affairs

This Advisory Committee to the Corporation completed its fifth year of operation and its third year under the chairmanship of James A. Champy. The Committee held ten regular open meetings during the year; these included sessions with the Chancellor, Members of the Corporation, and various officers of the administration. Topics given special attention by C. J. A. C. included: the status of graduate students at M. I. T., particularly with regard to financial support; the year-round operation of the Institute; and a review with the Institute's Equal Opportunity Committee of various equal opportunity issues. C. J. A. C. has made valuable contributions on these and other questions, in building respect and mutual understanding within the M. I. T. community. Particular credit is due the chairman, Mr. Champy, for his skillful and stimulating leadership. The Committee was assisted in its deliberations for the third year by the able staff support of Robert D. Blake and his office.

Dedications

The Corporation maintained prime responsibility for the dedication of major facilities. Notable ceremonies this year included the dedication of the Sherman M. Fairchild Electrical Engineering and Electronics Complex, the occupancy of the new Fraternities Collaborative on Memorial Drive, the opening of the renovated M. I. T. Faculty Club, and the naming of the Great Court as the Killian Court on Alumni Day, June 3, 1974. The Department of Electrical Engineering took responsibility for dedicating a laboratory in honor of Institute Professor Emeritus Arthur Von Hippel.

Corporation Visiting Committees

Each Visiting Committee presently includes three Corporation nominees, six presidential nominees, and six alumni nominees -- or 15-member Committees in place of the previous nine-member Committees. The expansion process was begun four years ago. A total of 400 individuals presently hold 446 positions on the 29 Visiting Committees.

The academic year 1973-74 was a good one for the Corporation Visiting Committees, with 17 meetings attended by 185 members, including a meeting of chairmen of Visiting Committees in the School of Engineering. For the second year in a row, there was no surfeit of meetings in one or two spring months. Seven of the meetings occurred prior to January 1, 1974. Several additional meetings were planned tentatively, but had to be postponed until the fall of 1974.

This year the Corporation continued the procedure of electing the chairmen of the Visiting Committees at the March Meeting of the Corporation, instead of in October. This change had been proposed as a means of promoting better academic-year scheduling of meetings, since it provides working time (before the quiet, relatively inactive summer months) for planning for the fall. The results to date suggest the efficacy of this move; nine Committees already have scheduled meetings for this coming fall, while seven are planning actively for January and the other winter months.

Two features of the meetings that have proved successful in the past were continued by most of the Committees this year. All but two of the meetings included dinner, at which Committee members were brought together informally with members of the faculty and administration, and in a few cases with students. Also, the Committees made effective use of sessions with students on their agenda, further formalizing this valuable means of gaining insight into the various departments' activities. Several of the Committees for larger departments held similar, separate sessions with junior faculty members. Discussions with the departments had many common themes, including review of departmental progress in the recruitment of minorities and women as students and faculty members. The Sloan School Visiting Committee, under the chairmanship of Paul V. Keyser, obtained excellent results with several small, highly organized task forces dealing with particular aspects of the School's program.

Attendance by members of the Visiting Committees has been excellent this year. The 17 meetings had an average of 11 members per meeting. In addition, the participation of senior officers and deans of the Institute in this year's series of meetings continued at a high level. The presence of these officers enhances communication between the individual Committee and the individual department, and often provides a welcome catalytic effect which contributes to the success of the meeting. Special thanks are due Provost Walter A. Rosenblith for his energetic participation in the meetings and in the selection of new

Committee members, and the more than 300 faculty members who participated in the sessions of the Visiting Committees.

Of the fifteen Committees which met in 1972-73, all of the chairmen have reported orally to the Corporation, and a total of 10 have submitted written reports. These reports to the Corporation are vital to the successful operation of the Committees; they also provide a broadened forum in which to consider the plans and progress of each department. They are invaluable to the functioning of trusteeship at M. I. T.

The increased size of the Committees has resulted in a proportionately larger number of members requesting reimbursement, as well as increased costs associated with the meetings themselves.

The continued service of Robert D. Blake as Special Assistant in the Office of the Secretary, providing staff support to the Corporation Visiting Committees and to C. J. A. C., is noted with appreciation. During the year the Institute lost the brilliant services of Leslie M. Boring, Jr., and Paul E. Johnson, both of whom resigned to accept promising positions in industry.

VINCENT A. FULMER

Vice President for Resource Development

As currently organized, the office of the Vice President for Resource Development is a year and a half old. Its scope, unchanged from the description in the report of a year ago, is to plan, execute, and coordinate all activities which provide private gift income to the Institute. Funding leadership is but one of the myriad responsibilities of the senior M. I. T. officers. Success in this area also depends on the active participation of others in the faculty and administration, and equally requires the time and financial commitments of alumni volunteers. This institution has the extraordinary good fortune to have unusual strength in each of these categories.

Gifts for fiscal year 1974 were \$22.7 million, which exceeds the totals for 1970, 1972, and 1973. This accomplishment, in the face of an uncertain stock market, a confusing economy, and a turbulent national scene, gives evidence of the strengths mentioned above, the support of a competent staff, and the groundwork laid in previous years.

Gratifying as they were, gift results were accompanied by inflation, revenue decreases associated with the Draper Laboratory divestment, and expense increases attributable to energy costs. Several pressing needs, therefore, could not be met from gift income. These problems -- inflation, expenses, needs -- are given special notice in this report, because of steps taken during the past year to increase gift flow.

For the past ten years, gift income has been in the \$20-22 million range, with occasionally greater amounts resulting from an extraordinary circumstance, such as the receipt of a large bequest. Extensive study and analysis demonstrate that this range must be brought closer to \$35 million, in order to deal with the financial exigencies suggested by the present economic situation, an analysis of the future, and M. I. T.'s continuing efforts to budget prudently and to manage the endowment carefully. Reaching that level in a relatively short time and catching up on the major capital needs already evident will require a major capital campaign. Experience at M. I. T. and elsewhere has been that success in such a campaign not only can fund current needs, but also can produce a higher subsequent annual gift flow than before. The Institute's officers, in discussions with the Corporation Development Committee and the Corporation, have addressed seriously the desirability of a large capital campaign extending over several years. Studies of the ramifications of such a campaign have taken much of the energies of the Resource Development staff during the past year.

Gift Income

Highlights of the past year's activities are reported below. Further details are provided in the separate report of the Vice President and Treasurer of the Institute.

Total gifts, grants, and bequests for the year were \$22.7 million. This compares with \$21.7 million in fiscal year 1973 and \$20.1 million in 1972.

Sources of gifts for fiscal year 1974 were: alumni and alumni clubs -- \$5,354,145; nonalumni friends -- \$817,908; corporations, corporate foundations, and trade associations -- \$7,300,800; foundations and charitable trusts -- \$9,045,153; and others -- \$79,208.

Among the major purposes for which gifts were designated by the donors in both endowed and expendable funds were: unrestricted -- \$4,178,203; departmental -- \$6,925,431; faculty salaries -- \$2,928,803; graduate scholarships and fellowships -- \$929,220; undergraduate scholarships, awards, and loan funds -- \$594,451; building construction funds -- \$5,593,398; and other funds -- \$1,447,707.

Organization

The Council on Resources of the Institute, comprising the Honorary Chairman of the Institute, the Chairman, President, Chancellor, Provost, Vice President and Treasurer, and Vice President for Resource Development, met regularly to coordinate planning, establish priorities, and provide a concentrated focus on financing the present and the future. As was the case with Resource Development staff, much of the Council's time was devoted to campaign planning, as well as to the overall direction of ongoing fund-raising activities.

The Corporation Development Committee held its annual meeting in December, 1973, with 53 members in attendance. The morning plenary sessions covered the state of the Institute's programs and financial operations, and a detailed exposition of those priority needs which require funding. Discussion periods were held in the afternoon. A consensus appeared clear that a campaign was the proper strategy for M. I. T. to undertake, and that active planning should begin immediately. Subsequently, meetings were held around the country with many of those who could not be present in December.

The importance and value of the 134-member Committee perhaps has never been so evident. As a geographically representative group of leading alumni who are informed about Institute affairs, familiar with the economic climate in their communities and industries, and oriented toward providing adequate gift resources, it is a forum uniquely qualified to evaluate the appropriateness of funding Institute needs and the timeliness of a major effort to do so. Its judgments are invaluable to the full-time staff at M. I. T. During the past year the Committee lost through death the services of its devoted member Robert W. Miller.

Several new members were added to the staff, both to complete the organizational structure already planned for Resource Development and to begin the extensive preparatory work required for the campaign. These are listed later in this report. One new departure, however, was the formation of a Resource/Alumni Data Systems Group, reporting to the Director of Resource Planning. Victor M. Maslov was appointed manager of this computer group, which will be responsible for the development, production, coordination, and operation of all existing computer systems serving the office of the Vice President for Resource Development, the Alumni Association, and the Alumni Fund, as well as new systems to be developed for the campaign. Formed after extensive discussion among all parties involved (including the Office of Administrative Information Systems) and with their concurrence, the new group should provide new levels of effectiveness and efficiency.

Individual Giving

The number of living donors whose gifts to M. I. T. total \$25,000 or more rose to 244. Further progress is needed, however, in helping donors to perceive their goals in cumulative terms, and in aiming at substantial sums that are personally gratifying to them. This program also is related intimately to planned giving. The following data applied to planned future gifts on June 30, 1974: estates in process of settlement -- 26; life income trust donors -- 41 (there are 49 funds held in trust, since some donors have more than one trust); other plans on record -- 757; for a total of plans and trust funds of 824.

Final distributions were received from 22 estates, on which the records now are closed. The modest reduction in these numbers is attributable to a comprehensive review of the files, and

the removal from the list of several on which there was insufficient documentation.

Long-term philanthropic planning continues to be affected by tax questions, and a very substantial staff investment has been made in monitoring legal developments. Inevitably, this has diminished the staff efforts devoted to cultivating new donors, uni-trust life income, pooled life income, and annuity plans. Allan S. Bufferd of the Alumni Association staff joins this group as Institute Secretary on July 1, 1974, and will provide much-needed additional staff support.

As reported elsewhere, the Alumni Fund received \$2,915,505 from 20,830 donors. The total amount was less than in the previous year, but it also was the second highest on record; the donor total was the second highest in the history of the Fund. Coordination and cooperation between the office of the Vice President for Resource Development and the Fund (and, indeed, the entire Alumni Association) continued at a superb level, and each group found ways to complement the other. One of the more dramatic illustrations of this was the series of eight leadership luncheons organized in various cities by the Fund. These provided 252 alumni, corporate, and foundation leaders with an opportunity to meet and exchange views with senior Institute officers.

Foundations and Charitable Trusts

During the year 135 foundations and charitable trusts made 216 gifts and grants to M. I. T., totaling \$9,098,888. This figure represents 40 percent of the \$22,666,769 total received from all philanthropic sources. The ten largest foundation donors, with payments ranging from a low of \$250,000 to a high of \$1,476,500, represented 7.4 percent of the total number of foundation donors and 71 percent of the total foundation support.

Total foundation pledges this year amounted to \$8,552,177 (the second highest in the past six years), and total foundation pledges outstanding at the end of the fiscal year amounted to \$11,145,844 -- on a par with 1973, and well in excess of the preceding three years.

Total foundation income this past fiscal year was \$2,534,833 more than fiscal year 1973, \$2,040,951 more than fiscal year 1972, and the highest in six years. This was achieved in spite of the continuing decline in payments from the Ford and Sloan Foundations, traditionally the two major sources of foundation support for M. I. T. Their contributions have decreased over the past three years from a combined total of \$2,716,365 in 1971 to \$1,429,284 in 1974. Excluding Ford and Sloan Foundation payments, the total yearly income from all foundations has risen steadily from \$3,302,569 in 1970 to \$7,669,604 in 1974, a five-year increase of 132 percent. This has been accompanied by continued broadening of the base of foundation support at both the low and high ends. The number of foundation donors has increased from 103 in 1970, to 118 in 1971, to 121 in 1972, to 134 in 1973, to 135 in 1974. There also has been a steady increase in the number of instances in which foundations have made total yearly payments in excess of \$100,000: from 11 in 1970 to 19 in 1974.

During the past year, a record 42 foundations made gifts and grants to M. I. T. for the first time, accounting for \$2,435,335 paid (27 percent of all foundation payments in 1974) on pledges totaling \$4,806,248.

Another increase was recorded in the amount contributed by medium-sized foundations and charitable trusts, typically those with assets ranging from several hundred thousand to 10 million dollars. A total of \$1,749,124 was contributed by 43 of these. This compares to grants from 44 the previous year, amounting to \$904,000. The increased amount is a consequence of payments on one large pledge, which illustrates the importance of a few large grants to the total contribution received from this sector of private philanthropy.

The Federal College Work-Study Program made it possible to engage students in several projects. One project, designed to refine further the classification of private foundations, has facilitated greatly the more effective use of alumni in the screening process. Extensive screening efforts, using these new tools, were undertaken in 10 of the 15 cities where major foundations are located. A second project sought to identify M. I. T. alumni who are associated closely with private foundations. This information will enable the Institute to develop and test a strategy to encourage grants from alumni related foundations that are contemplating termination because of the burdens imposed by recent tax legislation. Lastly, a project was completed which identified attorneys in all the major cities of the country who have M. I. T. undergraduate degrees. These individuals may be able to help the Institute approach foundation trustees who are also attorneys.

Corporations

The trend in recent years of increasing corporate support to M. I. T. was maintained, despite the effects of the oil embargo, inflation, and a tendency among some corporate executives to await clarification of the general economic scene before deciding on new commitments. Activity in the corporate gift area by many officers of M. I. T. and by members of the faculty was most effective. Those efforts, and payments on many outstanding pledges, maintained corporate giving at the record level of the previous year despite the economic disruptions.

The dedication of the new Sherman Fairchild Electrical Engineering and Electronics Complex was a significant milestone for M. I. T. this past academic year; substantial financial support for it came from corporate sources. The new Chemical Engineering Building drive was completed successfully; a majority of the funds pledged for it came from corporations and their foundations.

An outstanding effort was led by Professor Samuel A. Goldblith* to interest additional food industry companies in participating in the Industrial Liaison Program. As a result, four new companies have become members of the Program, and several more have responded favorably to initial solicitations.

Total industrial support for the year was maintained at the fiscal 1973 record level of \$7.3 million. In the past year, this represented 32 percent of the total support which M. I. T. received from private sources.

Industrial Liaison Program

The Industrial Liaison Program (I. L. P.) was expanded to 97 companies during this past year. Income for the Program was down approximately \$200,000 from the previous year, primarily because of the completion of several substantial pledges to the Electrical Engineering and Electronics Complex. However, the unrestricted portion of the Program's income was up slightly, to \$984,656. Eight new members were added to the Program during the past year, while five were terminated. Among the new members is the Naval Air Development Center, the first governmental agency to participate in the Program. It is hoped that other government laboratories will be interested in interacting with the Institute through the Program.

During the past year, additional steps were taken toward the objective of doubling the size of the Program within five years. A revenue-sharing plan was adopted by the Institute to enable faculty members who participate in the Program to share directly in the income received through the Program, and a significant effort was made to publicize the opportunities which

*Professor Goldblith, a distinguished member of the Department of Nutrition and Food Science, will become Director of Industrial Liaison and head of the Industrial Liaison Office on September 1, 1974.

the plan represents. This activity will continue with the first distribution of money early in fiscal year 1975. The staff of the Industrial Liaison Office worked closely with Robert Hagopian, the new Institute Secretary responsible for I. L. P. solicitation. The Industrial Liaison Office also sponsored two symposia during the year which were directed at prospective members. The first was aimed at the food industry, and has resulted in the addition of four companies to the Program. The second was not specific to industry and was done in part to commemorate the 25th anniversary of the Industrial Liaison Program. The meeting was cosponsored with the M. I. T. Associates Program, and already has resulted in several substantive contacts for both Programs; hopefully these will result in additional memberships.

As expected, activity during the past year increased markedly over the previous year, as three new liaison officers who joined the staff during fiscal year 1973 and one who joined the staff in early 1974 began to function effectively with their companies. Visits by faculty members to member companies, an activity initiated primarily by the Liaison Office, increased by more than a factor of two to 203 visits. Visits by the Industrial Liaison Officers to the member companies also increased, from 143 in 1973 to 203. Attendance at the 12 symposia sponsored by the Industrial Liaison Office remained about the same as in the previous year, an average of 100 per meeting. This activity was highlighted by a symposium on signal processing, held in Los Angeles in January, 1974, which was attended by 175 people from the member companies.

During this past year, a new service was offered to member companies and received enthusiastically by them. The Industrial Liaison Program Seminar was initiated as a way of providing access to information on timely topics which do not lend themselves to the symposium format. During the year, six seminars were held, two at M. I. T. and four at other locations. They attracted 89 participants from 35 member companies. The Industrial Liaison Program Seminar has proved to be a very cost-effective and visible way of interacting with people from companies located outside the immediate Boston area. It is expected that the I. L. P. will place increased emphasis on this activity.

The staff of the Industrial Liaison Office remained relatively stable, with Dilip Mathur filling the Industrial Liaison Officer vacancy which existed at the beginning of the year.

As always, the Industrial Liaison Office owes much to others at the Institute for the success of the Program's activities. The M. I. T. Libraries deserve special recognition for their contribution in making 608 library privilege cards available. The enthusiastic support of the faculty and staff is essential in making the Program a worthwhile endeavor for the participating companies. It is hoped that through revenue sharing, the faculty will feel an even closer affiliation with the Program's activities.

M.I.T. Associates Program

This year has been a milestone in the history of the M. I. T. Associates Program. An important internal change was the appointment of Jordan D. Carter to the position of assistant director in August, 1973. It was hoped that additional staff would provide a more responsive interaction between the Associates Program and its participating companies, and perhaps more importantly, would be a basis for growth in membership and revenue.

A new solicitation strategy resulted in 14 new member companies, making a total of 38. The level of interaction with M. I. T. faculty also increased. During the past year, company representatives made 165 visits to faculty members. Visits by M. I. T. staff to Associates Program companies also increased, to 55. In addition, there were 47 solicitation visits by the director and assistant director.

The second year of Round Table discussions included the two sessions, A Perspective on the Changing Environment of Business and Government in an Expanding Economy, and Short-term Strategic Market Planning in a Crisis Oriented Environment. These meetings were extremely well received, and were attended by 45 individuals from participating companies.

In addition, it was felt that a program similar to the Round Tables but staged on a working level within member companies would be a useful service. Therefore, the Associates Program Seminars were created. The two sponsored during the past year were entitled M. I. T. 's Program for Meeting the Current Energy Situation and Computers as a Financial Decision Making Tool. Total attendance at these meetings was 27.

The Associates Program participated in the presentation of a conference, M. I. T. Research: An Industrial Resource, which proved to be an extension of the New England Executives Conference. It was attended by 138 participants and was preceded by a reception and dinner on May 13 and 14, 1974.

During the past year, as plans for the development of the Program were implemented, the need to encourage faculty members' participation was recognized. The Associates Program cooperated with the Industrial Liaison Program in creating a revenue-sharing plan whereby 10 percent of the total revenue generated by both programs would be distributed among the participating faculty. This plan was implemented and presented to the faculty at their meeting in October, 1973, and revenues will be distributed for the first time as of July 1, 1974.

Resource Operations

Principal Activities

During the year, the three principal efforts of the Resource Operations staff were directed toward making its reorganization operationally effective, increasing its level of activities, and carrying forward planning and preparation for a possible capital campaign. The strengthened staff and redefined responsibilities enabled the Resource Operations staff to increase significantly its support of the Institute's development program in many ways.

1. It strongly increased its backup support of senior officers and staff.
2. It initiated an increased volume of visit suggestions which led to many successful visits by senior officers and staff to individuals, foundations, and corporations.
3. It augmented its research capacities with additional services and key personnel, resulting in a much stronger base of support for the Institute Secretaries.
4. It expanded contact with faculty and staff members on approved funding objectives, and assisted many of them in finding funding sources.
5. It collaborated actively in several funding activities of the Alumni Fund and helped to strengthen both organizations through closer ties.
6. It produced a significantly higher volume of proposals and brochures in support of many major funding objectives and smaller funding projects.
7. It increased the level of acknowledgment and stewardship activity with donors -- principally through personal letters from the President and other senior officers.

8. It strengthened its existing computer programs and initiated selected new ones, in support of efforts to identify and cultivate major prospects and donors.

Campaign Planning

The work of Resource Planning related to the possible capital campaign has taken up a major amount of time and has involved substantial efforts by the staff. These efforts have included a careful review of M. I. T. 's funding potential; the development through the Council on Resources of the Institute of a basic priorities list; the preparation of a first-draft casebook; the discussion and development of a proposed campaign organization; the initiation of extensive work to support a heavy program of campaign publications; the development and review of major prospect lists; and a proposed timetable for preparation for the campaign.

Personnel

The Development Office has increased further its support of senior officers and of the Resource Development group, and the staff of the Office is taking on increased responsibilities. Charles F. Fenno joined the Office as assistant director in the fall of 1973. Joyce Bowden joined the Office during the year as staff writer. The writing section will be supported further by Deborah Cohen and Michael K. Hubner, who joined the staff as assistant writer/researchers at the end of this year.

Other Events

An endowed professorship directed at the problems of contemporary technology was established by a pledge of \$1 million from the Mitsui Group of Companies in Japan. This represents the largest gift ever received from another country, and gives further evidence of the Institute's international influence. It is hoped that in future years there can be a broadened base of support from these sources.

Construction continues on the new Chemical Engineering Building at its East Campus site, marking the culmination of a \$14.5-million drive characterized by extraordinary support from industry and by substantial, generous participation of alumni of the Department of Chemical Engineering. James T. King joined the staff as project officer, and is working on this campaign. He succeeds Leslie M. Boring, who left the Institute for private industry.

The Sherman Fairchild building was dedicated in October, 1973, as the new home of the Department of Electrical Engineering and the Research Laboratory of Electronics (R. L. E.). President Emeritus Julius A. Stratton, a former director of the R. L. E. , made the dedicatory address following a two-day session highlighted by a panel discussion with all six former science advisers to the president of the United States.

Another completed building was the Fraternities Collaborative (on Memorial Drive), housing Alpha Tau Omega and Kappa Sigma. Their pioneering venture into one jointly shared building was financed largely through the Independent Residence Development Fund, and hopefully will rejuvenate interest in both the Fund and the commitment to a strong and viable fraternity system.

Construction continued on the Seeley G. Mudd Building (housing the Center for Cancer Research), and was begun on the new West Campus Undergraduate House. Funding for this latter, critically needed facility is being sought. Two new programs moved into gear: one for a \$5.8-million athletic facility to replace the existing cage and hockey rink with newer and more versatile units, the second for \$211,800 to renovate and expand the sailing pavilion.

The widely scattered offices of the Resource Development staff were concentrated in new quarters, focused around Buildings 4 and 10. In September, 1973, the staff took its turn at hosting the annual convention of the Ivy League-M. I. T. Fund Raisers, in a successful session held at

Vice President for Resource Development

Endicott House.

The Resource Development organization is keenly aware of its responsibilities to M.I.T. and to the Institute's alumni and friends. Its commitment to meeting these responsibilities is matched by an awareness of the ever greater importance of M.I.T. to the nation and to society.

JAMES B. LAMPERT

Other Offices

Alumni Association

Alumni Relations

In terms of alumni relations, 1973-74 may be characterized best as a year of reorganization and planning. Particular emphasis was given to strengthening the Association's data base, developing factual information on alumni attitudes and interest, strengthening boards and committees, and developing the organization in anticipation of a probable capital campaign.

The changes in priorities have been reflected in changes in staff responsibilities. The Director for Alumni Data Resources replaced an assistant secretary who had been primarily responsible for class reunions and alumni seminars. The reunion and seminar activities, in turn, were absorbed into the existing organization by redirecting club support priorities and by redefining the responsibilities of three other members of the staff.

As the following table indicates, overall attendance at alumni functions was slightly less than in 1971-72. However, the significant decrease from 1972-73 is attributable to the fact that the highly successful 1973 Symphony Orchestra tour was not replaced by another well-staffed activity.

By intentionally minimizing the staff support of regular club programs and by redirecting this effort to support regional seminars, the alumni programs were operated with one less staff member than in 1971-72. Despite this change in staff emphasis, regular club programs dropped only modestly, while the attendance at special events increased over the previous two years. The success of the individual seminars varied significantly as a function of subject matter, location, timing, and especially the amount of available lead time. The final seminar, entitled Management Amid Scarcity, was held May 10, 1974, in Chicago. It was attended by over 1,000 individuals and included not only alumni, but an excellent representation of the Chicago management leadership. The program was received extremely well by those present, and was publicized reasonably well by the national press. It will serve as a model for some of the regional conferences planned for the next few years.

Comparative Summary of Attendance at Alumni Activities

	<u>1973-74</u>	<u>1972-73</u>	<u>1971-72</u>
Annual Campus Events	3,080	3,110	3,245
General Club Activities	7,400	8,600	8,600
Special Convocations, Conferences, and Seminars	1,400	1,160	725
M. I. T. Symphony Tour	-	9,500	-
	<hr/>	<hr/>	<hr/>
	11,880	22,370	12,570

Among the 126 club meetings were the following highlights: a program on land use policies, jointly sponsored by the M. I. T. Club and the Wellesley Club of northern New Jersey, which attracted 320 people and resulted in a gift of more than \$2,000 to the Wellesley-M. I. T. Exchange Program; a program at the Hayden Planetarium in New York, featuring Professor Marvin L. Minsky, which attracted 350 people; a talk by Dr. Norman A. Copeland, Class of 1936, a senior vice president of E. I. DuPont de Nemours and Company in Wilmington, Delaware, on the appropriateness of science or engineering as preparation for a career in industry; talks by Institute Professor Emeritus Harold E. Edgerton, who drew large crowds in both Los Angeles and San Diego; the invitations extended to undergraduates, by 13 clubs, to Christmas vacation meetings for the purpose of assisting students in finding summer employment; and the identification by two clubs, Cleveland and Los Angeles, of 51 specific job opportunities, for which 64 students expressed an interest.

Nominations and Elections

The Association nominated three alumni for membership in the Corporation, and one additional candidate in the category of Representative from Recent Classes. The 1972-73 national ballot presented a choice of candidates, including the Corporation nominees, for the first time in recent history. This year's National Nominating Committee, with the concurrence of the Board of Directors, chose to return to a single candidate for each vacancy for elected officers of the Association and alumni nominees to the Corporation. This decision was based on the belief that a national office is more an opportunity and a responsibility earned through years of service than a campaign for office. In this spirit, the Committee sought to select the best candidate for each office, with particular emphasis on presenting a balanced slate. They were influenced by the fact that when multiple candidates were presented in 1972-73, the actual number of ballots cast by the alumni body declined slightly.

The interest in both the national ballot and in the balloting for Representatives from Recent Classes remains disappointingly low, as indicated below.

	<u>Ballots Cast</u>				<u>Percentage Eligible</u>			
	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
National	3,091	3,569	3,453	3,030	6.4%	7.4%	7.0%	6.2%
Recent Classes	1,240	1,096	665	460	22.2%	15.6%	10.9%	7.6%

Out-of-pocket expenses for printing and mailing these ballots have seemed excessive, in light of the response rate. This expenditure was reduced this year from \$11,600 to \$5,900, by utilizing newspaper format and newsprint paper for the Recent Classes ballot. Although the Corporation Screening Committee and many of the nominees felt that this greatly improved the ballot, it did not have the desired effect on response.

To increase further the number of qualified candidates for membership on the National Nominating Committee itself, the Bylaws of the Association were amended to eliminate a restriction which had excluded certain states from having another representative until six years lapsed.

A total of 98 alumni were nominated to fill vacancies on the Corporation Visiting Committees, and 25 were elected to national boards and committees of the Association. Because of the organizational changes mentioned above, more timely and detailed staff work for the three committees responsible for important selection processes provided the members with an opportunity to perform their tasks in a more thorough and thoughtful manner.

Alumni Records

As of May, 1974, the rolls of living alumni included 61,619 names, a net increase of 1,493, resulting from the addition of 2,043 from the Class of 1973 and the removal of 550 alumni reported deceased. The number of address changes was 15,700, down slightly from the previous year, and the total of 4,115 alumni with addresses missing is slightly larger than the previous year.

A high priority was assigned to beginning the conversion of the Association's manual records to computer based records, using microfiche output to replace the outdated manual Kardex file. Although there are many obvious reasons for having the alumni records properly coded in computer storage, the most immediate needs are: 1) to support production of an Alumni Register in 1975; 2) to provide a means of identifying all alumni who are employed in companies with matching gift programs; and 3) to identify alumni by position and company for purposes of the Alumni Fund, the alumni Development Office, and especially the forthcoming capital campaign. This activity was enhanced by the appointment of Barbara Durland as Director for Alumni Data Resources, by the establishment of a task force, and most recently by the establishment of the Resource Alumni Data Systems Group -- a group of systems analysts and programmers reporting jointly to the office of the Vice President for Resource Development and the Alumni Association. This conversion, including the computer generated production of an Alumni Register by the summer of 1975, is on schedule. Questionnaires for the Alumni Register will be mailed to all alumni starting in September, 1974.

Procedures for manually handling in-depth data on a limited number of alumni have been developed and keyed into the data base. Further development and coordination of these systems with the office of the Vice President for Resource Development is scheduled for the coming year. By the fall of 1975, it will be possible to provide continuously updated microfiche output of the basic data on all living alumni to any parts of the Institute needing and entitled to this information.

Alumni Fund

The 1974 Alumni Fund received from 20,909 donors a total of \$2,917,494, which is less than the previous year's total, but still the second highest on record. This is a remarkable achievement in this time of economic uncertainty, a depressed stock market, and rising inflation.

The 25th, 40th, and 50th reunion classes of 1949, 1934, and 1924 respectively reported five-year reunion gifts of \$502,869, \$392,707, and \$670,357. In addition, the sum of \$85,768 was designated by 934 donors for the Independent Residence Development Fund (I. R. D. F.). Of

the \$2.9 million total reported above, more than \$1.3 million (45 percent) were undesignated contributions, while the remaining gifts were allocated by donors for specific projects.

This past year, at the direction of the Alumni Fund Board, a five-year plan was adopted which will require an annual 10 percent increase in the amount of dollars in order for the Alumni Fund to be doubled by 1978. This action was undertaken in response to the needs expressed by the Institute for a substantial increase in gift flow over the next several years. To achieve such a significant change, several new steps have been taken this year, and others are in the offing.

The staff of the Alumni Fund has been reorganized on a geographic basis; each member is responsible for all Alumni Fund functions in his assigned territory.

The Direct Mail Program has been reorganized and integrated into a more cohesive annual package. The Fund received a direct mail award this year from the American Alumni Council in connection with this effort.

Through the staff reorganization, the Fund has attempted to reemphasize regional personal solicitation, personal solicitation for leadership gifts, and an increase in the number of Area Councils from 13 to 20. The Fund continued the highly successful telethons this year, which were held in 27 cities; 474 alumni callers spoke to 6,571 alumni (more than one-tenth of all alumni with addresses in North America) and secured 4,095 pledges to the 1974 Alumni Fund.

The Fund has undertaken several special projects designed to attract major gifts. These include: an Ellen Swallow Richards Professorship; the renovation and expansion of the sailing pavilion and the dinghy fleet; reactivation of the Independent Residence Development Fund and the Alumni Interfraternity Conference; a Charles Stark Draper Professorship from the Class of 1926; and part of the funding for the Council for the Arts. The goals for these projects amount to \$6 million over the next five years. Additional projects will be added.

The accomplishment of these goals requires additional staff for the Alumni Fund. Consequently, the Alumni Fund Board authorized the addition of one new staff member, Ena C. Squires, to become assistant to the director of the Alumni Fund, effective July 1, 1974.

Paul N. Stanton, Class of 1939, joined the staff as associate director in November, 1973, following a distinguished career of over 30 years in industry, and Jacquelyn M. Findlay, Class of 1944, was promoted to assistant director of the Alumni Fund, effective July 1, 1974, reflecting a significant increase and change in her responsibilities and an opportunity for major improvement in the Direct Mail Program.

Robert Hagopian, Class of 1947, transferred to the office of the Vice President for Resource Development in October, 1973, and Dr. Allan S. Bufferd, Class of 1959, transferred to that office effective July 1, 1974, each to be an Institute Secretary. The Association regrets the loss of these two key members of the staff. However, these transfers both represent important career opportunities, and augur well for the continuing cooperation between resource development and annual giving programs.

This report also marks the conclusion of 26 years of service by Donald P. Severance as a member of the staff of the Alumni Association; 12 of these years were as its executive vice president. He leaves this position to assume new duties with the office of the Vice President for Resource Development and the forthcoming capital campaign. A quarter-century procession of alumni officers, workers, and staff are particularly grateful for his service, leadership, and zeal.

Technology Review

Technology Review concluded early in the fall of 1973 that technology would have its greatest impact on human affairs during the winter through what came to be called the "energy crisis" -- a forecast fulfilled beyond expectations by the Arab nations' restrictions on oil exports. As a result of both effort and good fortune, the Review published 14 articles in Volume 76 which dealt with the economic effect of energy shortage and the economic and technological issues involved in increasing energy supplies. The climax of the series came in May, 1974, when the Review published the full report of the M. I. T. Energy Laboratory's Policy Study Group, entitled "Energy Self-Sufficiency: an Economic Evaluation." This represents the first time -- at least in recent history -- that the Review has had the privilege to be the primary publisher of a major M. I. T. technical report. The report was given far more circulation than it would have had through more conventional publication channels, and it is hoped that similar opportunities will occur in the future.

Other notable articles during the year included: the edited transcript of the remarks of the six presidential science advisers at the symposium for the dedication of the Sherman Fairchild Complex; an account by William C. Schneider, Class of 1949, and William D. Green, Jr., Class of 1943, of the operation to restore electrical power to the Skylab; and an important paper on the future supplies of minerals, by Vincent E. McKelvey, Director of the U. S. Geological Survey.

Contributions by two columnists new to the Review appeared regularly in Volume 76 -- Ian C. T. Nisbet of the scientific staff of the Massachusetts Audubon Society, and Kenneth E. Boulding, Professor of Economics at the University of Colorado. They dealt with issues relating technology to natural systems and ecology, and to economics, respectively.

Circulation and Advertising

A modest progress in the development of circulation and advertising income is reported for the year 1973-74. The total advertising income will be very close to the \$55,000 budget target -- higher than in any recent year. Though the Review continues to be rejected for a number of national campaigns which it feels are appropriate to its audience, Review advertising has proved to be an effective medium for recruiting engineering and management personnel, and income from that type of advertising is expected to grow in future years.

Alumni circulation continued essentially unchanged -- approximately 35,000 -- and on the same basis as in recent years. Direct mail promotion of nonalumni "paid" circulation continued, with the result that such circulation reached over 18,000 by the end of the year -- a new record. The renewal rate hovers around 50 percent.

Personnel

Sara Jane Neustadtl joined the staff of Technology Review in September, 1973, as assistant editor, upon completing graduate study at the University of Illinois; she has made outstanding contributions to Volume 76. The Review unfortunately lost the services of Ralph Segman, Managing Editor, as of June 30, 1974.

The support of Gregory Smith, Class of 1930, as chairman of the Advisory Board has been invaluable. He presided at monthly staff sessions for discussion of issues before the magazine, and he led with great skill the extraordinarily successful session of the Advisory Board in June, 1974.

Prospectus

Despite some disappointments and frustrations, 1973-74 was surely a year of considerable progress for Technology Review. Five and six years ago, when the task of developing the Review

into a magazine to serve the M. I. T. community's professional as well as typical "alumni" interests was begun, it was felt that success would be measured over a long period of time as people throughout the United States interested in technology and its implications for human affairs gradually came to recognize the Review as a journal serving this field. Commercial publications, seeking to reduce the time required to achieve such recognition, employ massive capital funding which simply is not available to the Alumni Association. There is accumulating evidence that the Review now is accepted as an important journal -- increasing literature citations, increasing requests for reprinting, and, most recently, a dramatic increase in the number of acceptable articles arriving "over the transom" without solicitation.

At the end of the year, the Review was honored by the American Alumni Council with a position among the "top 13" college and university magazines in the U. S. ; with two special citations for coverage of the "energy crisis" and for dealing competently with "difficult technical subjects"; and with the Ernie Stewart Award. The latter is the highest honor conferred by the American Alumni Council, given "for outstanding examples of service rendered during the year to institutions or to the cause of education by organized alumni effort." The Review shared the 1974 award with The Portable Stanford, a publishing project of the Stanford Alumni Association. Both were cited for rendering service "not only to their alumni, but others as well, by offering intellectual stimulation of uncompromising quality."

The Review is pledged to keep its general editorial thrust consistent with the academic and intellectual interests of the Institute. About 65 percent of the major articles in Volume 76 were written by members of the M. I. T. community -- defined as including members of the faculty and staff, alumni, and Institute guests. Seventy-eight of the 131 items published in "Trend of Affairs" made reference to work by members of the M. I. T. community.

A more difficult issue involves Technology Review's reporting of activities at the Institute for its alumni readers. It is clearly both M. I. T.'s and the Review's intention that the magazine serve as the primary link between the Institute and its alumni, with responsibility for informing alumni of all aspects of M. I. T. affairs. Its mandate is to seek, in discharging this responsibility, a "positive" view of the Institute, its activities, and its problems. Accordingly, the Board of Directors of the Alumni Association has provided resources for an additional member of the staff in 1974-75 so that reportage of activities of the Institute community can be broadened and deepened in Volume 77.

The staff of the Review continues to strive for the best articles and contributors, the most timely and important subjects, and the most effective presentation of this material. It is reminded constantly that its editorial work is not yet of the standard of some publications with which it would like to be compared. Clearly there are challenges for the future.

DONALD P. SEVERANCE

Council for the Arts

The year 1973-74 was, in effect, the Council's first full working year, the year in which the organizational work and initial programs of the first two years began to assume regular operational shape. Two general accomplishments are worth mentioning at the outset. During the week of September 18, 1973, the videotape of the M. I. T. Symphony Orchestra -- coproduced by television station WGBH, Boston, and the Council after the Symphony's national tour in the spring -- was given national distribution over the Public Broadcasting System. Also during the spring, the Council's Constitution, which first was proposed to the membership of the Council at its second Annual Meeting, October 25, 1973, and subsequently revised to include suggestions made by Council members and the Institute's legal staff, was adopted by the Council's Executive Committee and approved by President Jerome B. Wiesner.

The Council's major work of the year was conducted through its standing committees.

The Education Committee Chaired by George Taber, this Committee had two meetings during the year, one at which general principles were discussed, and one at which two small study projects were launched, on drama at M. I. T. and on extracurricular arts activities. A survey of drama was conducted by Michael Murray, a New York based director, producer, and writer, at the request of Dean Harold J. Hanham of the School of Humanities and Social Science. The Council provided a matching grant for this report, which will be used as a basis for future planning.

The Financial Development Committee Under the chairmanship of Max Wasserman, this Committee met numerous times throughout the year at M. I. T. (with trips by Committee members to New York, Chicago, and the West Coast as well) in pursuit of the Committee's basic plan of soliciting ten \$25,000-a-year units for the Council's first five years. By June 30, 1974, five such units were pledged from single donors, and four group units were being investigated in Boston, Chicago, New York, and Washington, D. C.

The Museum and Acquisitions Committee This Committee, chaired by Ida Rubin, met several times at M. I. T. and several times in New York. It broadened its original assignment to include support for a proper physical context for the display and preservation of works of art, and began a program of cooperation with the M. I. T. Faculty Committee on the Visual Arts for acquisitions for new buildings. The New York meetings, for example, were concerned with art for the new Chemical Engineering building, designed by Council member I. M. Pei.

The Planning and Facilities Committee Chaired by Armand Bartos, this Committee met several times during the year in conjunction with the Arts Facilities Study under Professor Donlyn Lyndon. Prototype plans for a variety of arts facilities -- derived from consultation with members of the Faculty Arts Advisory Group -- were drawn up and refined, and will contribute to medium- and long-range Institute planning for the arts.

The Program and Information Committee The Committee, chaired by Leo Beranek, met at bimonthly intervals during the year and made 34 grants to a wide variety of programs in the arts at M. I. T. Four of these grants were unused; the remaining 30 were allocated a total of \$67,085. The Committee also oversaw publication of the Council NewsLetter, which was issued four times during the year. The Committee decided to expand the information program by beginning a monthly calendar of arts events at M. I. T. in the fall of 1974. Text on the arts at M. I. T. and on the Council itself was prepared for the M. I. T. General Catalogue and for a publication of the Educational Council sent to schools and alumni working with prospective students.

Membership

The Council received one resignation during the year, from Robert Meyerhoff. Nine new members were appointed to three-year terms by the President: Ruth Bowman, John Burchar, Helene Cahners, Joseph Dietzgen, Bartlett Hayes, Bates Lowry, Thomas Meloy, and Josephine Pomerance. Professor Donlyn Lyndon, Chairman of the Faculty Arts Advisory Group, was appointed an ex officio member of the Executive Committee. Total Council membership at the end of the year was 67.

Office and Staff

During the year, the Council moved its offices to Building 20D and increased its staff by one person. Ellen Burbank resigned as the Council's associate director to take a job with the National Endowment for the Arts, and was replaced by Susan Knight. Annette Anderson, the Council's staff secretary, was promoted to the previously vacant position of assistant director.

Meredyth Patterson became the new staff secretary. Peter Spackman continued as executive director, and the Council office as a whole continued under the guidance of Professor Roy Lamson, Special Assistant to the President for the Arts.

The year ended with an amenity: the Council sponsored a lunch for the fiftieth reunion class -- which includes Council Chairman Paul Tishman and Council Member Luis Ferré -- to mark the occasion of a Hayden Gallery show mounted from the collection of Mr. Ferré's Ponce Museum of Art in Puerto Rico.

PETER SPACKMAN

Information Processing Services

This report covers the activities of the Information Processing Services office at M.I.T. for the year 1973-74. These activities continue to be administered through a headquarters group and three constituent departments: the Information Processing Center (I.P.C.), the Programming Development Office (P.D.O.), and the Office of Administrative Information Systems (O.A.I.S.). This report outlines the major accomplishments of these offices during the past academic year and examines their major efforts currently under way.

Operations

Information Processing Center

During the year, the Information Processing Center continued to provide over half of the computer services utilized by the M.I.T. community. Support of I.P.C. operating systems and major programming languages was provided by the P.D.O. The Job Processing System (JPS), operating on the IBM System/370, Model 165 hardware, experienced no substantial change in usage volume during the year. The average number of jobs processed each day remained essentially unchanged, and the average central processor utilization per job grew by only 3 percent. Use of the TSO system, also operating on the Model 165, continued to grow during the year, but other use characteristics remained essentially unchanged.

On August 9, 1973, the Honeywell 6180 hardware system became the standard hardware system supporting MULTICS operations at the Information Processing Center. This hardware system succeeded the Honeywell 645, which had been operating for approximately three years. As a result of the new hardware installation, a significant increase in the use of MULTICS occurred during the year, with the average number of users climbing to 1,400, and the average terminal hours per month rising to 14,000. System performance degraded slightly after installation of the new hardware, but it has improved steadily since the middle of the year. Reliability remains at a high level.

Office of Administrative Information Systems

During the year, the total work load processed by the O.A.I.S. grew by approximately 23 percent. The available capacity within the Office made it possible to accommodate this work load with a total operations cost increase of only 13 percent. However, the increased work load saturated the System/370, Model 135 computer on which most administrative applications at M.I.T. operate, and a larger System/370, Model 145 computer was ordered for the O.A.I.S. at the end of the year. The major client continued to be the Comptroller's Accounting Office, which accounted for approximately 65 percent of client billings. Major system development efforts were undertaken during the year by the expanded and restaffed Systems Development Section. New systems are under development in the areas of payroll and personnel, student registration, student accounts receivable, and several other areas. Priorities for system

development continue to be set by the Administrative Operations Subgroup of the Academic Council. During the year, responsibility for maintaining the operating system on the System/370, Model 135 was transferred to the P. D. O.

Major Efforts

During the past academic year, several major thrusts were evident within the Information Processing Services organization. These included the following.

Time-sharing During the year, the I. P. C. continued to develop the time-sharing offerings managed on its service facilities. These include the TSO system operating on the System/370, Model 165, the APL system operating within TSO, and the MULTICS system operating on the Honeywell 6180. Use of time-sharing grew during the year over the IBM and Honeywell systems, as more people in the community became attracted to this convenient mode of computer use. On MULTICS, the time-sharing growth was substantial, while on the IBM system, growth was smaller and represented transfer of work previously done in batch-processing mode. The APL service is being used more widely each month, and the major customer continues to be the Department of Electrical Engineering.

Networking The issue of networking became more current during the past academic year. The term networking refers to the sharing of computer work load among several computers connected by a system of low- and high-speed telecommunications lines. M. I. T. is participating in several networking activities. First, MULTICS is a node on the Advanced Research Projects Agency (ARPA) network which has been developed to connect research sites supported by ARPA. Through this network, considerable use is made of the MULTICS system by those at sites outside the Institute, and M. I. T. faculty and staff can use computers at other installations for their research work. Second, M. I. T. and Harvard University have been cooperating for several years in the joint provision of computer services to the two communities. This arrangement is handled through a network involving computer systems at M. I. T. and Harvard and telecommunications lines to appropriate locations on the two campuses. This service continued in this mode during the current academic year without major change. Third, under the auspices of the New England Regional Computing Program (NERComp), a network is being established to facilitate computer communication among universities and colleges, primarily in the New England area. This network, which is similar to the ARPA network, involves the construction of a small interface computer to provide a match between slow- and intermediate-speed telecommunications lines and communication channels and computers located at colleges and universities in the area. M. I. T. plans to be an early site on this network and to provide computer services to other institutions.

M. I. T. is cooperating in several national studies of networking directed at understanding ways in which universities can utilize computing resources on a joint basis more effectively and thus minimize costs to each institution. These studies will be continued during the coming year, and it is expected that networking will become an increasingly important method for the provision of computer services within the university environment. As M. I. T. is a large-scale computer user, it is likely that it will be both a server and a user in many of these networks.

Decentralized Computing Several actions were taken during the past year to strengthen the decentralized use of computers on the M. I. T. campus. First, the Departments of Mechanical and Civil Engineering completed the merger of their computer facilities (which had begun a year earlier) and experienced a year of successful operation after an initial shakedown period. This joint facility serves the needs of several departments in the School of Engineering in a coordinated fashion at reduced total cost, and with capacity beyond that which the individual departments could provide on their own.

As part of an experiment designed to provide better computing service for faculty and students on the M.I.T. campus, a staff member was appointed Computer Services Officer for the Sloan campus, with the goal of providing an "impedance match" between the provision of computer services through the Information Processing Center and the using community on the East Campus (consisting primarily of the Sloan School of Management and the Departments of Economics and Political Science). This experiment appears to be developing successfully, and may serve as a model for improved methods of user services in the future. However, while it provides improved user services, this method is more expensive.

During the academic year, a major study was begun which is directed at identifying all mini-computers on the M.I.T. campus, with the goal of finding ways in which the Information Processing Services office can provide programs to help those operating these computer facilities to achieve their aims. The first step in this program is the provision of a complete inventory of all such computer equipment. It is hoped that this base of information will: assist students, faculty, and researchers in finding others who may be doing work related to their own; help to avoid needless duplication of developmental efforts across different departments, thus allowing substantive problems to be solved more readily; and help to establish core special interest groups within the M.I.T. community for resource sharing, intellectual cross-fertilization, and generally improved communication among computer users with similar concerns.

Data Base Management Data base management facilities were provided to the Institute through the I. P. C. and O. A. I. S. during the year. The Relational Data Management System (RDMS), initially developed in the School of Engineering, was refined during the year by the P. D. O. into a useful tool for the management of complex information. This tool now is used to create management systems for several departments at the Institute and for several other data base projects.

Technology During the year, the Programming Development Office concerned itself with the maintenance of the MULTICS and IBM System/370 systems in the I. P. C. and the O. A. I. S., and also with planning for the installation of OS/VS2 Release 2 in the I. P. C. at the end of the year 1974-75. Planning for this major change consumed substantial resources in the P. D. O., and will be the major thrust of that Office during the coming year.

ROBERT H. SCOTT

Institute Information Services

During the past year, the Institute Information Services (I.I.S.) continued to move toward greater effectiveness in publications and communications. This was reflected in staff reorganization, in adoption of new production procedures or design for a number of publications, and in the continued public recognition given to M.I.T.'s publication and communication efforts.

Reorganization of some facets of I.I.S. occurred during the spring term. The resignation in January, 1974, of Paul Johnson, Associate Director of I.I.S., was followed by a number of promotions and redistribution of responsibilities. Mr. Johnson, who left the Institute to join private industry, had provided administrative support and guidance to many of the information services, and was a valued colleague in numerous other capacities over the years of his association with M.I.T. At the beginning of May, 1974, Mary Morrissey, who had been Administrative Assistant for Information, was promoted to director of the Information Center. At the same time, Kathryn Lombardi, Associate in the Analytical Studies and Planning Group, assumed additional responsibilities as Manager of Campus Information Services. In this role, Ms. Lombardi has overall administrative responsibility for the Design Services,

Information Center, and Registry of Guests, and also provides liaison with the Vice President in the Office of the President and Chancellor in the general area of information services. Robert M. Byers, Director of the News Office, continues to report directly to the Vice President in the Office of the President and Chancellor. During the summer of 1974, Susan C. Knight resigned her position as Editorial Manager of the M.I.T. Bulletin to accept new responsibilities as the associate director of the M.I.T. Council for the Arts.

The Office of Design Services continued to garner critical acclaim for the quality of its graphic design. In recognition of the exceptional quality of her accomplishments, its director, Jacqueline Casey, was elected in June, 1974, to the Alliance Graphique Internationale -- an honorary society of 179 outstanding graphic designers and educators whose work represents significant contributions to design within their own countries and internationally.

Substantial revision and a new design for the General Catalogue and the Courses and Degree Programs issues of the M.I.T. Bulletin was a major project which moved toward completion during the year. Conducted under the supervision of Miss Knight, this project was carried out in consultation with the Committee on Educational Policy and others throughout the Institute. It was coordinated with a new graphic design for the application materials for prospective students.

News Office

The 1973-74 year was extraordinarily busy for the M.I.T. News Office, which reflects a year of vigorous activity for the Institute community.

National news media gave extensive coverage during the year to several stories on M.I.T., including the Center for Policy Alternatives report on consumer durables; the near-synthesis of an artificial gene by Professor Har Gobind Khorana of the Department of Biology; and the publication of the report on the M.I.T. Workshop on Women in Science and Technology, together with M.I.T.'s publication of a new booklet aimed at potential women students.

Coverage also was given to the Energy Laboratory publication in Technology Review of its report on Project Independence, the effort to make the United States fuel independent by 1980; growth of semiconductor crystals in a zero-gravity environment aboard Skylab 3 and Skylab 4, experiments designed by, and carried out for, Professors Harry C. Gatos and August Wick, both of the Center for Materials Science and Engineering; and a new subject that studies the recurring phenomenon of failure in human systems.

The report of the Joint Center for Urban Studies setting United States housing goals at 23 million units by 1980; efforts by students in the Department of Aeronautics and Astronautics to construct a human powered airplane; studies in the Operations Research Center projecting the probability of murder in major metropolitan areas; student activities during M.I.T.'s unique Independent Activities Period (I.A.P.), including the resurgence of interest in ballroom dancing as evidenced by enrollment in an I.A.P. class; and efforts by a student group in the Department of Mechanical Engineering to construct -- during I.A.P. -- the world's largest yo-yo all were given national coverage. At the academic year's end, widespread news interest was given to President Jerome B. Wiesner's commencement address, "Freedom of Information."

Stories generated by the News Office, however, were not the only ones involving members of the M.I.T. community to appear in the news media. Studies on nuclear power reactor safety by Professor Norman C. Rasmussen of the Department of Nuclear Engineering, under a consultant agreement with the Atomic Energy Commission, and appearances by Professor Henry W. Kendall of the Department of Physics on behalf of the Union of Concerned Scientists, which drew attention to potential hazards with such reactors, were continuing stories in the news.

Other Offices

At year's end, considerable attention was given to a report on a National Academy of Sciences study, headed by Honorary Chairman of the Corporation James R. Killian, Jr., on mechanisms for providing science advice for the president of the United States.

These are by no means all the stories about M. I. T. that appeared in print around the nation. They represent only the highlights of an extraordinarily busy year for the M. I. T. News Office. Statistically, News Office operations reflected this unusual activity. During the year, the Office issued 467 press releases, compared with 304 during the previous year. Of these, 101 dealt with activities in the arts at M. I. T. Another 89 were major stories dealing with the substance of research at the Institute.

Tech Talk, the university newspaper issued by the News Office weekly for 50 weeks in each year, published 452 total pages during academic year 1973-74, compared with 416 in the previous year. Reports on Research resumed normal monthly frequency, as a four-page newsletter on research in progress at the Institute. M. I. T. Observer, a five-times-a-year collection of news clippings about M. I. T., appeared on schedule in five issues totaling 76 pages. Two supplements to Tech Talk also were published -- one the complete M. I. T. Affirmative Action Plan, and the other the full Report of the President and Chancellor. Finally, more than 1,000 individual news stories about students were sent to hometown newspapers during the year -- ranging from news about admission and graduation to news about participation in research projects.

Changes in senior staff were relatively minimal during the year. William T. Struble, Assistant Director of the News Office, assumed direct responsibility for (among other things) publicity having to do with art and music, areas which are burgeoning at M. I. T. At year's end, the News Office photojournalist, Assistant Director Margo Foote, resigned to return to nursing. Arrangements were completed for her to be replaced by Calvin Campbell, a 30-year veteran of news photography at the Boston Herald and Herald-Traveler. Also at year's end, Patricia Maroni was added to the professional staff as an assistant director, available for general assignment. She has had previous news-reporting and writing experience at the Providence Journal-Bulletin. Assistant Director Joanne Miller assumed responsibility for Tech Talk production, and Assistant Director Charles Ball assumed responsibility for publication of the M. I. T. Observer. Assistant Director Dennis Meredith, a specialist in science writing, continued to be a major contributor to Reports on Research, but during the year other staff members gradually began to contribute, giving the publication a broader base within the Office. Special attention should be given to the work of Assistant Director Robert Di Iorio in handling several major news events during the year, including an important conference on management during times of scarcity held in Chicago under the sponsorship of the Sloan School of Management, where details of the Project Independence study first were released.

While 1973-74 was marked by a high level of activity, the News Office fully expects that even greater demands will be placed upon it during the next few years. With careful planning and imaginative execution, it hopes to be able to meet those responsibilities in a professional and orderly manner.

Office of Design Services

The Office of Design Services completed 295 graphic design and publishing projects in 1973-74. In April, 1974, Nancy C. Pokross was appointed a full-time graphic designer; she is also a guest lecturer in graphic design at Simmons College. Ralph Coburn was a guest lecturer at the School of the Museum of Fine Arts, and was represented in an exhibition entitled "Color" which opened at the Whitney Museum in September, 1974.

M. I. T. graphic designs appeared in special articles in two international design periodicals, Communications Arts and NOVUM Gebrauchsgraphik. The work of this Office also has appeared

in an exhibition at the Ryder Gallery in Chicago, along with the work of the M. I. T. Press. An article on the exhibition will appear in an upcoming issue of the Swiss magazine GRAPHIS. The graphics also have appeared in other journals and in other exhibitions in Japan and the United States.

Jacqueline Casey, Director of the Office of Design Services, was appointed a design consultant to the National Endowment for the Arts, and was one of the planners of the Second Federal Design Assembly which took place in Washington, D. C. , during September 11-12, 1974. During the past year, Ms. Casey also served as a judge for the 1973-74 Washington, D. C. , Art Directors Show.

Campus Information Center

The Campus Information Center provides general information about the Institute and its current programs and activities to members of the M. I. T. community and to visitors to the campus. During the past academic year, the Center continued its extended services to the M. I. T. community and to visitors at large. It is now in the process of establishing a central clearinghouse for information on all meetings and seminars conducted at the Institute.

In September, 1973, the Student Guide Service was transferred from the Office of Admissions to the Information Center. The following are figures on the numbers of visitors and prospective students who visited the Center from September, 1973, through June, 1974.

Prospective Students and Visitors	5,541
Special Tours	461
Foreign Visitors on Special Tours	<u>173</u>
Total	6,175

Most visitors to campus expressed interest in seeing dormitories, laboratories and research facilities, and general views of the campus.

Registry of Guests

The group of foreign staff and faculty members on appointment at the Institute as of December, 1973, included nine Soviet citizens, for a total of 500 long-term visitors. Fifty-four countries were represented, with England contributing by far the greatest number of such visitors.

A considerable number of the nonimmigrant staff and faculty members have been seeking advice and assistance in adjusting their status to permanent residence in the United States. A major portion of the time of the director of the Registry has been devoted to this and to implementing the necessary documentation for appropriate petitions.

There were 515 short-term foreign visitors from 66 countries scheduled through the Registry; the largest proportion of these were from Japan. There were fewer large groups and fewer individuals taking tours than there had been in many years. The smaller overall number of short-term visitors in 1973-74 undoubtedly is due to the considerably reduced amount of United States dollars budgeted for the State Department to sponsor such visitors in full. Most of those who do come, since their support tends to come from their own country or their own pocket, have quite definite objectives and wish to have as full a program as possible during their visit to M. I. T.

Other Offices

Throughout the year, more time than usual was devoted to commencement matters. A series of meetings culminated in an Academic Calendar change for Commencement Day to Monday, June 2, 1975; further, a President's Reception was established in lieu of the previous formal luncheon following the exercises, and held May 31, 1974. The Reception appeared to be a great success.

As usual, the Registry worked to secure delegates to represent the Institute at academic celebrations at other institutions and to prepare suitable greetings; in general, however, the trend seems to be toward less formal and more "in-house" functions.

During the winter, the director of the Registry, Carolyn Cox, sustained a serious back injury, and it was only with the invaluable assistance of Ginger Lyons that the Registry was able to continue a smooth and efficient operation.

CONSTANTINE B. SIMONIDES

The M.I.T. Press

A total of 112 new books were published by the M.I.T. Press during the past year. This brings the number of titles issued under the Institute imprint, since the Press became an independent publishing organization in 1963, to a total of 1,180. The contribution to the advance of learning in a wide variety of fields made by the Press is incalculable. The financial impact of that advance as expressed in inventory write-down, debt write-off and reserve accumulation, interest to the Institute, and occupancy expense, is unfortunately quite calculable. This year's unaudited initial operating statement shows a deficit of \$1,005,000. Prior-year adjustments made some months ago as the result of rigorous audit raise the total deficit to \$1,156,000. Approximately \$866,000 of this year's deficit is attributable to the four areas noted above.

As a result of this experience, the direct operating expense (including staff salary expense) budgeted for fiscal year 1975 was reduced sharply to a level comparable to that shown by other presses at the income level anticipated. A general program of price increase was implemented. Plans were made for a major direct-mail book sale. Major personnel and policy changes were applied in other areas of Press operations, particularly financial management, where it is necessary to reduce accretions to accounts receivable and to increase the rate of cash recovery from existing accounts. Press activities have been reconceptualized radically in order to cut losses and increase income.

As is its practice, the Press during the past year published a significantly larger number of titles in the sciences, pure and applied, than any other university house. Over 1,100 manuscripts and manuscript proposals were reviewed during the year. A steady call was made upon specialist readers, many of them members of the Institute faculty, in processing these submissions. The accuracy of their counsel, and of the judgment of the acquisitions staff and the Editorial Board, is testified to by the year's review experience -- Press books earned an average of 50 reviews weekly, apart from listings and similar notices -- and by the quality of that notice: unfavorable reviewer comment was a rarity. Travelog, by Charles Harbutt, was awarded the internationally recognized Grand Prix of the Arles Festival. The design standard of the Press continued to lead the industry, and the M.I.T. representation in the American Institute of Graphic Arts Fifty Books competition was larger than that of any other publisher.

The annual book output reached the target level of 110 books. New submissions to the Editorial Board rose, though not yet sharply enough to maintain that level of output. It is true that rising thresholds of feasibility, editorial and financial, now rule out some projects which earlier might have been acceptable. Still, a new kind of editorial vigor -- which can be developed only over a period of time -- must be another aim for the future. It is currently present

in some disciplinary areas in which the Press has been active; it must be extended to others.

Net book sales for the year (after returns and allowances) were \$2,314,000. This amount was close to that which was budgeted, and approximately \$65,000 lower than the previous year. Total income from books and journals and other sources is expected to be about \$2,554,000, or about \$90,000 higher than budgeted. Returns of books were an exceptionally high 19.5 percent of net. (During the previous year, the average for all presses in the Press's income range was 13.4.) This, of course, influenced the decline in net. Salaries and wages, including benefits, were more than \$20,000 below the spring revision of the budget. It is expected that audit will show that other direct operating expenses (excluding interest, amortization, and bad debt expense) were about \$67,000 above budget in the book publishing program and about \$10,000 above budget in the journals publishing program. In the whole area of direct operating expense there was a variance of about \$55,000 over budget, according to figures now available, or about 3 percent of the budgeted figure. (Total income, however, was about 4 percent higher than budgeted.)

Inventory write-down (including books, sheets, and paper) is a major expense in itself, amounting to about \$371,000 (16.0 percent of net book sales, compared to the most recent industry figure of 12.8 percent for presses at a similar income level). In this difficult year the "bath" principle, in which all such capital expenses are concentrated within the year, is defensible, though it also should be noted that recent transitions in the marketing department might have justified extending that write-down over a longer period of time, to be sure that it was a reflection of reality and not of temporary circumstance. It is not necessarily the case that the books so written down will not generate future income for the Press (e. g. through the direct-mail sale), though in many cases it also should be recognized that the inventory levels and current rate of sales make further substantial distribution, by whatever method, unlikely. According to the terms of the Press's write-down policy, the titles so affected were published between July 1, 1968, and June 30, 1972. Most entered processing about a year in advance of actual publication, and many were contracted well prior to entering processing. This schedule provides some evidence of the extreme ponderousness of recovery from an excessive-inventory situation.

With regard to debt write-off, \$126,000 of accounts receivable was written off during the course of the year (in addition to \$64,000 the previous year). Further, the existing bad-debt reserve of \$115,000 was increased to about \$156,000 (or over 17 percent of the book value of domestic accounts receivable at the close of the year, which compares with an average reserve, according to the most recent industry figures, of under 6 percent).

Interest owed the Institute, which during one quarter of the year reached 10 percent, was nearly \$300,000.

The cost of the Press building consisted both of an amortization charge of a little over \$29,000, and interest on unamortized building cost of approximately \$20,000 (included in the interest charge recorded above).

In fiscal year 1972, the Press operated approximately on a break-even basis. What happened in the interval? Income did not rise to expectations (the year cited was that of the first direct-mail book sale), and operating expense exceeded what would have been proper, given that lower income level. The Press was unable to move enough existing inventory, even by the extraordinary means applied. It may have been that too much new inventory was created (though that thesis cannot be tested until write-down procedures take their effect). Also, too much credit was extended in order to encourage sales. To each of these circumstances the Press is making a vigorous response.

Acquisitions Department

This department brought before the Editorial Board 102 book proposals at 11 meetings of that body. Ninety-two of those projects were accepted for publication, two were declined, and eight were deferred for further consideration. Two-hundred fifty projects were reviewed by outside specialist readers during the year, and 850 were rejected without such outside referral.

The following table records the annual percentage of total titles published falling within certain broad disciplines.

<u>Year</u>	<u>Social Science</u>	<u>Humanities</u>	<u>Engineering</u>	<u>Science and Mathematics</u>	<u>Art and Architecture</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

It is noticeable that the proportion of the list located in the sciences and applied sciences (engineering) has fallen this year from that of the preceding year (from 46 to 33 percent), but it is also noticeable that during several recent years the percentage of the list devoted to those areas had been the highest in the history of the house.

Twenty-nine percent of the authors and editors of new books published during the year had some relationship to M. I. T.

Professors Charles P. Kindleberger, J. P. Ruina, and Edgar H. Schein completed their three-year terms of service on the nine-person Editorial Board, and to them the Press expresses its thanks for their generous counsel. Such thanks is particularly due the tenth person, the chairman of the Board, Dean Robert A. Alberty, who guided that body during a time of challenge with strong interest and unfailing humaneness.

Editorial Department

This department edited about 30,000 pages of text during the year. A large part of this work required sophisticated technical skills of a kind probably present in no other university house. Over 230 books were processed in some form during the year. As one step in the reduction of operating expense, approximately one-third of the editing activity was performed by free-lance editors under the supervision of the department.

Media Department

This department continued to labor under great weight, since it remains true that the M. I. T. Press processes more demanding text than any other university house. The range of Press publications stretches from the most complicated technical books to volumes in architecture that present strenuous visual challenges. In addition, the rising costs of manufacture and the necessity of reducing operating expenses have created further burdens upon the department.

A total of 19,000 pages of text were composed under the supervision of the department during the year; over 69,000 pages were printed. Including new books and reprints, about 900,000 copies were printed during the year and 850,000 copies bound. The department also produced

29 journal issues and a variety of marketing materials.

As of September 30, 1974, the department's strength will be reduced to 6.7 persons. In addition, the promising in-house manufacturing program, part of which made use of a minicomputer based electronic composition, editing, and formatting system, has been discontinued as an economy measure.

Marketing Department

This department moved during the year toward a distinct reorientation of objective and pattern of expense. Return on marketing investment over a period of time may be summarized as follows.

	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74
Total marketing expense	\$ 346,000	492,000	511,000	493,000	544,000	540,000
Net sales (books)	1,905,000	2,572,000	2,435,000	2,637,000	2,430,000	2,314,000
Volume of sales per dollar invested	5.51	5.23	4.77	5.35	4.47	4.29

It is clear that rising marketing expense has not produced a corresponding income benefit, and the budget for fiscal year 1975 reflects a substantially more conservative posture, though not one that allows the department lower funding than most departments in large university presses.

The percentage of marketing expense to net sales was 23.3 (compared to the previous year's 22.8). Next year's figure is anticipated to be a sharply lower 16.1, which is approximately the average proportion of expense for marketing recorded by other presses of M.I.T.'s size.

During the year of report, M.I.T. Press salesmen called on over 600 accounts, many of them four or more times. The direct-mail activity reached almost 250,000 bookbuyers and announced 48 titles. Over 100,000 copies of Press catalogues were distributed by mail and other means. There were 107 space advertisements placed by the Press; its books were exhibited at 34 scholarly and trade meetings cooperatively, and at 12 additional such meetings from its own booths. About 40 percent of the Press's income was earned from new books (published within the past 18 months); about 60 percent was earned from the backlist.

The London office of the Press, operated cooperatively with the University of Chicago Press and Harvard University Press, was responsible for sales during the year of over \$350,000. Further cooperative marketing activities, in direct sales and other areas, are likely to be necessary in order to maintain marketing effect while adhering to the new expense levels.

Financial Department

This department already has made important changes in the character of Press operations, and more are in prospect. More careful forecast, more accurate control, and more frequent reporting are needed. A systematic program of backlist price increases was implemented by the Press, and that action in itself has corrected the underpricing of the recent past. Furthermore, new book prices are being established according to the same revised standard. The financial department also has acquired responsibility for the supervision of the subcontracted shipping and warehousing operation.

Journals Department

This department, though its operating expenses were over budget by the amount indicated earlier, during the year earned resoundingly more than budgeted. Six journals are published by the Press at this time: Cell, The Journal of Interdisciplinary History, Linguistic Inquiry, Public Science, Studies in Applied Mathematics, and Visible Language. The direct-mail advertising program reached over 130,000 potential journal buyers during the year.

* * * * *

The Management Board, constituted as a body collateral to the Editorial Board, consists, in addition to its chairman, Vice President Constantine B. Simonides, of the chairman of the Editorial Board and the director of the Press (these serve ex officio); Vice President for Fiscal Relations Paul V. Cusick; two members of the faculty, Professors Michael S. Scott Morton and Michael L. Dertouzos; and two publishers, Jack Schulman, Director of the Cambridge University Press (America), and W. Bradford Wiley, Chairman of John Wiley & Sons, Inc.

During the year, the Management Board met in full session twice. In addition, its M.I.T. affiliated members met monthly from December through May, and the outside members visited the Press in July, 1974. The Institute is deeply grateful to these publishing professionals, for they have given freely of their time and judgment, without any call of institutional loyalty, in a time of persistent challenge to the whole idea of university publishing.

It may be useful to generalize about these challenges. First, they are usual, rather than exceptional among university presses, as the media have noted. Certainly the degree of challenge at M.I.T., as represented by the operating figures cited earlier, is unusual; however, it is also unusual for a university press never to have received direct subsidy (the effects of which are felt years after it is applied) and to be charged interest on its entire capitalization at a rate only slightly below prime. The very considerable momentum in Press operations in the direction of what might be called conspicuous trade publishing needed to be reversed, and that reversal necessarily took some time to accomplish.

A temptation exists to reach two conclusions, both of which must be scrutinized very carefully. The first is that the Press can operate as a scholarly publisher without exterior subsidy (by endowment, appropriation, or separate revenue-generating activity). The director of the Press holds that the special character of a university press makes this difficult. The second is that an emphasis on the applied sciences will assist financial recovery. Profound changes have taken place in the transmission of new information (distinguished from the kind of information that is in texts, for example) in applied sciences over the past several years, and conventional book publishing may no longer be the principal means of such transmission. Curtis Benjamin and others have noticed the decline in the size of the market for the monograph in specific scientific disciplines. On the other hand, the interface between the applied and pure sciences and other disciplines is an area of exciting activity (as the experience of the Press in linguistics and architecture has shown).

The ultimate prosperity of the Press, and probably of all other university publishing organizations, will depend on their ability to relocate themselves more centrally among the information transactions associated with higher education.

In reaching these conclusions, it is important to bear in mind that the books published during this past academic year and during all the years of the Press stand as monuments to those who chose, made, and sold them, and to M.I.T. and the kind of intellectual life that is possible within it.

HOWARD R. WEBBER

Principal Professional Honors and Activities of the Staff, 1972-73 and 1973-74

Institute Professors

ROMAN JAKOBSON

Corresponding Fellow, British Academy.

Honorary Member, Associazione Italiana di Studi Semiotica.

Honorary Member, Philological Society (London).

Honorary Member, Royal Anthropological Institute of Great Britain and Ireland.

Member, Honorary Council, Phonetic Society of Japan.

Vice-President, International Association for Semiotic Studies.

School of Architecture and Planning

Department of Architecture

ARTHUR D. BERNHARDT

Member, Governor's Advisory Committee on Mobile Homes.

Member, International Council for Building Research.

ALBERT DIETZ

Walter C. Voss Award, American Society for Testing and Materials.

NICHOLAS NEGROPONTE

American Federation of Information Processing Societies Award, 1973.

WILLIAM L. PORTER

Member, Education Committee, Association of Collegiate Schools of Architecture.

ROBERT PREUSSER

Coeditor, Leonardo.

JUDITH G. WECHSLER

Younger Humanists Fellowship, National Endowment for the Humanities, 1973.

Selected Fields Fellowship, National Endowment for the Humanities, 1974.

Department of Urban Studies and Planning

LEONARD BUCKLE

Everett Moore Baker Award for excellence in undergraduate education (corecipient).

SUZANN THOMAS BUCKLE

Everett Moore Baker Award for excellence in undergraduate education (corecipient).

Principal Professional Honors and Activities

KENT COLTON

Director, Housing Program Development, Boston Redevelopment Authority.
White House Fellow, 1974-75.

WILLIAM DAVIS

Finance Commission, City of Boston, 1973.
Mellon Fellowship in Humanities, Aspen Institute for Humanistic Studies.

JOSEPH FERREIRA

Class of 1922 Career Development Assistant Professorship, 1971-1974.

BERNARD FRIEDEN

Member, Editorial Advisory Board, Journal of the American Institute of Planners.

HUBERT JONES

Award for Distinguished Public Service, Boston University Alumni Association.
Director, Task Force on Children out of School.

RICHARD LARSON

Lanchester Prize, Operations Research Society of America, 1972.

KEVIN LYNCH

Allied Professions Medal, American Institute of Architects, 1974.

THOMAS NUTT

Member, Board of Governors, American Institute of Planners.

DONALD SCHON

Reith Lecturer in England, 1973-74.

IAN DONALD TERNER

Ford Foundation International Career Development Professorship.

School of Engineering

Department of Aeronautics and Astronautics

RICHARD H. BATTIN

Louis W. Hill Space Transportation Award, 1972 (corecipient).
Member, Astrodynamics Committee, Honors and Awards Committee, and Fellow Grade
Committee, of American Institute of Aeronautics and Astronautics.
Member, National Academy of Engineering.

JOHN F. MCCARTHY, JR.

Department of the Air Force Award for Meritorious Civilian Service.

THEODORE H. H. PIAN

Second Prize, von Karman Memorial Contest (corecipient).

PIN TONG

Second Prize, von Karman Memorial Contest (corecipient).

Principal Professional Honors and Activities

WALTER WRIGLEY

Chairman, Academy Advisory Council, United States Air Force.
Member, Board of Academic Visitors, New England Aeronautical Institute.
Chairman, Committee on Relativity and Space Travel, International Academy of Astronautics.
Chairman, First International Symposium on Effects of Relativity in Present Day Space Travel, International Academy of Astronautics, Baku, U.S.S.R., 1973.

LAURENCE R. YOUNG

Member, Bárány Society (Uppsala) for Vestibular Research.
Member, Space Biology and Medicine Committee, Space Sciences Board, National Academy of Sciences.

Department of Chemical Engineering

ROBERT A. ALBERTY

Chairman, Commission on Human Resources, National Research Council.

RAYMOND F. BADDOUR

Lammot du Pont Professorship.

CLARK K. COLTON

Teacher-Scholar Award, Camille and Henry Dreyfus Foundation.

LAWRENCE B. EVANS

Chairman, CACHE (Computer Aids for Chemical Engineering Education) Committee, National Academy of Engineering Commission on Education.
Co-chairman, Engineering Foundation Conference on Process Design, Operation, and Control for Safety and Reliability, held in Henniker, New Hampshire, 1974.

EDWARD W. MERRILL

Carbon P. Dubbs Professorship.
President, Board of Trustees, Buckingham School, 1972-73.
Chairman, Executive Committee, Buckingham Browne and Nichols School, 1973-74.

CHARLES N. SATTERFIELD

Member, Editorial Board, Advances in Chemistry.
Member, Sulfur Oxides Technology Forecast Panel, Environmental Protection Agency.

J. EDWARD VIVIAN

Fellow, American Institute of Chemical Engineers.

HAROLD C. WEBER

Certificate of appreciation, from the Secretary of the Army, for service as a member of the Army Scientific Advisory Panel since 1954.

Department of Civil Engineering

MICHAEL S. BARAM

Member, Committee on Biological Effects of Ionizing Radiation, National Academy of Sciences.
Member, Law and Science Committee, City of New York Bar Association.
Vice-Chairman and member, Executive Council, Environmental Law Committee, General Practice Section, American Bar Association.
Member, Professional Advisory Committee, Harvard Square Task Force.

Principal Professional Honors and Activities

RICHARD L. DENEUFVILLE
Guggenheim Fellowship, 1973-74.

ROBERT J. HANSEN
Moisseiff Award, American Society of Civil Engineers, 1974 (corecipient).

DONALD R. F. HARLEMAN
J. R. Freeman Lecturer, Boston Society of Civil Engineers.
J. C. Stevens Award, American Society of Civil Engineers.
Karl Hilgard Prize, American Society of Civil Engineers.
Member, National Academy of Engineering.
Member, Board of Editors, Journal of Hydraulic Research.
Member, U.S. National Committee, International Association on Water Pollution Research.

THOMAS G. HARMON
Moisseiff Award, American Society of Civil Engineers, 1974 (corecipient).

WILLIAM A. LITTLE
Moisseiff Award, American Society of Civil Engineers, 1973.

ROBERT D. LOGCHER
Moisseiff Award, American Society of Civil Engineers, 1974 (corecipient).

E. ALFRED PICARDI
Moisseiff Award, American Society of Civil Engineers, 1974 (corecipient).

JOSÉ M. ROESSET
Moisseiff Award, American Society of Civil Engineers, 1974 (corecipient).

Department of Electrical Engineering

DAVID ADLER
Fellow, American Physical Society.
Senior Member, American Vacuum Society.
Editorial Board, Journal of Nonmetals.
Member, Committee on Basic Research, Advisory to U.S. Army Research Office, National Research Council.
Member, Editorial Committee, Fifth International Conference on Amorphous and Liquid Semiconductors.
Cecil H. Green Professorship.

MICHAEL ATHANS
President, Control System Society, Institute of Electrical and Electronic Engineers, 1972-74.
Fellow, Institute of Electrical and Electronic Engineers, 1973.
Associate Editor, Automatica.
Technical Program Cochairman, Workshop on Stochastic Control and Economic Systems, National Bureau of Economic Research and the Governors of the Federal Reserve System, 1972, 1973, 1974.

JACK B. DENNIS
Fellow, Institute of Electrical and Electronic Engineers.

Principal Professional Honors and Activities

MILDRED S. DRESSELHAUS

Hunter College Hall of Fame Alumni Award.
Alumnae Medal, Radcliffe College.
Member, National Academy of Engineering.
Member, American Academy of Arts and Sciences.
Member, Directors of the Associated Harvard Alumni.

HAROLD E. EDGERTON

Distinguished Service Award, University of Nebraska, 1972.
NOGI Award, Underwater Society of America, 1973.
Holley Medal, American Society of Mechanical Engineers, 1973 (corecipient).
National Medal of Science, awarded by President Richard Nixon, 1973.

RICHARD H. FRAZIER

Member, Technical Advisory Council, Emerson Electric Co., St. Louis.

IRA GOLDSTEIN

Invited Lecturer, Advanced Study Institute on Computer Oriented Learning Processes,
North Atlantic Treaty Organization, 1974.
Invited Lecturer, Mathematics Colloquium, Rensselaer Polytechnic Institute.
Visiting Research Fellow, Edinburgh University, 1974.

ALAN GRODZINSKY

Member, Tau Beta Pi.
Member, Eta Kappa Nu.
Member, Sigma Xi.
Goodwin Medal for teaching, 1973.

TIMOTHY L. JOHNSON

Esther and Harold E. Edgerton Assistant Professorship.
Donald P. Eckman Award, American Automatic Control Council.
Editor, Control System Society Newsletter.

ALBERT R. MEYER

Invited Speaker, Preceptorial Introduction to Computer Science, American Mathematical
Society.
Invited Speaker, International Congress of Mathematicians, Vancouver, Canada.

ALAN V. OPPENHEIM

Guggenheim Fellowship, 1972-73.

VERA PLESS

Chairperson, W. I. S. E. (Women in Science and Engineering), 1972-74.

STEPHEN D. SENTURIA

Second prize, International Reclamation Competition, Reclamation Industries International
(corecipient).

DAVID C. WHITE

Member, U.S. Papers Committee, World Energy Conference.
Member, International Editorial Board, Energy Policy.
Chairman, Task Force on Technical Aspects, Technical Advisory Committee on Conser-
vation of Energy, Federal Power Commission.
Chairman, Energy: Demand, Conservation, and Institutional Problems Conference,
Cambridge, Massachusetts, 1973.

Department of Mechanical Engineering

STANLEY BACKER

Honorary Member, American Society for Testing and Materials.
Honorary Life Member, European Council of Textile Research Directors.
Honorary Fellow, The Textile Institute (British).
Special Information Systems Award, Textile Information Users Council.
Chairman, American Section, The Textile Institute, 1972.
Member, Advisory Board on Military Personnel Supplies, Division of Engineering,
National Research Council.

STEPHEN P. LOUTREL

Blackall Machine Tool and Gage Award, American Society of Mechanical Engineers.

ROBERT W. MANN

Uncas A. Whitaker Professor in Biomedical Engineering, 1974.
Member, National Academy of Engineering.
Fellow, American Academy of Arts and Sciences.
Member, Executive Committee on Rehabilitation Planning, Harvard Medical School.
Member, Dean's Committee for West Roxbury Veterans Administration Hospital, Harvard
Medical School.
Member, Committee on Science Policy, and Institute of Medicine Research Associate in
Orthopedic Surgery, Children's Hospital Medical Center.
Chairman, Committee on Prosthetic and Sensory Aids, Institute of Electrical and Electronic
Engineers.

HENRY M. PAYNTER

Robert Henry Thurston Lecturer, American Society of Mechanical Engineers, 1973.
Chairman, Advisory Committee to the Instruments and Controls Division, Oak Ridge
National Laboratory.

WARREN M. ROHSENOW

Max Jakob Memorial Award, American Society of Mechanical Engineers-American Insti-
tute of Chemical Engineers, 1972.

ASCHER H. SHAPIRO

Member, Panel of Reviewers, National Academy of Sciences, 1972-73.
National Academy of Sciences Representative, National Research Council, 1972-73.
Member, National Academy of Engineering.
Member, COSPUP (Committee on Science and Public Policy), National Academy of Sciences,
1973-74.

THOMAS B. SHERIDAN

President, Systems, Man, and Cybernetics Society, Institute of Electrical and Electronic
Engineers, 1973-74.

AIN A. SONIN

M. I. T. Graduate Student Council Award for Outstanding Graduate Teaching.

GIULIANA TESORO

President, Fiber Society, 1974.
Member, Ad Hoc Committee on Fire Safety Aspects of Polymeric Materials, National Ma-
terials Advisory Board, National Academy of Sciences.

TAU-YI TOONG

Member, Editorial Advisory Board, Combustion Science and Technology.
Member, Program Subcommittee, Fifteenth Symposium (International) on Combustion, Combustion Institute.

IOANNIS V. YANNAS

Invited Lecturer, Polymer Technology Section, IUPAC International Symposium on Macromolecules, Rio de Janeiro.
Invited Lecturer, Solid-state Properties of Polymers, American Chemical Society.
Visiting Professor, Federal University of Sao Paulo, Brazil.
Visiting Professor, Royal Institute of Technology, Stockholm.

Department of Metallurgy and Materials Science

BENJAMIN L. AVERBACH

Chairman, Electrical, Magnetic, and Optical Committee, American Society for Metals, 1973-74.
President, International Conference on Fracture, 1973-77.

WALTER A. BACKOFEN

Fellow, American Society for Metals.
Edward DeMille Campbell Lecturer, American Society for Metals.

ARDEN L. BEMENT

Member, Editorial Advisory Board, Journal of Nuclear Materials.
Member, Publications Committee, American Society of Testing and Materials.
Team Chairman, U.S. -U.S.S.R. Cooperative Scientific Exchange on MHD Power Generation.
Cochairman, U.S. -Japan Scientific Exchange on Radiation Effects in Metals.

H. KENT BOWEN

Member, U.S. -U.S.S.R. Cooperative Scientific Exchange on MHD Power Generation.
Member, Task Force on MHD, Office of Coal Research.
Editor, Ceramic Education Council Review Papers.

JOHN W. CAHN

Member, National Academy of Sciences.
Participant, International Discussion Meeting on Studies of Lattice Distortions and Local Atomic Arrangements by X-ray, Neutron, and Electron Diffraction, Kernforschungsanlage Julich, Germany.

JOHN CHIPMAN

Honorary Membership, American Institute of Mining, Metallurgical, and Petroleum Engineers.
The Mineral Industry Education Award, American Institute of Mining, Metallurgical, and Petroleum Engineers.
Honorary Doctorate, University of Michigan.
The Gold Medal, The Japan Institute of Metals, 1973.

ROBERT L. COBLE

Ross Coffin Purdy Award, American Ceramics Society.
Member, Federal Materials Research Council.
Visiting Professor, Japanese Society for the Promotion of Science, lecturing at University of Tokyo and Tokyo Institute of Technology, 1973-74.

Principal Professional Honors and Activities

MORRIS COHEN

Member, Steering Committee, Joint National Academy of Sciences - National Academy of Engineering Meeting on Materials Policy.

Member, Report Review Committee, National Academy of Sciences.

Chairman, Committee on the Survey of Materials Science and Engineering (COSMAT), National Academy of Sciences.

Member, National Academy of Engineering.

Fellow, American Society for Metals.

Member, Advisory Panel, Institute of Materials Science, National Bureau of Standards.

Member, Council of Materials Science Division, American Society for Metals.

Member, Education Committee, The Metallurgical Society.

Member, Distinguished Lecture Committee, American Society for Metals - The Metallurgical Society.

Member, International Committee on the Strength of Metals and Alloys.

Member, Editorial Advisory Board, Journal of Materials Science and Engineering.

Distinguished Lecturer, University of Connecticut, 1973.

Visiting Scholar, Virginia Polytechnic Institute and State University, 1973.

JOHN F. ELLIOTT

Charles W. Briggs Award, Electric Furnace Committee, American Institute of Mining, Metallurgical, and Petroleum Engineers.

John Chipman Award, Process Technology Committee, American Institute of Mining, Metallurgical, and Petroleum Engineers.

Yakawa Memorial Lecturer, Iron and Steel Institute of Japan.

Honorary Member, Iron and Steel Institute of Japan.

Visiting Professor, Japanese Society for the Promotion of Science, lecturing at Tohoku University.

MERTON C. FLEMINGS

Howe Memorial Lecturer, American Institute of Mining, Metallurgical, and Petroleum Engineers, 1974.

American Exchange Lecturer, International Foundry Congress, Moscow.

Member, U.S. -U.S.S.R. Technical Exchange Commission, Moscow, 1973-74.

Member, M. I. T. -Iranian team on cooperation in technical education.

Henry Marion Howe Medal, American Society for Metals, 1973.

Chairman, Advisory Committee of ARPA sponsored joint industry-university steel casting program, 1973.

Chairman, Committee on Electro-Slag Remelting and Plasma Arc Melting, National Advisory Board.

Chairman, Subcommittee on Electro-Slag Remelting, U.S. -U.S.S.R. Technology Exchange Agreement.

HARRY C. GATOS

Member, Ad Hoc Subcommittee for the Review of Investigations on the Apollo-Soyuz Test Program Mission.

Member, Visiting Committee, Materials Research Laboratory, Pennsylvania State University.

Chairman, Evaluation Panel, Office of Standard Reference Data, National Bureau of Standards.

Member, National Materials Advisory Board, Division of Engineering, National Academy of Sciences.

Member, Numerical Data Advisory Board, National Academy of Sciences.

Member, Executive Committee of the Academy Panels, National Academy of Sciences.

Chairman, Palladium Medal Award Subcommittee, and Member, Honors and Awards Committee, Electrochemical Society.

Principal Professional Honors and Activities

NICHOLAS J. GRANT

Member, Research Advisory Committee, National Aeronautics and Space Administration.
Chairman, Directors Group, Materials Research Laboratory, National Science Foundation.

KEITH H. JOHNSON

Award of the International Academy of Quantum Molecular Science, 1973.

ROY KAPLOW

Member, Advisory Board, Northeastern Academic Science Information Center, New England Board of Higher Education.

THOMAS B. KING

Member, Physical Chemistry Committee, The Metallurgical Society, American Institute of Mining, Metallurgical, and Petroleum Engineers.

WILLIAM D. KINGERY

First Distinguished Sosman Lecturer, American Ceramic Society.

WALTER S. OWEN

Robert S. Williams Lecturer.

Sauveur Memorial Lecturer, Philadelphia Chapter, American Society for Metals.

Member, Board of Trustees, Acta Metallurgica.

ROBERT M. ROSE

Kappa Delta Award, American Academy of Orthopedic Surgeons, 1973.

Chairman, Boston Chapter, American Society for Metals, 1972-73.

CYRIL STANLEY SMITH

Honorary Member, American Society for Metals.

Honorary Member, Indian Institute of Metals.

Honorary Doctorate, University of Pennsylvania.

Member, Council of Smithsonian Institute.

University lecturer, University of London, 1974.

AUGUST F. WITT

Member, Advisory Committee for Materials Research, National Aeronautics and Space Administration.

BERNHARDT J. WUENSCH

Fellow, American Ceramic Society.

Fellow, Mineralogical Society of America.

Visiting Professor, The University of the Saarland, Germany.

Department of Nuclear Engineering

ARDEN L. BEMENT

Fellow, American Nuclear Society.

Member, Advisory Committee to Mexican Institute of Nuclear Energy, International Atomic Energy Agency.

MANSON BENEDICT

Enrico Fermi Award, U. S. Atomic Energy Commission.

Member, Energy Research and Development Advisory Council, Federal Energy Administration and Office of the Management of the Budget.

Principal Professional Honors and Activities

CHARLES V. BERNEY

National Academy of Sciences - National Research Council Senior Research Associate,
Rocket Propulsion Laboratory, Edwards Air Force Base.
Member, Summer Institute on Neutron and X-ray Diffraction and Related Techniques in
Chemical and Biological Problems, U. S. Atomic Energy Commission.

SOW-HSIN CHEN

Advisor, National Science Council and National Tsing-Hua University, Republic of China.

LINCOLN CLARK, JR.

Vice-Chairman, Northeastern Section, American Nuclear Society, 1972-73.
Chairman, Northeastern Section, American Nuclear Society, 1973-74.

MICHAEL J. DRISCOLL

Member, Executive Committee, Reactor Physics Division, American Nuclear Society.

MICHAEL W. GOLAY

Arthur D. Little Professor of Environmental Sciences and Engineering.

ELIAS P. GYFTOPOULOS

Chairman, M. I. T. Faculty, 1973-74.

KENT F. HANSEN

Fellow, American Nuclear Society.
Member, Board of Directors, American Nuclear Society.

ALLAN F. HENRY

Member, Advisory Committee on Reactor Physics, U. S. Atomic Energy Commission.

EDWARD A. MASON

Member, Board of Directors, American Nuclear Society.
Member, Advisory Committee on Reactor Safeguards, U. S. Atomic Energy Commission,
1972.
Vice-Chairman, Advisory Committee on Reactor Safeguards, U. S. Atomic Energy Com-
mission, 1973.

NORMAN C. RASMUSSEN

Director, Special Study on Reactor Safety, U. S. Atomic Energy Commission.

DAVID J. ROSE

Cochairman, Culham International Workshop on Fusion Reactor Design.

SIDNEY YIP

Guggenheim Fellow, 1972-73.
Advisor, National Science Council and National Tsing-Hua University, Republic of China.
Invited Lecturer, Enrico Fermi Summer School, Varenna, Italy, 1974.

Department of Ocean Engineering

CHRYSSOSTOMOS CHRYSSOSTOMIDIS

Member, Advisory Group I, Ship Response and Load Criteria, National Academy of
Engineering.

Principal Professional Honors and Activities

JOSEPH G. DEBANNE

First Prize, Annual Institute of Management Sciences Competition.
Consultant, Office of Systems Integration and Analysis, National Science Foundation.

IRA DYER

Member, National Academy of Engineering.
Member, Non-Acoustics ASW Sensors Committee, National Academy of Engineering.
Chairman, Sea Floor Engineering Committee, National Academy of Engineering.
Member, Board of Visitors, Maine Maritime Academy.
Member, Science Advisory Committee, United States Coast Guard.
Vice President, Acoustical Society of America, 1972-73.

J. HARVEY EVANS

Member, Council of the Society of Naval Architects and Marine Engineers.

E. G. FRANKEL

Member, Special Advisory Committee to the Dean of Engineering, U.S. Merchant Marine Academy.
Visiting Professor, Tel Aviv University, Israel.

DEAN A. HORN

Member, Panel on Marine Engineering Information and Data Exchange, Marine Board, National Academy of Engineering.
Member, Special Legislative Commission on Marine Boundaries and Resources.

ALFRED H. KEIL

Chairman, Marine Board, National Academy of Engineering.
Member, Assembly of Engineering Executive Committee, National Research Council.
Member, Johnson-Sea-Link Expert Panel Review, Smithsonian Institute.
Member, Committee on Public Engineering Policy, National Academy of Engineering.
Meritorious Public Service Award, U.S. Coast Guard.

JUDITH T. KILDOW

Member, Massachusetts State Task Force on Coastal Resources.
Lilly Fellowship.

J. B. LASSITER

Member, National Gas Survey Panel, Federal Power Commission.
Member, Ocean Shipping Technology Forecast and Assessment Advisory Committee, Maritime Administration.

P. MANDEL

Member, Naval Ship Systems Command.
Member, Catamaran Seakindliness Committee.
Member, Advisory Committee on Reactor Safety, Atomic Energy Commission.

ALAA MANSOUR

Member, Sea Floor Engineering Committee, National Academy of Engineering.
Member, Advisory Group II, Ship Research Committee, National Academy of Sciences.
Visiting Professor, University of Sao Paulo, Brazil, 1973.

HENRY S. MARCUS

Member, Ocean Shipping Technology Forecast and Assessment Advisory Committee, Maritime Administration.

Principal Professional Honors and Activities

KOICHI MASUBUCHI

Advisor, Marine Facilities Panel, U.S. - Japan Conference on Natural Resources.
Member, Committee III, Fabrication Factors Affecting Structural Capability, International Ship Structures Congress.
Member, Committee on Underwater Electrical Safety Practices, National Academy of Engineering.
Adams Memorial Membership Award, American Welding Society.

J.H. MILGRAM

Member, Buoy Technology Panel, National Academy of Engineering.

JOHN NICHOLAS NEWMAN

Member, Buoy Technology Panel, National Academy of Engineering.
Fellowship, Australian-American Educational Foundation and John Simon Guggenheim Foundation.
Visiting Professor, University of New South Wales, University of Adelaide, and the University of Melbourne, 1973-74.

School of Humanities and Social Science

Department of Economics

FRANKLIN M. FISHER

Editor, Econometrica.
John Bates Clark Award, American Economic Association, 1973.

ROBERT E. HALL

Associate Editor, Econometrica.
Associate Editor, Journal of Econometrics.
Member, Board of Editors, American Economic Review.
Member, Advisory Panel for Economics, National Science Foundation.
Member and Senior Advisor to Brookings Panel on Economic Activity.

PAUL A. SAMUELSON

Honorary Doctorates, Gustavus Adolphus College, Harvard University, Northern Michigan University, University of Massachusetts, and University of Rhode Island.

Department of Foreign Literatures and Linguistics

MARTIN DYCK

Member, Editorial Board, Historia Mathematica.

MORRIS HALLE

Vice President, Linguistic Society of America, 1973.
President, Linguistic Society of America, 1974.

KRYSTYNA POMORSKA

Honorary Guest, opening of the exhibition "Bizanzio e Venezia," Venice.
Invited guest, International Congress of Semiotics, Milan.

Principal Professional Honors and Activities

MARCIA G. WILLIAMS

Old Dominion Fellowship for research in medieval French literature.

Department of Humanities

ELZBIETA CHODAKOWSKA

Senior Fellow, Radcliffe Institute, 1972-74.

PATRICIA CUMMING

Borestone Mountain Award, 1973.

PETER S. DONALDSON

Old Dominion Fellowship.

Younger Humanist Fellowship, National Endowment for the Humanities.

DAVID M. EPSTEIN

Ford Foundation Recording Grant.

American Society of Composers, Authors, and Publishers Awards, 1972, 1973, 1974.

Visiting Professor of Music, Eastman School of Music, 1973.

Guest Conductor, Symphonieorchester des Bayerischer Rundfunk, Munich, 1973.

Guest Conductor, Wiener Tonkünstlerorchester, Vienna, 1973.

HAROLD J. HANHAM

Member, American Academy of Arts and Sciences.

W. E. Collins lecturer, Victoria University of Wellington, New Zealand.

ROBERT RATHBONE

Visiting Lecturer, University of Wales Institute of Science and Technology, Cardiff.

KENNETH SKIER

Eloranta Research Fellowship.

Member, M.I.T. Xi chapter, Phi Beta Kappa.

NATHAN SIVIN

Advisory Editor, Technology and Culture.

Member, Steering Committee, Second International Congress on Taoism, Japan.

Alternate Delegate of National Academy of Sciences-National Research Council, to Fourteenth General Assembly of the Division of the History of Science, International Union of the History and Philosophy of Science.

Member, Committee on Undergraduate Education, History of Science Society.

Member, Committee on the History of Recent Science and Technology, American Academy of Arts and Sciences.

BARRY SPACKS

Judge, Brandeis Creative Arts Awards, 1974.

Department of Political Science

HAROLD R. ISAACS

Fellow, American Academy of Arts and Sciences.

Fellowship, Japan Society Intellectual Interchange.

HARVEY M. SAPOLSKY

Secretary, Section on Economics and Social Sciences, American Association for the Advancement of Science.

EUGENE B. SKOLNIKOFF

Member, International Commission for Science Policy Studies.
Fellow, American Academy of Arts and Sciences.

Alfred P. Sloan School of Management

JAY W. FORRESTER

Honorary Doctorates, University of Notre Dame and Union College, Schenectady, New York.

Engineering Society of New England Award.

Award for Outstanding Accomplishment, Systems, Man, and Cybernetics Society, Institute of Electrical and Electronic Engineers, 1972.

Medal of Honor, Institute of Electrical and Electronic Engineers, 1972.

Benjamin Franklin Fellowship, Royal Society of Arts (London).

PETER P. GIL

Member, Advisory Board, European Management Forum, Davos/Geneva, Switzerland.
Visiting Professor, University of Cape Town, South Africa.

PAUL W. MACAVOY

Henry R. Luce Professorship of Public Policy, 1974-78.

Member, Board of Economic Advisors, Federal Energy Office.

Consultant to the Minister of Finance of Indonesia.

Editor-in-chief, Bell Journal of Economics and Management Science.

Senior Fellow, Brookings Institution.

Member, Rockefeller Council.

Senior Member, Energy Laboratory Policy Study Group.

CHARLES A. MYERS

Chairman, National Manpower Policy Task Force.

WILLIAM F. POUNDS

Distinguished Alumni Award, Carnegie-Mellon University, 1974.

Member, American Academy of Arts and Sciences.

ALVIN J. SILK

Chairman, College on Marketing, The Institute for Management Sciences.

Publication Liaison Officer, Business and Economics Statistical Section, American Statistical Association.

Associate Editor, Management Science.

Member, Editorial Board, Journal of Marketing Research.

School of Science

Department of Biology

DAVID BALTIMORE

United States Steel Foundation Award in Molecular Biology, National Academy of Sciences, 1974.

Member, National Academy of Sciences.

Member, American Academy of Arts and Sciences.

Member, Cancer Research Cancer Review Committee, National Institutes of Health.

Member, Cancer Special Program Advisory Committee, National Institutes of Health.

Principal Professional Honors and Activities

HAR GOBIND KHORANA

Member, U.S.S.R. Academy of Sciences.
First Acharya Jagadish Chandra Bose Memorial Award, Bose Institute, Calcutta, 1972.
Honorary Doctorate, University of Delhi.
Honorary Fellow, Council of the Indian Chemical Society.
Willard Gibbs Medal Award, 1974.
Andrew D. White Professor-at-large, Cornell University, 1974.

HARVEY LODISH

Advisory Panel in Developmental Biology, National Science Foundation.
Invited lecturer, Ninth International Congress of Biochemistry, Stockholm.
Invited lecturer, Third Linderstrøm-Lang meeting, Helsinki.

ALEXANDER RICH

Invited Guest, Academia Sinica, People's Republic of China.
Sedgwick Professor of Biophysics.
Skylab Achievement Award, National Aeronautics and Space Administration.

FRANCIS O. SCHMITT

The Francis O. Schmitt Lectureship was established in 1973.

IRWIN W. SIZER

Director, Health Sciences Fund.
Director, Biological Sciences Curriculum Study, Inc.

LISA A. STEINER

Member, Editorial Board, Immunochemistry.
Member, Editorial Board, Journal of Immunology.
Chairman, Committee on the Status of Women, American Association of Immunologists.
Member, Nominating Committee, Biophysical Society.
Member, Program Committee, American Association of Immunologists.
Member, Allergy and Immunology Study Section, National Institutes of Health.
Member, Biochemistry Training Committee, National Institutes of Health.

CLAIR E. TURNER

Ira V. Hiscock Medal, New England Public Health Association, 1973.
First Parisot Medal, International Union for Health Education, Paris, France, 1973.

Department of Chemistry

KLAUS BIEMANN

Justin L. Powers Award, American Academy of Pharmaceutical Sciences.

DAVID N. HUME

Outstanding Achievement Award, University of Minnesota.
Silver Medal, University of Helsinki.

DIETMAR SEYFERTH

Visiting Professor, Memorial University, St. John's, Newfoundland.
Frederic Stanley Kipping Award in Organosilicon Chemistry, American Chemical Society, 1972.
Chairman, Gordon Research Conference on Organometallic Chemistry, 1974.

JEFFREY I. STEINFELD

John Simon Guggenheim Memorial Foundation Fellow, 1972-73.
Member, Editorial Board, Chemistry and Lasers.
Member, Chemical Physics Panel, Committee on Basic Research, National Academy of Sciences-National Research Council.
Member, Scientific Review Panel, U.S. -Israel Binational Science Foundation.
Vice-Chairman, First Conference on Electronic Transition Lasers.

JOHN S. WAUGH

Arthur Amos Noyes Professorship.
Member, National Academy of Sciences.

Department of Earth and Planetary Sciences

WILLIAM F. BRACE

Rock Mechanics Award, American Institute of Mining, Metallurgical, and Petroleum Engineers.

GORDON H. PETTENGILL

Member, American Academy of Arts and Sciences.
Principal Investigator, Wind Speeds on Venus Experiment, NASA Pioneer-Venus 1978 Probe Mission.
Member, Committee on Planetary and Lunar Exploration, Space Science Board.

FRANK PRESS

Arthur L. Day Medal, Geological Society of America.
Honorary Membership, Society of Exploration Geophysicists.
Honorary Doctorates, University of Notre Dame and University of the City of New York.
Distinguished Public Service Medal, National Aeronautics and Space Administration.
President, American Geophysical Union, 1974.

IRWIN I. SHAPIRO

Fairchild Distinguished Scholar, California Institute of Technology, 1974.
Member, National Academy of Sciences.

M. NAFI TOKSÖZ

President-Elect, Section on Planetology, American Geophysical Union.

Department of Mathematics

MICHAEL L. FREDMAN

Member, American Mathematical Society.
Member, Mathematical Association of America.
Member, Sigma Xi.

SIGURDUR HELGASON

Member, The Royal Danish Academy of Sciences.

JEFFREY E. MANDULA

Alfred P. Sloan Research Fellowship.
Invited Lecturer, Seventeenth International Conference on High Energy Physics.

Principal Professional Honors and Activities

ARTHUR MATTUCK

Class of 1922 Professorship.

JULIAN I. PALMORE III

Lilly Fellowship, 1974-75.

Bernard Friedman Prize, University of California at Berkeley, 1973.

FRANKLIN P. PETERSON

Member, American Academy of Arts and Sciences.

Treasurer, American Mathematical Society, 1973.

Department of Meteorology

JULE G. CHARNEY

President, Meteorology Section, American Geophysical Union, 1972.

Overseas Fellow, Churchill College, Cambridge, England.

Guggenheim Fellowship, Cambridge University, England, and Weizmann Institute of Science, Israel.

Symons Lecturer, Royal Meteorological Society.

Von Neumann Lecturer, Society for Industrial and Applied Mathematics.

NORMAN A. PHILLIPS

Karl-Gustav Rossby Research Medal, American Meteorological Society.

Department of Nutrition and Food Science

NICHOLAS CATSIMPOOLAS

Organizer and General Chairman, American Chemical Society Symposium, Atlantic City, New Jersey, 1974.

CHARLES S. DAVIDSON

William Bosworth Castle Professor of Medicine, Harvard University.

Mastership, American College of Physicians.

NEVIN S. SCRIMSHAW

First James R. Killian, Jr. Faculty Achievement Award.

Honorary Doctorate, University of Rochester.

RICHARD J. WURTMAN

Member, Editorial Board, Circulation Research.

Member, Editorial Board, Life Sciences.

Member, Editorial Board, Journal of Neurochemistry.

Member, Preclinical Psychopharmacology Study Section, National Institute of Mental Health.

Member, Research Advisory Board, Parkinson's Disease Foundation.

Member, Committee on Phototherapy in the Newborn, National Research Council, National Academy of Sciences.

Oppenheimer Prize, Endocrine Society, 1973.

Foster Elting Bennett Lecturer, American Neurological Association, 1974.

Principal Professional Honors and Activities

Department of Physics

SANBORN C. BROWN

Vice Chairman, U. S. National Committee, International Union of Pure and Applied Physics.
Chairman, Plasma Commission, International Union of Pure and Applied Physics.
Chairman, Committee on the History of American Scientific Societies, American Academy of Arts and Sciences.
Chairman, Governor's Task Force on Future of Hanscom Field.

ROBLEY D. EVANS

President and Chairman, Board of Directors, Health Physics Society.
Past President, Member of the Board of Directors, and Chairman of the Awards Committee, Health Physics Society.

MICHAEL S. FELD

Sloan Fellowship, 1973.

VERA KISTIAKOWSKY

Bicentennial Award, Mount Holyoke College Alumnae Association.
Member, Executive Committee, National Accelerator Laboratory User's Organization.
Member, Physics Panel on National Science Foundation Fellowships, National Research Council.
Member, Panel on Churchill Foundation Fellowships, National Research Council.
Member, Council of the American Physical Society.
Member, Budget Committee, American Physical Society.

MARGARET L. A. MACVICAR

Member, Board of Directors, Oral Education Center of Southern California.
Trustee, Carnegie Foundation for the Advancement of Teaching.
Member, Technical Advisory Committee, Sprague Electric Company.
Member, Editorial Review Board, Review of Scientific Instruments.
Secretary-Treasurer, New England Chapter, American Vacuum Society.
Member, National Committee on Science in the Promotion of Human Welfare, American Academy of Arts and Sciences.
Invited Faculty, Danforth Foundation Workshop on Liberal Arts Education.
Member, Board of Directors, Shared Experiences, Inc.
Class of 1922 Career Development Award.
Member, Danforth Foundation Associate Program.

IRWIN PLESS

Member, Physics Advisory Committee, Oak Ridge National Laboratory.

Administration

W. GERALD AUSTEN, M. D.

President, Society of University Surgeons.
President, Massachusetts Heart Association.
Edward D. Churchill Professor of Surgery, Harvard Medical School.
Member, American Academy of Arts and Sciences.
Member, Institute of Medicine, National Academy of Sciences.

Principal Professional Honors and Activities

ROBERT V. DODD
National Director, National Association of Accountants

JAMES J. FANDEL
Chairman, Eastern Region, College and University Personnel Association.

VINCENT A. FULMER
Trustee, Suffolk University.
Trustee, The Nutrition Foundation.
Trustee, Carroll Rehabilitation Center For the Visually Impaired.
Member, Board of Directors, Institute of Social Technology, Puerto Rico.
Trustee, Planning Office for Urban Affairs, Inc., Archdiocese of Boston.
Member, Financial Development Advisory Board, National Urban Coalition.

WILLIAM J. HECHT
Member, Massachusetts State Science Fair Committee, 1972-73.
Chairman, Massachusetts State Science Fair Committee, 1973-74.

WALTER L. KOLTUN
Chairman, Education Committee, Biophysical Society.
Vice President, Boston Center for Adult Education, 1973-74.

THADDEUS W. KOWILCIK
Order of the Brick, The Contractors Association of Boston, Inc.

DOROTHY R. LATSEY
President, Massachusetts Association of Nonprofit Schools and Colleges, 1973-74.

REV. CONSTANCE F. PARVEY
Delegate, World Council of Churches, Berlin.
Alexis de Tocqueville Prize.

WALTER A. ROSENBLITH
Chairman, Scientific Advisory Council, Callier Hearing and Speech Center.
Member, Council-Executive Committee, Institute of Medicine, National Academy of Sciences.
Member, Board of Governors, Weizmann Institute of Science.

JULIUS A. STRATTON
Honorary Doctorate, Cambridge University, England.
Member, National Advisory Committee on Oceans and Atmosphere.

Libraries

LAURA M. CARCHIA
Member, Committee of University Industrial Relations Librarians.

JACQUELINE Z. COLBY
President, New England Technical Services Librarians.

EDGAR W. DAVY
Advisor, Korea Development Institute.

Principal Professional Honors and Activities

FRANCES R. L. NEEDLEMAN

Member, Committee on Computer Filing, American Library Association.
Member, Nominating Committee of the Resources and Technical Services Division,
Nominating Committee of the Cataloging and Classification Section, and the Descriptive
Cataloging Committee, American Library Association.

NATALIE N. NICHOLSON

Member, Standards and Accreditation Committee, Association of College and Research
Libraries.
Member, Urban Universities Library Committee, American Library Association.

MARGARET A. OTTO

Fellowship, Council on Library Resources.
Chairman, Boston Chapter Scientific/Technical Committee, Special Libraries Association.
Member, Committee on Public Relations to Libraries, Library Administration Division,
American Library Association.

PETER R. SCOTT

Chairman, Committee PH5-2, Microfiche and Micro-Opaques, and Member, Committee
PH5, Documentary Reproduction, and Committee PH5-1, Microtransparencies, American
National Standards Institute.
Chairman, Information Retrieval Committee, and Member, Company of Fellows, Microfiche
Committee, and Library Relations Committee, National Microfilm Association.

LINDA I. SOLOW

Program Chairman, Music Library Association.

ANNE REUTER

President, Library Staff Association, M. I. T.

LENIS H. WILLIAMS

Vice Chairperson, New England Chapter, Art Libraries Society/North America.

Medical Department

ALFRED J. R. LOUMANS, M. D.

Fellow, American Psychiatric Association.

HENRY BROWN, M. D.

Visiting Professor, National University, Tegucigalpa, Honduras.
Visiting Consultant in Hand Surgery, Ganta Leprosarium, Hospital, and Rehabilitation
Center, Ganta, Liberia.

BARBARA L. O'PRAY, M. D.

Member, Committee on Drug Abuse and Sex Education, Cambridge School System.

ROBERT F. TILLEY, M. D.

President, Norfolk District Medical Society.
Assistant Secretary Treasurer, Massachusetts Medical Society.
Chairman, Membership Committee, American Academy of Dermatology.

Other Offices, Centers, and Laboratories

J. HERBERT HOLLOMON

Member, Committee on Transportation, Committee on Membership Panel on Nomination, and Energy Task Force, National Academy of Engineering.

Member, Committee on Industry, Technology, and Society, and Subcommittee on Federal Civilian Technology, American Academy of Arts and Sciences.

Member, Business Advisory Council on National Priorities, National Planning Association.

GYORGY KEPES

Fellow, American Academy of Arts and Sciences.

First Prize, Biennial Coltejer III, Medellin, Colombia, 1972.

JOHN I. MATTILL

Member, Corporation, Editorial Projects for Education.

Stewart Award, American Alumni Council (to Technology Review), 1974.

MARGARET SAND

Member, Boston 200 Task Force on Child Care.

President, Cambridge Local Council for Children.

BRUCE D. WEDLOCK

Chairman, Boston Section, Institute of Electrical and Electronic Engineers.

Lincoln Laboratory

FRANK J. BACHNER

Member, Steering Committee, Combined New England Chapter, American Vacuum Society.

THEODORE BIALLY

Senior Award, Audio and Electroacoustics Group, Institute of Electrical and Electronic Engineers (corecipient).

GRACE E. BROCIENER

Chairman, Special Committee on Translations, Special Libraries Association.

JACK CAPON

Member, Board of Governors, Information Theory Group, Institute of Electrical and Electronic Engineers.

Associate Editor, Transactions on Information Theory, Institute of Electrical and Electronic Engineers.

MICHAEL A. CHINNERY

Chairman, Eastern Section, and Member, Nominations Committee, Seismological Society of America.

Associate Editor, Geophysical Research Letters.

THEODORE F. CLOUGH

Member, Subcommittee on Beam Lead Bonding, Institute of Electrical and Electronic Engineers.

Member, Computer Society Committee on Packaging, Institute of Electrical and Electronic Engineers.

Principal Professional Honors and Activities

ROBERT K. CRANE

Associate Editor, Transactions on Antennas and Propagation.

MARCUS S. EDELSTEIN

Member, Sigma Xi.

JOHN V. EVANS

Vice Chairman, U. S. National Committee, International Union of Radio Science.

JOHN R. FILSON

Editor, Geophysical Journal.

JAMES W. FORGIE

Fellow, Acoustical Society of America.

THOMAS J. GOBLICK, JR.

Secretary-Treasurer, Boston Section, Information Theory Group, Institute of Electrical and Electronic Engineers, 1972-73.

Chairman, Boston Section, Information Theory Group, Institute of Electrical and Electronic Engineers, 1973-74.

IRVING GOLDBERG

Member, Board of Directors, National Property Management Association.

JOHN B. GOODENOUGH

Member, Ad Hoc Committee on High-Pressure Technology, and Solid-State Science Panel, National Research Council.

Consultant to Advisory Panel, Materials Research Laboratories, National Science Foundation.

LEONARD M. GOODMAN

Chairman, Boston Section, Computer Society, and Member, Executive Committee, Boston Section, Institute of Electrical and Electronic Engineers.

EDWARD G. GOULART

Member, Board of Directors, American Society for Industrial Security.

MARY A. GRANESE

Member, Board of Directors, Boston Chapter, Special Libraries Association.

ELIS A. GUDITZ

Secretary, Parts, Hybrids, and Packaging Group, Institute of Electrical and Electronic Engineers.

THEODORE C. HARMAN

Editor, Journal of Electronic Materials.

HAROLD L. KASNITZ

Member, Governing Board, Society of Photo-Optical Instrumentation Engineers.

RICHARD T. LACOSS

Secretary-Treasurer, Geoscience Electronics Group, Institute of Electrical and Electronic Engineers.

Associate Technical Editor, Transactions on Geoscience Electronics.

Principal Professional Honors and Activities

THOMAS E. LANDERS
Editor, Earthquake Notes.

DAVID M. LARSEN
Senior Visiting Fellow, British Science Research Council.

J. J. GERALD MCCUE
Member, Editorial Board, Proceedings of the Institute of Electrical and Electronic Engineers.

NORMAN MENYUK
Chairman, Conference on Magnetism and Magnetic Materials, Boston, 1973.

CHARLES W. NIESSEN
Vice-Chairman, Boston Chapter, Communications Society, Institute of Electrical and Electronic Engineers.

EDWARD B. OWENS
Director at Large, American Society for Mass Spectrometry.

HOMER C. PETERSON
Chairman, Scientific Program Committee, Users of Automatic Information Display Equipment.

CHARLES M. RADER
Member, Administrative Committee, Acoustics, Speech, and Signal Processing Group, Institute of Electrical and Electronic Engineers.

LEON J. RICARDI
Editor, Transactions on Antennas and Propagation.
Fellow, Institute of Electrical and Electronic Engineers.
Special Lecturer, Institute of Electrical and Electronic Engineers and American Physical Society.

THOMAS S. SEAY
Member, Technical Committee on Communications Systems, American Institute of Aeronautics and Astronautics.

HERBERT SHERMAN
Member, Board of Directors, Society for Advanced Medical Systems.

THOMAS M. SMITH
Chairman, Chicago Chapter, Antennas and Propagation Group, Institute of Electrical and Electronic Engineers.

ALAN G. STANLEY
Chairman, Boston Chapter, Nuclear Science Section, Institute of Electrical and Electronic Engineers.

ERNEST STERN
Editor, Special Issue on Surface Wave Devices, Proceedings of the Institute of Electrical and Electronic Engineers.

Principal Professional Honors and Activities

JOSEPH R. WATERMAN

Meritorious Service Medal, U.S. Air Force.

JERALD A. WEISS

Member, Editorial Board, Transactions on Microwave Theory and Techniques.

RICHARD C. WILLIAMSON

Chairman, Microwave Acoustics Subcommittee, Microwave Theory and Techniques Group,
Institute of Electrical and Electronic Engineers.

Vice President, Boston Section, Sonics and Ultrasonics Group, Institute of Electrical
and Electronic Engineers.