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**Report of the President and the Chancellor
1978-79
Massachusetts Institute of Technology**

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Contents

PRESIDENT AND CHANCELLOR	7
Statistics for the Year	24
Personnel Changes	30
DEAN FOR STUDENT AFFAIRS	41
Introduction: A Year of Review	41
Office of the Dean for Student Affairs	47
Office of Freshman Advising	48
Undergraduate Seminars Program	51
Undesignated Sophomore Program	51
Office of Preprofessional Advising and Education	52
Minority Support Activities	54
Women's Program	55
Advising and Counseling	56
Student Community Affairs, Student Activities, and Governance	57
Residential Program	59
Talbot House	63
Foreign Study Office	64
Disciplinary Concerns	64
PROVOST	67
Artificial Intelligence Laboratory	73
Cell Culture Center	77
Center for Advanced Visual Studies	78
Center for Cancer Research	81
Center for Cognitive Science	82
Center for International Studies	85
Center for Materials Research in Archaeology and Ethnology	89
Clinical Research Center	90
Committee on the Visual Arts	91
Division for Study and Research in Education	100
Educational Video Resources	105
Harvard-M.I.T. Division of Health Sciences and Technology	106
Whitaker College of Health Sciences, Technology, and Management	111
Independent Activities Period	112
Laboratory for Computer Science	114
Laboratory for Information and Decision Systems	116
Libraries	119
Lowell Institute School	130
Neurosciences Research Program	131
Northeast Radio Observatory Corporation	
Haystack Observatory	132
Office of Minority Education	134
Operations Research Center	136
R.O.T.C. Programs	138
Sea Grant Program	139
Summer Session	145
Technology Adaptation Program	145
Upward Bound Program	151
Wellesley-M.I.T. Exchange Program	152

SCHOOL OF ARCHITECTURE AND PLANNING	155
Department of Architecture	163
Department of Urban Studies and Planning	168
Laboratory of Architecture and Planning	172
SCHOOL OF ENGINEERING	177
Department of Aeronautics and Astronautics	185
Department of Chemical Engineering	190
Department of Civil Engineering	196
Department of Electrical Engineering and Computer Science	201
Department of Materials Science and Engineering	206
Department of Mechanical Engineering	208
Department of Nuclear Engineering	222
Department of Ocean Engineering	226
Center for Advanced Engineering Study	230
Center for Policy Alternatives	233
Center for Transportation Studies	238
Innovation Center	242
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE	243
Program in Science, Technology, and Society	249
Department of Economics	254
Department of Humanities	256
Department of Linguistics and Philosophy	273
Department of Political Science	275
Department of Psychology	279
SLOAN SCHOOL OF MANAGEMENT	283
SCHOOL OF SCIENCE	305
Department of Biology	307
Department of Chemistry	309
Department of Earth and Planetary Sciences	313
Department of Mathematics	317
Department of Meteorology	319
Department of Nutrition and Food Science	322
Department of Physics	324
Interdisciplinary Science Program	332
Spectroscopy Laboratory	334
George R. Wallace, Jr. Astrophysical Observatory	337
VICE PRESIDENT AND DEAN OF THE GRADUATE SCHOOL	339
Medical Department	365
Registrar	377
OFFICE OF THE PRESIDENT AND THE CHANCELLOR	405
Department of Athletics	405
Council for the Arts	416
Institute Information Services	419
Information Processing Services	425
MIT Press	427
Undergraduate Research Opportunities Program (UROP)	435

VICE PRESIDENT, ADMINISTRATION AND PERSONNEL	437
Affirmative Action Program	439
Office of Admissions	440
Office of Student Financial Aid	442
Career Planning and Placement Office	444
Office of Child Care	445
Personnel Office	446
M.I.T. Quarter Century Club	449
VICE PRESIDENT, FINANCIAL OPERATIONS	451
Audit Division	452
Office of the Comptroller	453
Office of Sponsored Programs	453
Office of the Director of Finance	455
VICE PRESIDENT, OPERATIONS	457
VICE PRESIDENT, RESEARCH	469
Francis Bitter National Magnet Laboratory	470
Center for Materials Science and Engineering	474
Center for Space Research	479
Energy Laboratory	483
Laboratory for Nuclear Science	498
Nuclear Reactor Laboratory	502
Patent and Copyright Office	
Patent Marketing Office	503
Plasma Fusion Center	504
Research Laboratory of Electronics	513
LINCOLN LABORATORY	521
VICE PRESIDENT, RESOURCE DEVELOPMENT	525
TREASURER OF THE CORPORATION	535
SECRETARY OF THE INSTITUTE	555
ALUMNI ASSOCIATION	563

President and Chancellor

The year just completed was one of considerable movement and excitement on many fronts. As the Leadership Campaign nears its completion, its effects are evident in many ways: the traditional departmental and disciplinary activities are receiving added support in the form of new professorships, more adequate space, new equipment, and additional academic and research funds; the maturing Energy Laboratory, the Harvard-M.I.T. Division of Health Sciences and Technology, and many other programs are providing widespread support for faculty and students throughout the Institute; there is the rapid development of programs (and in many cases, facilities) for the Whitaker College, the Plasma Fusion Center, the Program in Science, Technology, and Society, and the Energy Laboratory; and we are in the active planning stages for several new interdisciplinary centers or programs. This sense of movement comes as well from imminent construction of sorely needed and long-planned new dormitory and athletic facilities.

The ferment and dynamic nature of the Institute were reflected on the student front this year as we reviewed the organization of student services and, in the process, asked questions about our insitutional responsibilities which extend beyond the formal curricular offerings to the provision of a supportive environment for all of our students.

The year marks as well a special milestone in the educational life of the Institute -- the tenth anniversary of the Undergraduate Research Opportunities Program, the remarkably successful innovation in the learning encounter between teacher and student.

We have been pleased too by considerable progress in our relationships with funding agencies, as evidenced by a number of actions during the past year. Signs of this improving relationship can be seen in the responsiveness of various Federal agencies and the committees of Congress to the difficulties posed by policy changes regarding fiscal responsibility in Federal relationships. More importantly, we sense a growing appreciation of the structure, needs, and serious problems of the research universities by these groups, whose sympathetic understanding and support is so essential to the well-being and vitality of the research universities in general, and of M.I.T. in particular.

In April we completed the fourth year of the Leadership Campaign. At the close of the 1978-79 academic year on June 30, the Campaign total was \$215 million. As we write this report the total has exceeded \$220 million, very near the Campaign goal of \$225 million. It is clear that we shall make our target, thanks to M.I.T.'s friends and supporters, especially those in the M.I.T. Corporation and the Corporation Development Committee. Unfortunately, the relentless pace of inflation makes it impossible to meet all of the objectives which this sum originally encompassed, and even at the start it represented an estimate of our fund-raising capacity, not the Institute's true need. Finding additional support for faculty members, students, and desired facilities must remain one of our major efforts.

In 1975, at the beginning of the Leadership Campaign, we said that our purpose was to provide facilities, talent, and support that would "make it possible for M.I.T. to address more effectively through teaching and research, the sociotechnological dilemmas now confronting the nation and the world -- to scale its contributions to the needs and opportunities appropriate for today and tomorrow." The degree to which this has actually occurred can be seen in many specific programs, but it is even more apparent if one examines, as we shall do here, the contributions of the Leadership Campaign to the continuing evolution of the intellectual map of M.I.T. and its congruence with the vital problems of American society.

The Evolving Intellectual Map of M.I.T.

As we write this report at the close of the 1970s, it seems that a brief look at the Institute over the past 50 years would provide an appropriate introduction to our discussion of M.I.T. today.

The depression that began in 1929 was the most severe this country has seen, and the half century that has elapsed since then has been marked by political cataclysms. At the same time, this period has been both a golden era in the natural sciences and related technologies, and one in which these areas have become matters of serious public concern. These years also coincide with the emergence and the maturing of M.I.T. as a leading international university with a scope that mirrors the nature of contemporary society, and with special emphasis upon science and technology. This evolution dates back to the assumption of the M.I.T. presidency by Karl T. Compton in 1930: his vision made what followed possible.

It is clearly not possible in this report to detail the changes that have taken place in science and engineering or, indeed, the changes in M.I.T. that this half century has seen. The most we can do is to contrast in a few broad brushstrokes this landscape as it appeared in 1930 and as it is today, and to highlight certain events along the way. In selecting dimensions for comparison, we chose certain indicators relevant to M.I.T.'s purposes and goals -- milestones in the natural sciences and engineering fields which, while not reflecting all of M.I.T.'s endeavors, are close to the heart of the institution.

In the natural sciences, an enumeration of some of the Nobel Prizes that were awarded during the early 1930s will give some idea of the major trends at that time. Quantum mechanics had just come onto the scene and it was thus no accident that the Nobel Prize for Physics in 1932 was given to Heisenberg and in 1933 to Dirac and Schrödinger. The Nobel Prize for Physics in 1935 recognized the discovery of the neutron by Chadwick, a landmark in the history of atomic structure. In Chemistry, Harold Urey was awarded the Prize in 1934 for the discovery of heavy hydrogen, and the Curies received it in 1935 for the synthesis of new radioactive elements. In Physiology and Medicine, the 1930 Prize went to Landsteiner for discovery of blood groups; the 1932 Prize went to Sherrington and Adrian for discoveries of the function of the neuron; and the 1933 Prize went to Thomas Morgan for his work on the hereditary function of the chromosome. These prizes reflect much of what came to be the classical textbook material of our youth.

While the Nobel Prizes give us some limited idea of the major intellectual thrusts in the natural sciences, they fail to present a picture of the remarkable exploits of engineering of that period: the great bridges, the airplanes, the advent of air conditioning, the electrical machines, and the great dams that characterized that epoch. The various fields of engineering reflected rather closely relevant industrial practice of the time, and in their relation to the physical sciences, they differed strikingly from the contemporary technologies.

One illustration of the perception of engineering education in relation to basic science can be found in Karl Compton's own description of a conversation he had when he received the invitation to become President of M.I.T.:

I was not too sure I wanted to be President of M.I.T. I wanted to think it over and talk it over with Frank B. Jewett, President of Bell Laboratories, and made an appointment to see him. As I left the house that morning, I told my wife that I was pretty sure I would turn the job down, and in fact Dr. Jewett did nothing positive to try to influence me. He said that he had observed some things about engineering schools in the United States; they had performed a useful function several decades ago and had done a marvelous job in his opinion but were far behind in their usefulness in the present and particularly in any future. They were too much on the pattern of technical trade schools. The only solution was to try to inject into the politics of these institutions a greater interest in fundamental science and research if someone could be found to do it. So I thought it was up to me to try to help.

These words contain in outline the challenge which M.I.T. held for Compton. To the School of Engineering and the School of Architecture, he added the School of Science and the Graduate School, and in asking Vannevar Bush to become Dean of Engineering he ensured a strong infusion of applied science into the engineering programs. The new emphasis upon graduate study created the orientation needed to make M.I.T. not only a source of trained people for industry but a force in creating new industries, new technologically based systems, and, ultimately, new social realities.

In Compton's inaugural address he formulated the purpose of the Institute as "the development of science and its useful applications." And time and time again he stressed the necessity of greater emphasis upon the fundamental sciences both in their own right and as the bases of the various branches of engineering. To undertake the necessary research, Compton stated the need for an endowed research fund of \$5 million, the income of which would support faculty research. He could not conceive of a more appropriate or urgent program for the Institute than to continue its work of developing both principles and people for applying science to the problems of human welfare. It was this vision that enabled M.I.T. to become a leading force in the development of the natural sciences and the related technologies.

The emergence of M.I.T.'s leaders as science advisors at the national level started during that period: in the early 1930s President Roosevelt formed a Science Advisory Board, with Compton as chairman, with the task of recommending a more effective general governmental policy with respect to scientific work. During the Second World War, Karl Compton, Vannevar Bush, and many other members of the Institute were to play extraordinarily important roles in Washington as members of the National Defense Research Committee, the Office of Scientific Research and Development, and other war-related agencies; and M.I.T. undertook to build a "national" laboratory -- the Radiation Laboratory -- where 4,000 staff members were concerned with the development of radar in the broadest sense of the word, from the basic physics of magnetrons and electromagnetic theory to the testing of various radars on the battlefield.

With its size, its scope, and its style, the Laboratory created a new way of doing scientific and technical research for the public welfare. It also changed M.I.T. in the sense that interdisciplinary and interdepartmental cooperative efforts oriented toward the solution of major national and societal problems became a hallmark of the Institute. Under the leadership of Julius Stratton, Albert Hill, John Slater, and others, the Radiation Laboratory was transformed into the Research Laboratory of Electronics, oriented toward certain areas of physics and the problems of communication in synthetic and living systems.

Soon after the end of World War II, there came a book that presented a new synthesis and changed the way in which many came to view the second "industrial revolution." The book, written by M.I.T.'s famous mathematician, Norbert Wiener was called *Cybernetics*, after the Greek word meaning "steersman" in the sense of governor. Subtitled "Communication and Control in the Animal and in the Machine," the book tried to bring together statistical communication theory, servomechanisms and feedback, and advanced views on the potential of computers. *Cybernetics* became something akin to an intellectual endowment for the early years of the Research Laboratory of Electronics, and from this stimulus grew most of M.I.T.'s contemporary work in human communication, including the neurosciences, psychology, and linguistics, as well as much of the computation activities.

The world after the Second World War saw a blossoming of new technologies. Building especially on new knowledge in solid-state physics, electronics began to pervade our lives: from television to copying machines, from transistorized hearing aids to magnetic computer memories, from air defense and air navigation to tape recorders. Electronics became the lead technology and Boston's Route 128 exhibited the many uses, practical and analytical, to which electronics and information processing could be put.

But electronics was not the only technology to intervene forcefully into our lives. The post-World War II period saw also the first flowering of the biomedical technology of drugs and vaccines. Thanks to sulfonamides, the penicillins, (it was the M.I.T. chemist John Sheehan who achieved the first synthesis of penicillin), the streptomycins, and so forth, the infectious disease patterns and the death rates of the industrialized world were irreversibly changed.

At M.I.T. toward the mid-century, the issues that science, technological development, and especially the bomb, had started to pose were reflected in the Report of the Lewis Commission, which had been established to review the state of education at the Institute. Central to that report was the view that we should be able not only to create new science and to innovate technology, but also to relate them to human values and aspirations; that we should have a certain responsibility for forecasting the impact of scientific and technical developments on society; and that we should learn how to manage the new technologies in a humane fashion.

These concerns were expressed at M.I.T. in the foundation in the early 1950s of the School of Humanities and Social Science (originally called Humanities and Social Studies) and the Sloan School of Management (originally called the School of Industrial Management).

In reviewing this half century, therefore, we can see enormous changes in the Institute and in the fields represented here. In the natural sciences, for example, the physical sciences clearly occupied most of the "map" in the 1930s. It was not until the post-World War period, when the tools of physics, chemistry, and modern engineering became increasingly used to study the structures and phenomena of life that the biological sciences started to occupy an ever increasing fraction of the map. This quest to understand the physical chemistry of living structures was expressed as early as 1944 by Schrödinger's little book entitled *What is Life*. By 1953, numerous experiments on the hereditary substance DNA and Pauling's discovery of the helical structure of protein led Watson and Crick to formulate their model of DNA: a double helix which thus provided a mechanism for the copying of genetic material. There followed numerous discoveries relating to the genetic code, to the functional regulation of genes, to immunology, as well as many others which contributed to our understanding of complex biological functions at the molecular level.

But far from standing still during that same period, the physical sciences moved on many fronts. In the wake of the pre-World War II cyclotron, nuclear accelerators became more and more powerful and the traditional "ultimate" building blocks of the atom were smashed into more and more fragments. The catalogue of nuclear particles now has more than 100 entries, many with rather colorful names. It is only, literally, in the past few weeks that Murray Gell-Mann's quark model and the theory of quantum chromodynamics have found strong support in an experiment conducted in Hamburg under the leadership of Samuel C.C. Ting, holder of M.I.T.'s Thomas Dudley Cabot Institute Chair. The Ting team, composed of 57 scientists and engineers from seven countries (including the People's Republic of China), was able to detect through inference a *gluon*, whose existence is crucial to our understanding of the fundamental binding forces in nature. The excitement created by this discovery in the year of the Einstein centennial is attributable, at least in part, to the possibility that it may permit us to progress toward a more unified theory of the four forces of nature that have been identified to date.

Almost the same excitement is perceived in astrophysics, where the 1930s appear now to be the distant Middle Ages of the field. Satellites, data processing, computers, radio and X-ray astronomy have transformed the disciplines. With these new technologies astrophysicists are delving further into ancient questions as well as mysteries previously unimagined: pulsars, quasars, black holes, the origin of the universe, the evolution of stars, life on Mars and in the cosmos. At M.I.T., the key data processing devices for the radio telescope were developed at the Research Laboratory of Electronics and our astrophysicists have played a leading role in many key experiments, such as the quite recent discovery of the double quasar.

Again, comparable progress has been made in the earth sciences where chemistry, oceanography, and the signal processing approach to the study of seismic waves, together with the unifying model of plate tectonics, have brought about new understandings, ranging from the nature of earthquakes to the exploration and utilization of the earth's resources.

The past 50 years have been a time of extraordinary accomplishment in mathematics as well. Benefiting, as have the other sciences, from an enriching stream of refugee scholars and researchers from central Europe in the 1930s and 1940s, American mathematics took a leap forward, and our nation has become, as medals and prizes now testify, the foremost center of world mathematical research. The great currents and discoveries of mathematics in the past several decades -- among them the deeper understanding of the higher dimensional spaces in which much of science and technology builds its models, a new overview of algebraic and combinatorial aspects of mathematics and its applications, significant progress on such difficult and complex areas of analysis as partial differential equations, and discovery of deep and unexpected connections among various previously distant fields of pure and applied mathematics -- all of these have been enriched in major ways by work done at M.I.T.

There is not enough space to document -- be it ever so briefly -- progress in the other natural sciences, in economics, in linguistics, in the neurosciences, and in the many fields of engineering that build on progress in basic science. All that we have attempted is to sketch how Karl Compton's vision has shaped the Institute and served human welfare.

There has been no attempt to document here the equally important complementary influences of technological progress upon other branches of human knowledge and action. New technologies enhance the potential of the natural sciences and medicine, they shape the theoretical concepts of the social sciences and the practices of management. Not only do new instruments, tools and software enable us to make previously "impossible" measurements, but most profoundly they raise new scientific, human, and societal problems. Progress in technology often forces us to admit that we don't really understand what we thought we did and thereby leads us to inquire much more deeply into new areas of basic science. By its ability to affect crucial human events such as birth and death, contemporary technology confronts humanity with questions of value and choice that transcend and challenge our established mores.

Today M.I.T. is a university *sui generis*. It is unique because there is no other institution of higher education so deeply involved with research. It is unique because of its international character, which does justice to the fact that the natural sciences are invariant under different skies. And it is unique in its concern not only with the sciences and engineering but with their human and societal consequences.

When one talks about research at M.I.T. one needs to realize that about half of this community of roughly 18,000 people are students. And practically all of the graduate students, more than half of the undergraduates, and all of the more than 500 postdoctoral fellows are involved in research. So are the nearly 1,000 members of the faculty, and so too, of course, are the members of the research staff. Today, the sponsored research budget represents roughly half of M.I.T.'s campus expenditures. In other words, M.I.T.'s activities -- in education and in public service -- have research as the most explicit motivating force.

The people who make up M.I.T. are obviously attracted to the Institute as a research university of a special kind. Over the years, these people have changed. They now come from all states and from all over the globe. Their backgrounds, interests, and ages are now more diverse. Increasingly, they are women as well as men. And while we have not yet met our goals for equal opportunity for minorities and women among our faculty, students, and staff, M.I.T. today is, in these terms, a much different place from M.I.T. in 1930.

This multi-faceted, multi-cultural community has developed a lifestyle which is probably unequalled in tempo and intensity of atmosphere. People live and work at the Institute almost 24 hours a day and 12 months a year. And they do not confine their activities to research and teaching on the campus. They are bridge builders: between the university and industry or government -- seeking, in the tradition set by M.I.T.'s founder, to put knowledge to work for social purpose.

The Development of Academic Programs

One pleasant surprise of the Leadership Campaign was that it stimulated extensive conceptualization and development of emerging academic programs -- those new activities that departments, faculty members, and laboratory groups were just beginning, and whose success depended upon the availability of support and, often, new facilities. The preparation of the goals for the Campaign required an extensive dialogue between the central administration and the many academic groups of the Institute. The development of specific proposals for programs and facilities continued that dialogue and brought the projects and programs into sharp focus. In the process, we have found that the need for seeking outside support has accelerated the conceptualization of many nascent programs.

In the casebook for the Campaign, we discussed the many faces of communications, information, and computation at M.I.T. and the central and growing role of these processes in the society at large. Today, the concepts of computation and information pervade almost every activity at M.I.T. to some degree, sometimes unknowingly, sometimes as a central purpose.

Two programs that came into focus as part of the Leadership Campaign during the past year present exciting illustrations of this influence. They are: the bringing together of activities in the Department of Psychology, the Department of Nutrition and Food Science, the Department of Linguistics and Philosophy, and elsewhere in the Institute to form centers for the study of cognitive science and the brain sciences; and the plan to bring together M.I.T.'s many teaching, research activities, and public exhibition programs in the areas of the visual arts and of media technology. Activities in the arts and related media are burgeoning at M.I.T. Each year more than 1,000 students enroll in visual arts courses and the Institute's galleries attract thousands of visitors. Media research includes such developments as computer-based video and graphic information systems, computer-controlled electronic music, and innovative work in film, video photography, graphics, and various other forms of image processing. A diverse faculty group has been designing the initial stages of a new environment for the Visual Arts and Media Technology, in which the first phase would contain primarily areas for exhibitions and archival storage together with a media gallery, a "listening gallery," and work space for resident artists.

Several other academic programs have emerged during the year to the point where they require support from our fund-raising effort. Among these are: 1) the development of a major program in the field of microstructures and large-scale integrated circuits; 2) an enhanced teaching and research program in the field of polymers; 3) a new center for study and research in materials processing; and 4) a broad-based program relating to chemicals, human health, and the environment.

Funds are needed as well to help meet the needs for additional and improved space for programs in the Alfred P. Sloan School of Management. Since its establishment in 1950, the Sloan School has grown both in size and stature. Its alumni occupy numerous positions of leadership both in the United States and abroad. Its student applications, enrollment, faculty research activities, and instructional programs (including those for mid-career and senior executives) have increased so dramatically that the School's facilities can no longer meet its varied needs. The School plays an increasingly key role in M.I.T.'s interdisciplinary efforts involving complex technological and societal problems, such as energy, health, and management of the environment. There is thus an urgent need to improve both the quantity and the quality of the School's space including the construction of new classrooms and the renovation of offices and seminar rooms, and to increase the size of the School's faculty.

Cognitive Science and the Brain Sciences: Two Centers in Formation. Earlier in this report we noted that under the influence of Norbert Wiener, the Research Laboratory of Electronics interpreted its mission in communication quite broadly, so as to include both the nervous system and linguistics. Since then, research and teaching related to these two areas have grown substantially at the Institute, as new experimental tools in the neurosciences and new models of language become available.

Understanding brain function, perception, and cognition is clearly central to M.I.T.'s Department of Psychology, but these interests have spread throughout the Institute. For example, faculty members in the Department of Nutrition and Food Science offer a graduate program in neural and endocrine regulation and do frontier research ranging from neurotransmitters to the influence of nutrition on behavior; members of the Department of Linguistics and Philosophy are deeply involved in studying the relation of language and mind. Furthermore, interest in the brain and/or cognition extends to most departments in the School of Engineering, to the Departments of Chemistry and Biology, and to such interdisciplinary units as the Division for Study and Research in Education, the Research Laboratory of Electronics, the Laboratory for Computer Science, the Artificial Intelligence Laboratory, the Harvard-M.I.T. Division of Health Sciences and Technology, and the Whitaker College.

In the last two years, scientists from several of the above mentioned academic units have held, under the sponsorship of the Sloan Foundation, a series of critical discussions and workshops from which emerged a certain consensus regarding the nature and the objectives of cognitive science. The participants from M.I.T. (and several other academic institutions and industrial laboratories) were able to formulate certain common approaches to the study of mental representation and computation. Initially they are attempting to construct theories capable of accounting for the knowledge that underlies one's ability to use one's native language, to represent objects in three dimensional space, or to engage in logical thinking, temporal planning, or memory. This is obviously an ambitious undertaking, but so strong was the desire of these colleagues from several M.I.T. departments to cooperate in a center that would provide a focus for individual and collaborative research that during the spring a Center for Cognitive Science was formed with partial support from the Sloan Foundation. This Center is not only undertaking theoretical research but is also taking responsibility for outlining educational programs for predoctoral students and postdoctoral fellows. With regard to facilities for such a center, there is little need to build or combine intricate laboratory facilities, although the Institute has tried to provide a modest amount of additional contiguous space for the program.

In the brain sciences, there has been a comparable explosion of interest and excitement in gaining a better understanding of how the brain functions -- from the role of minute quantities of highly specific chemicals to the behavior of humans. Faculty from throughout the Institute have expressed an interest in collaborating in this field, in both teaching and research programs, and their activities and enthusiasm have encouraged us to attempt to draw the relevant programs together in a Center for the Brain Sciences. We are seeking support for the space and sophisticated laboratory facilities needed to provide a suitable working environment in this field. In the meantime, we asked a group of faculty members from several departments to examine opportunities and the need for a coherent educational program. Out of their efforts have come not only a heightened awareness but also a better utilization of existing courses and facilities as well as better academic counseling for our students.

Recognizing that it will take time to obtain funds for an entire building for such a center, which would house the Psychology Department as well as faculty and staff from other departments or laboratories who would participate in the center's programs, we plan to add a floor to the building being constructed for the Whitaker College. In the meanwhile, we are actively seeking support for the Center's long-range program.

It seems highly appropriate that an institution dedicated to the progress of science and technology should also be in the forefront of trying to understand the functioning of the human brain, this prime generator of knowledge and learning.

Engineering and Industrial Innovation. A number of new programs in the School of Engineering reflect the Institute's continuing concern with the problems of industry and industrial society.

The Department of Electrical Engineering and Computer Science, for example, is developing, in collaboration with several interdepartmental laboratories and faculty from other departments, a major new educational and research thrust in the fabrication, design, and architecture of very large-scale integrated electronic circuits. The program reflects the needs of industry for people with theoretical and design capabilities that are far beyond the current state of the art.

During the past 20 years we have seen an astonishing development in the complexity of integrated electronic circuits capable of performing sophisticated logic functions. In the early development of integrated circuits, the problem was not so much the selection of logic functions or the design of the circuits as it was the problem of resolving materials defects associated with their fabrication. During the past decade, the primary question became one of which functions to incorporate in integrated circuits, that is, which functions would be general enough to allow for large-scale production. (This was the period which saw the development of microprocessors capable of incorporating in one or a few integrated circuits all the elements of a programmable general purpose computer.) Today, except for circuits with repetitive structures (such as memories), industrial ability to manufacture integrated circuits outstrips the ability to design them. We are now faced with the need for and the enormous difficulty of designing circuits containing several hundreds of thousands of components.

The program under development includes study of the traditional problem of improving fabrication techniques and reducing the size of components so that larger, more dense circuits can be made with fewer defects. However, it goes beyond these issues to consider design aids that are necessary if complex geometrical designs embodying random logic are to be fabricated, and to consider questions of computer architecture. The two-dimensional physical structure of integrated circuits allows parallelism in structure and organization which we now do not know how to use effectively, but which could lead to fundamental changes in the organization of computers and computation.

Another area in which education and research will have an influence on industrial development is the field of polymeric materials. For more than three decades, members of the M.I.T. faculty have made important contributions to our understanding of the properties and uses of polymers, and have tried successful contributors to the field. Nevertheless, in spite of the size, quality, and diversity of these efforts, the Institute is not recognized as a world leader in this field. We believe that this lack of recognition is a reflection of the lack of internal organization in polymers research and education, as well as insufficient interaction with industry where much of the creative work in polymers is done.

The School of Engineering, in collaboration with the Center for Materials Science and Engineering, is developing a new interdepartmental research and graduate educational program which will involve faculty from Chemistry, Chemical Engineering, Materials Science and Engineering, and Mechanical Engineering.

The new program will help establish an internal sense of community, greater external visibility, and a means by which continued evolution and improvement can occur. The program will provide a forum for educational activities in polymers at the graduate level, for strengthened interaction with the industrial community in the area of polymers, and for several new research initiatives.

The School of Engineering is establishing as well a Materials Processing Center, which will be concerned with process fundamentals and applications, materials systems engineering, and the societal issues which arise in the processing of raw and semifinished materials and in the impact of new materials processing technologies.

Advances in the usefulness and reliability of materials depend on a combination of modern scientific understanding and the art of the traditional artisan. An important concept is that performance of materials can be controlled through control of internal structure, from the macroscopic to the atomic level. Without this concept, the performance and reliability we have come to expect from modern aircraft and computers, for example, could never be achieved. A second important concept underlying the center is that economic and low energy processing of materials in a competitive world depends on assimilation of new technologies such as robotization and adaptation of processes to utilize these technologies.

The new center will provide a way for staff and faculty to contribute effectively to broad materials processing problems and to interact with industry and government in finding solutions to these problems. Research activities in the center will include work on lighter-weight materials for energy-efficient automobiles, primary-materials production processes which have lower economic and social costs, computer-aided and adaptive materials processing, and processing by supercooling and ultra-rapid solidification.

Chemicals, Human Health, and the Environment. During recent years the public has become increasingly aware of the problems of the control of chemical hazards. The resolution of these issues is often left to adversary proceedings in which industry, governmental agencies, and public interest groups are often far apart in their approaches. M.I.T. and Harvard have faculty members of outstanding competence in toxicology, epidemiology, and other disciplines necessary to a thorough understanding of these complex issues. Thus it is not surprising that both industry and government have encouraged the two institutions to undertake a major joint program that would contribute to the development of the requisite scientific and technical knowledge and to the education of the large number of toxicologists, epidemiologists, and so forth, who are needed.

During the last year the faculty members and academic administrators from Harvard and M.I.T. met repeatedly to explore how a joint program on the impact of chemicals on human health and the environment could come into being. We at M.I.T. have been helped by the experience with our Center for the Study of Health Effects of Combustion. This center combines the efforts of the Harvard-M.I.T. Division of Health Sciences and Technology and of the Energy Laboratory in exploring the health effects of present and potential fossil fuels. Key objectives include the assessment of potentially mutagenic and/or carcinogenic species from combustion of fossil fuels and the identification of possible alternative combustion methods and fuel utilization strategies that could reduce or eliminate health hazards. The utilization of fossil fuel resources in an environmentally and economically acceptable manner depends upon our acquiring critical knowledge that relates to both technology and public health.

In our exploratory discussions with our Harvard colleagues we have focused on four basic areas: health sciences, environmental sciences and engineering, analytical methods and instrumentation, and policy analysis and regulation. Such a program would range from basic biology, chemistry, and chemical technology to economics, public policy, management, and law. It would need to be able to identify and diagnose problems, working in conjunction with both industry and regulatory agencies. There is the hope that it might help in creating a climate for rational discussion of a variety of viewpoints on these issues and that such discussions might result in materials for information and education of the public.

This summer we ran a small educational pilot operation: about 50 young professionals took a 10-week program dealing with toxicology, analytical chemical methodology, epidemiology, occupational health, the regulatory framework, and environmental decision making. The program was

taught by M.I.T. faculty members, augmented by Harvard colleagues and lecturers from industry and government.

The forthcoming year is one in which we intend to develop rather specific plans for cooperation between our two institutions, to clarify an appropriate organizational structure, and to explore funding possibilities from a variety of sources at a level that will make such an ambitious program possible.

Computational Environment and Challenges. Many of the previous programs illustrate pioneering areas of research related to information and communications. As noted above, the uses of information processing throughout the Institute's educational, research, and administrative programs have become so pervasive that we decided to take a critical look at the adequacy of M.I.T.'s computational resources and its needs for the future.

During the year, the Committee on Future Computational Needs and Resources, which was appointed in the spring of 1978 by the Chancellor and the Provost, reported on its conclusions and recommendations. The committee concluded that we do not make full use of computers in education and research, that our present path is not leading in the right direction, and that, except in specific situations, the Institute's overall use of information processing cannot be characterized as pioneering. In sum, the committee felt that, although the Institute is pre-eminent in research in the computer sciences and in the applications of information processing, we are, with respect to our use of information processing, particularly in instruction, not unlike the shoemaker's children.

In contrast to the present state, the vision of the near future proposed by the committee includes widespread use of interconnected personal computers or terminals for use by students and faculty, for such diverse purposes as assisting in research, new modes of teaching and learning, preparing or solving homework problems, maintaining schedules, report writing and editing, and communicating with fellow students or instructors.

As a first step in moving toward this computational environment, the committee recommended the establishment of an "M.I.T. Network" for tying together various information resources, and the creation of regional computing centers within the Institute. Further, they recommended that a number of experiments be conducted in education, office automation, graphics, personal computers, computerized classrooms, mixed media, and library uses of computers, as well as far-reaching reorganization of Institute resources relating to information processing and communication. The Committee recommended as well that responsibility for all information processing and communication technology at M.I.T. be centralized under a single senior individual, and that a standing faculty committee be created to maintain oversight in these areas.

There has been extensive discussion of this report during the year, and of the educational and institutional climate which it portends. While decisions have yet to be made concerning implementation of the recommendations, the general directions outlined in the report have been accepted in principle and several departments within the School of Engineering are moving toward the establishment of significant decentralized computing resources -- an indication that the committee's view of the future is founded in already perceived needs.

Undergraduate Research: Opportunities and Achievements

This year marked the tenth anniversary of the founding of the Undergraduate Research Opportunities Program. This unique program -- known as UROP to all -- has had a significant effect on the educational climate of the Institute as it is perceived by both students and faculty, and is, we believe, the most important single development in education at M.I.T. in the past several decades. It provides the opportunity for undergraduates to join with faculty members in an inquiry of mutual fascination.

Through UROP the Institute has sought, as early as possible in the undergraduate experience, to: 1) teach students by example the process of seeking answers and assimilating knowledge; 2) foster meaningful student-faculty relationships on several levels, with inquiry into a topic of intellectual interest providing a framework for advising, tutoring, and related needs of the students; and 3) develop student maturity and self-confidence in both personal and professional dimensions.

Perhaps UROP's most valuable contribution is that it provides ways for our undergraduate students to achieve a sense of individual accomplishment and to generate for themselves the excitement of intellectual discovery.

At M.I.T., undergraduates have the opportunity to inhabit a very special moral and intellectual universe, a world that is both demanding and rigorous, but also sympathetic. It is the responsibility of our faculty to guide these young people, to encourage their earnestness and drive, but especially to firmly require that they fulfill the promise that got them into M.I.T. in the first place. Simply offering such students a modern campus and a plentiful menu of good courses does not distinguish the foremost universities of the world from one another. But in the providing of a research-based undergraduate educational experience, M.I.T. offers a special challenge and opportunity to students who want to take an active role in their own education.

The program had its intellectual genesis in a lecture delivered at the Institute in 1957 by Dr. Edwin H. Land, president and founder of the Polaroid Corporation. The lecture, entitled "The Generation of Greatness," had a profound impact on M.I.T. Dr. Land said of undergraduates:

One feels, when among our young students, that they are honest and honorable and full of ideals; that they come to the door of our universities with the dream of being our colleagues; that if we could provide them intimate leadership there would be no discipline to which they would not subject themselves and no task so arduous in the pursuit of knowledge and science that they would not devote themselves to it.

Dr. Land elaborated his view that if students were provided with "intellectual ushers" -- senior colleagues who would guide them through the university and start them on personal research projects -- they would gain first-hand, and early-on, a sense of intellectual excitement and individual accomplishment.

The Undergraduate Research Opportunities Program began in September 1969 with nearly 300 participants (more than twice our estimate of initial interest), and grew to 600 in the second semester. It began without fanfare, without a bureaucratic master plan, without staff or clerical support, and without formal administrative housing in any particular office. It also began at a time of unprecedented ferment and deep discontent at M.I.T. and on campuses throughout the nation. In the midst of this, M.I.T. invited its undergraduates to come into campus research pursuits as full, contributory citizens. It was a bold move against a swift current of development that had followed the massive World War II research efforts -- a development which converted several leading universities into world class research institutions at the price of orienting faculties toward graduate and postdoctoral education with such intensity that undergraduates were effectively disenfranchised from the mainstream of intellectual action.

Ten years and several thousand undergraduate researchers later, UROP has come of age at M.I.T. For the past several years about 2,500 students each year have been engaged in undergraduate research. The program now spans all 23 academic departments, including those which do not award undergraduate degrees. And while UROP is the principal vehicle for undergraduate research, this kind of activity is also available through senior thesis, project laboratories, special topics in engineering, special problems in physics, political science internships, or the cooperative programs in several engineering departments, to name a few. The total atmosphere is what counts. The genesis of this atmosphere lies in the origins and tradition of M.I.T.; UROP's contributions have been primarily the provision of scale, interdisciplinary links, articulation, and overview.

The scope and complexity of UROP has consistently enlarged and deepened: from the original program of research for credit during the academic year, UROP has grown to include summer research (which usually carries stipend support), and ties with off-campus professional organizations (including a special emphasis in the medical and health-related fields). Students can begin or end a research effort whenever they wish at any point during the year, without being bound by the formal academic calendar; the "average" UROP student spends 8 to 15 hours per week (over a period of one and one-half years) on his or her research project. And by engaging research staff as well as faculty in this type of educational encounter, the UROP experience heightens the sense of shared purpose which is a special feature of M.I.T.

The success of the program is demonstrated by the increasing sophistication of students' work and the routine expectation of many faculty that high-quality research contributions will come from undergraduates. A significant number of entering freshmen state that the opportunity to participate in research is the determining factor in their decision to enter the Institute. For a student to undertake a UROP project today means to become engaged with the full range and complexity of the research experience: defining a problem, writing proposals, securing funding, communicating with colleagues, dealing with recalcitrant equipment, interpreting results, making formal presentations, and reaping rewards (such as they may be).

Read what some of the students have said about their experience:

Again I must acclaim UROP for the opportunity it has given me to see how the field of experimental physics really is; the experience has been a great help to me in choosing possible career goals, in addition to being one of the finest methods for learning a subject I've ever come across. UROP is still the one major reason that M.I.T. is worth suffering through over and above any other undergraduate institution.

Aside from the obvious increase in practical lab experience which I gained through my summer UROP work, there were two more important lessons. The first was learning when to quit. That is, when should a project be abandoned as simply not being possible or profitable. In a standard lab course this problem is never faced. Even when things don't work, there is the knowledge that somebody else in the lab got the product and you better get it too. The second important lesson was in learning to work with people in the development and carrying out of a research project.

Frankly, my only regrets are that I didn't do UROP sooner. When you are responsible to an individual or group for the knowledge in an area, you apply yourself to it more thoroughly. Sometimes it is easy to just get by with a B in a course if you aren't called upon to recite on the subject. But when you're a UROP-er, you kind of set your standards higher. In other words, I didn't dare not know some things once I undertook the project. I've had to really learn (and am still learning) because of this project. Without UROP, I may have just let it slip by.

Faculty take supervision of undergraduate research seriously. Just as students come to M.I.T. to learn from and with M.I.T.'s faculty, so too do first-rate professionals join M.I.T.'s faculty to work with these fresh, spirited colleagues.

There is a personal return to the faculty member in such a collaboration. Beyond the pride in seeing one's protege develop, there is professional pride in conveying the knowledge, culture, and traditions of a field. In the UROP partnership there is relaxing of the tension between the demands, sometimes distracting, of conventional teaching formats and the unrelenting pressures of research management.

There is also tangible professional benefit to the faculty member, not unlike the returns of working with other research colleagues, but perhaps with greater humor and less formality. The influence of a particular collaboration on a faculty member outlasts the individual undergraduate and affects the professional life of the faculty member, perhaps by letting him or her start a new field or approach, perhaps by accomplishing the feasibility study that finally elicits major moral and financial support, perhaps by questioning a long-held tenet or theory, perhaps by adding a measure of humanity to a lonely pursuit.

Thus, faculty development is a major aspect of UROP's overall contribution to M.I.T., especially in the junior faculty ranks, where assistant professors scramble to get research programs supported and under way, to attract research students, and to establish themselves professionally. These enterprises are greatly aided by the presence of undergraduate research colleagues, who in exchange, want greater access to precisely these faculty members because of their verve, rapport, up-to-date knowledge, and youth. As these faculty enter the senior ranks, they know no norm other than that of undergraduates as bona fide research partners. An increasing number of these faculty are passing through the tenure threshold, permanently building undergraduate research into M.I.T.'s future. This is as we believe it should be.

The Learning Environment Beyond the Classroom

In our annual report last year we mentioned our intention to review the organization of student support services at the Institute, with particular focus on the Office of the Dean for Student Affairs and the various services it provides.

This review led to changes aimed principally at improving services for graduate students; strengthening institutional support to undergraduate students and particularly to the departmental and the general freshman advising programs; and rationalizing the services for women students, international students, and the student residence programs, both on and off campus. As of the writing of this report the reorganization of the Dean's Office suggested by the study has been completed and a national search is under way for the new Dean. A broader review of the organization of various student-related responsibilities which are found in offices and departments throughout the Institute has yet to be completed.

In addition to clarifying the service and management issues of organization, the review of student services has raised again some important questions of educational and institutional policy, and we wish to reflect on these questions here.

First is the question of how to meet the Institute's responsibility to support and to complement the academic program. Besides the formal offerings in the classroom and the laboratory, American universities have traditionally provided advising and other support activities -- including a variety of residential, social, and cultural programs on campus -- which are not a part of the formal curriculum, but which add significantly to the education and to the opportunities for personal growth and development of students. At M.I.T. these support activities have been provided by faculty members and administrative staff members both within the departmental framework and Institute-wide. A growing concern in recent years, highlighted by the review, is how to meet students' wish for more support and advice from faculty members outside of the formal classroom setting. It is understandable that faculty may have limited involvement in educational support activities, given the many other demands on their time in this period, the restricted departmental budgets, and the pressure on younger faculty to compete for research support and for professional recognition. The continued personal interest and involvement of our faculty members in the professional and the personal growth of students, however, is a cardinal ingredient in an M.I.T. education. We have heard this time and time again from alumni and students; and the success of the UROP experience is a testimony to the value of such one-to-one interactions. The dramatic increase of student and faculty participation in UROP during the past decade is a positive sign in this respect. But growing student criticism and concern over the quality and availability of advising suggest that we need to pay more attention to the supportive roles that M.I.T. faculty play outside, as well as within, the context of their own research. We are particularly struck by the growing interest among undergraduates to receive more, better, and earlier help in making their career choices. They see a need for career counseling, reaching down to their early academic decisions about a major, and they see a need for more help in exploring possible shifts or combinations of departmental majors in their upperclass years. Quite often they feel uncomfortable in discussing these topics with their departmental advisors who appear to them to be knowledgeable about and committed to a specific profession or field.

It is not very clear to what extent this malaise about advising is occasioned by changing expectations of students or even by the changing and complex configurations in the fields of knowledge, rather than by a lack of faculty involvement. All of these factors are probably influential to some extent. But whatever the cause, there is an important need for the faculty, collectively and individually, to respond to these student needs. And there is a need for the administration to plan the institutional responses, so as to encourage and facilitate faculty involvement, rather than substitute for it with professional counseling.

Several universities have chosen to provide professional academic counseling outside their departmental structure. But we believe that would tend to change the character and dilute the quality of our education. A major section within the Dean's Office, devoted to Undergraduate Academic Support, was created this summer to operate as an academic information center for students and for their advisors and for departments in order to strengthen (rather than substitute) the student-faculty bonds, and encourage the integration of career counseling and academic advising to the extent possible. The Committee on Educational Policy is studying how to improve advising,

and we have had several discussions about this problem with department heads. We hope that the heightened awareness about the needs as perceived by the students will bring about a needed improvement, and we plan to reassess the situation next year.

A second concern highlighted by the review has to do with a need to make more support services available to our students who do not have major problems of adjustment, but whose education and experience at M.I.T. would be enhanced if they had more opportunities for engagement in academic, intellectual, cultural, or social activities. Many of these opportunities can be provided in the context of the campus residential environment. In principle there is a great variety and choice in the residential program for undergraduate students both in the dormitory system on campus and off campus in fraternities and independent living groups. A combination of circumstances, however, including the lack of resources for adequate development of both facilities and programs under the Housemaster-Graduate Resident system, have led to the conclusion that our residential system is not developed to its full potential, and that we should take better advantage of the living environment as a focus for programs which can support and complement our academic offerings. We are taking some steps this year, including the addition of a full-time business advisor for fraternities and independent living groups, a modest increase in program support to Housemasters and Tutors, and a major study and review of all dining programs and facilities on campus.

Perhaps the most significant gain on the residential front was our decision in June to proceed with the building of a new dormitory for 300 undergraduates, made possible by an anonymous gift of \$2 million. Serious crowding during the past five years had exacerbated the housing problems and, although the cost of the new house will require significant debt financing (if no additional gift capital is found), we felt that going forward with the building at this time will alleviate the serious crowding and will limit the rapid escalation of the cost of this necessary facility.

Unfortunately we cannot report progress on the problem of housing for graduate students. Campus facilities cannot begin to meet the demand here, and the housing in the Greater Boston area becomes scarcer and more expensive each year.

We are very happy, on the other hand, to report that we are moving ahead with the construction of a much expanded athletic facility, whose funding from generous gifts of alumni and friends is almost complete.

In the past 30 years universities have gone through major transformations as far as their relations to students are concerned. Following World War II universities were viewed as intensive suppliers of trained professionals for industry and government; in the 1950s and early 1960s they were expected to fill a parental role for a fast growing college population; in the late 1960s they became the battleground for youth independence and for social and political activism; and in the 1970s they have been characterized by privatism and a utilitarian emphasis.

We cannot make a prediction about student attitudes in the 1980s any more than we could have predicted today's state 10 years ago. But we can say that our students seem to be making more out of what is available to them at the Institute today than they did during the previous decade. And we can also speak of the value of a periodic stock taking, such as we did last year, with ample time to listen and to reflect before taking institutional steps which should provide the best possible climate for the growth of our students.

Research and Relations with the Government

In our report last year we noted the growing impact of governmental action on the Institute and suggested that it was necessary for the research universities to strive to improve communications with both the Executive Branch and the Congress. We were particularly apprehensive about the apparent deterioration of the spirit of collaborative partnership between the universities and the Federal government. Forged in World War II and reinforced in the years following Sputnik, that partnership encouraged and sustained university research and, in turn, brought the nation to world preeminence in science and technology and contributed to the welfare and prosperity of society.

Underlying that partnership was a consensus regarding the inherent importance and contribution of basic research. In recent years, however, in the absence of proof that such work will produce immediate practical results, basic research had come to be measured primarily in terms of fiscal accountability. In the last few years this had become a pervasive theme.

This year we can report a considerable improvement in the university-government relationship -- an improvement based on continuing efforts to achieve mutual understanding of complex and diverse problems and to rectify misunderstandings of the nature and role of university-based research in the nation.

At the beginning of the year, the emphasis on fiscal accountability by the Federal government and the apprehensions of the universities were focused on proposed revisions of the cost principles governing Federal reimbursement of research costs at colleges and universities. The university community feared that the proposed revisions represented an abandonment of the partnership concept and a point of transition to a different relationship between them and the Federal government -- a relationship in which universities would be regarded as vendors essentially indistinguishable from commercial organizations.

M.I.T. joined the debate and took strong exception to those proposed revisions which would have seriously impaired the financial viability of the Institute's specialized research facilities, and would treat students, however deeply involved in research, solely as course-taking students in calculations of reimbursable indirect costs. We particularly stressed the concept that research and instruction, especially at the graduate level, are interactive, mutually-supportive activities which cannot be separated one from the other except in the most artificial and mechanical ways, and with great cost to both.

The Office of Management and Budget responded to the expressions of alarm by providing an opportunity for further comment and discussion and by giving serious consideration to the views of both Federal and university representatives. When finally issued last spring, the revised principles required some significant changes in university procedures, but had been sufficiently modified from the earlier proposals that M.I.T. can accommodate itself to them without sacrificing its ability to conduct research effectively.

The mood and attitude of Congress toward the universities had also been reflected in the 1978-79 National Science Foundation appropriations bill, which included a limitation on the level of faculty salaries which could be charged to NSF grants. The implications of this in terms of Federal involvement in the internal compensation and other policies of universities were enormous and disturbing. Our discussions of these concerns with Congressional sponsors of the requirement and their staffs appear to have been successful, for the limitation did not recur in the NSF appropriations bill for the 1979-80 year.

These and other examples of interaction with the Congress and Federal agencies have provided both encouragement and hope. They suggest that problems with the relationship are in large part the result of misunderstanding, inadvertence, and inattention of the kind that can result in any relationship taken too much for granted. While the Congress and the executive agencies have perceptions of the universities with which we might take issue, they are held without malice, and those who hold them are both accessible and willing to change their views if the arguments are well articulated on the basis of fact rather than rhetoric. Where the perceptions are not in our favor, but nonetheless accurate, the universities must listen more closely to criticism.

Encouraged by the fair hearing we received in connection with the revised cost principles, we have since communicated to OMB our concern that technological innovation in the country has been impaired by the increasing difficulty which major research universities are finding in their efforts to preserve their dynamism and freedom of inquiry. One reason for this difficulty is the fact that there are few discretionary funds, independent of specific research grants and contracts, which universities can use to maintain the vitality of their research efforts by seeding the exploration of new ideas, supporting talented young investigators, acquiring equipment not otherwise available for critical on-going experiments, and smoothing out the discontinuities inherent in project-by-project annual funding. We have suggested that regular provision of funds for the support of independent research, which is already available to non-university contractors, would provide a partial remedy. We also have urged that modifications be made in the cost principles relating to interest cost in order to permit universities to acquire the capital funding necessary to acquire new research facilities and equipment.

President and Chancellor

If we are to build effectively on the dialogue which has already been initiated, however, we must go beyond the discussion of cost principles and engage in a meaningful exchange as to the role and purposes of the research universities and the nature of the relationship which they and the Federal government should preserve.

In most major US universities, research is so deeply woven into the fabric of the general university that it no longer stands clearly outlined; the fact that it is an essential part of the national basic research effort is therefore obscured. In contrast, most other nations separate their scientific and technical research from their teaching efforts. They support governmentally financed research institutes separate from their teaching institutions to the serious detriment to both. We must explain this difference and the dynamics of our research universities more effectively if we expect the Federal government to truly understand our special problems and needs.

During the past year a more meaningful dialogue was conducted between the universities and the Federal government than at any prior time in this decade. Both have developed a far deeper understanding of the attitudes and problems of the other.

We look forward now with the hope that this dialogue will provide the foundation upon which we can build once more a relationship which strengthens the universities as institutions and thereby their capacity to help the nation sustain its position of scientific and technological preeminence.

IN SPECIAL RECOGNITION

The individual efforts and distinctions on the part of our faculty have been many during this past year. Two members of the faculty were elected to the National Academy of Engineering, bringing to 50 the total number of M.I.T. faculty in the Academy. The new members this year, both members of the Department of Electrical Engineering and Computer Science, are Professor Peter Elias and Professor Robert G. Gallager. In April, the National Academy of Sciences elected three M.I.T. faculty members, and another who will join our faculty in September 1979, to its ranks, thus bringing the total number of M.I.T. officers and faculty members in the Academy to 76. The new members are Professor Keiiti Aki and Professor Gordon H. Pettengill, both of the Department of Earth and Planetary Sciences, and Dr. Norman C. Rasmussen, head of the Department of Nuclear Engineering. Also elected was Dr. Thomas S. Kuhn of Princeton University who will join our faculty this fall as a professor in the Department of Linguistics and Philosophy and in the Program in Science, Technology, and Society.

In May, three members of the M.I.T. faculty were elected fellows of the American Academy of Arts and Sciences. They are: Professor Daniel G. Quillen of the Department of Mathematics; Professor Carl Wunsch, head of the Department of Earth and Planetary Sciences; and Professor Gene M. Brown, head of the Department of Biology.

Within the Institute, special honor was given this year to Professor David J. Rose of the Department of Nuclear Engineering, who was selected as the recipient of the 1979-80 James R. Killian, Jr., Faculty Achievement Award. The Award is given each year to a member of the faculty in recognition of extraordinary professional accomplishment and service to the Institute. Known for his work in fusion technology, nuclear waste disposal, and his concern for the ethical problems arising from advances in science and technology, Professor Rose was cited by the Faculty selection committee as having had three distinguished careers: "that of scientist and engineer, that of the technology/policy analyst, and that of the bridge builder between the scientific and theological communities."

This past year saw several new appointments to senior posts in the academic administration. They include Dr. Herbert S. Bridge, director of the Center for Space Research; Dr. Ronald C. Davidson, director of the Plasma Fusion Center; Dr. Kent F. Hansen, associate dean of the School of Engineering; Dr. James L. Elliot, director of the George R. Wallace, Jr. Astrophysical Observatory; Dr. John F. Elliott, director of the Mining and Minerals Resources Research Institute established at

President and Chancellor

M.I.T. by the Department of the Interior; Dr. Daniel J. Kleitman, head of the Department of Mathematics (effective July 1, 1979); Dr. Francis E. Low, director of the Laboratory for Nuclear Science; and Dr. Gerald N. Wogan, head of the Department of Nutrition and Food Science.

Several new appointments to senior administrative positions also should receive special mention. Professor James D. Bruce was appointed director of the Industrial Liaison Program, to succeed Professor Samuel A. Goldblith, who was appointed in September as Vice President for Resource Development at the Institute. In November, Dr. James A. Hester was selected Executive Vice President of the M.I.T. Alumni Association, succeeding Mr. James A. Champy, who left the Institute to enter private business.

The past year also marked the retirement of seven distinguished members of the faculty. Their years of service to the Institute and to their students will long be remembered and appreciated. They are James M. Austin, professor of meteorology and director since 1969 of the Summer Session; Murray Eden, professor of electrical engineering on leave at the National Institutes of Health; John W. Irvine, Jr., professor of chemistry; Robert I. Rathbone, professor of technical communication; Claude E. Shannon, Donner Professor of Science and professor of electrical engineering and mathematics; Theodore Wood, Jr., professor of literature and American studies; and Henry J. Zimmermann, professor of electrical engineering and former director of the Research Laboratory of Electronics.

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

Professor Frederick J. Adams, an internationally known city planner and first head of the Department of City and Regional Planning (as it was called in 1944), died in March 1979, at the age of 77. He guided the department in its development as a foremost center in the field and was a valued member of the M.I.T. faculty for 38 years.

Dr. Henry A. Hill, an M.I.T. alumnus and distinguished member of the Corporation, died suddenly in March 1979, at the age of 63. An organic chemist himself, Dr. Hill strongly encouraged the expansion of educational opportunities for members of minority groups in science and engineering at the Institute, and was especially interested in fostering closer working relationships between science and industry.

Professor Daniel B. Ray of the Department of Mathematics died in February 1979, following a heart attack. A member of the M.I.T. faculty since 1957, Professor Ray was an international authority on many aspects of mathematical analysis and for many years took an active and valued role in the administration of the department.

Dr. Louis S. Scaturro, an assistant professor of nuclear engineering, died in May 1979, following a heart attack. At the age of 28 he was considered a pioneer in the study of power loss from plasmas, and his untimely death cut short a life of promise.

Dr. Donald S. Tucker, professor of economics at M.I.T. from 1919 until his retirement in 1955, died in February 1979, at the age of 94. His enthusiasm for teaching was legendary and his spirit of good cheer infected his colleagues and classrooms alike.

Mr. George R. Wallace, Jr., donor of M.I.T.'s Wallace Astrophysical Observatory and the Wallace Geophysical Observatory, died in September 1978, at the age of 88. An M.I.T. alumnus and noted philanthropist, his generosity and vision contributed greatly to the development of the earth and planetary sciences at the Institute.

JEROME B. WIESNER, PRESIDENT
PAUL E. GRAY, CHANCELLOR

Statistics for the Year

The following paragraphs report briefly on the various aspects of the Institute's activities and operations during 1978-79.

Registration

In 1978-79 student enrollment was 8,881, an increase of 169 over the 8,712 in 1977-78. This total was comprised of 4,594 undergraduates and 4,287 graduate students. Graduate students who entered M.I.T. last year held degrees from 388 colleges and universities, 239 American and 149 foreign. The foreign student population was 1,633, representing 18 percent of the total population. The foreign students were citizens of 93 countries.

Degrees awarded by the Institute in 1978-79 included 1,187 bachelor's degrees, 972 master's degrees, 65 engineer's degrees, 381 doctoral degrees -- a total of 2,605.

The number of women at M.I.T., both graduate and undergraduate, has increased continually. In 1978-79, there were 1,466 women students at the Institute, compared with 1,382 in 1977-78. In September 1978, 231 first-year women entered M.I.T., representing 22 percent of the entering class.

Minority* students at M.I.T. have increased in numbers as well. In 1978-79, there were 685 minority students (graduate and undergraduate) at the Institute, compared with 635 in 1977-78. The first-year class entering in September 1978 contained 162 minority students, representing 15 percent of the class.

Student Financial Aid

During the 1978-79 year the student financial program was again characterized by increases in the overall need for financial aid.

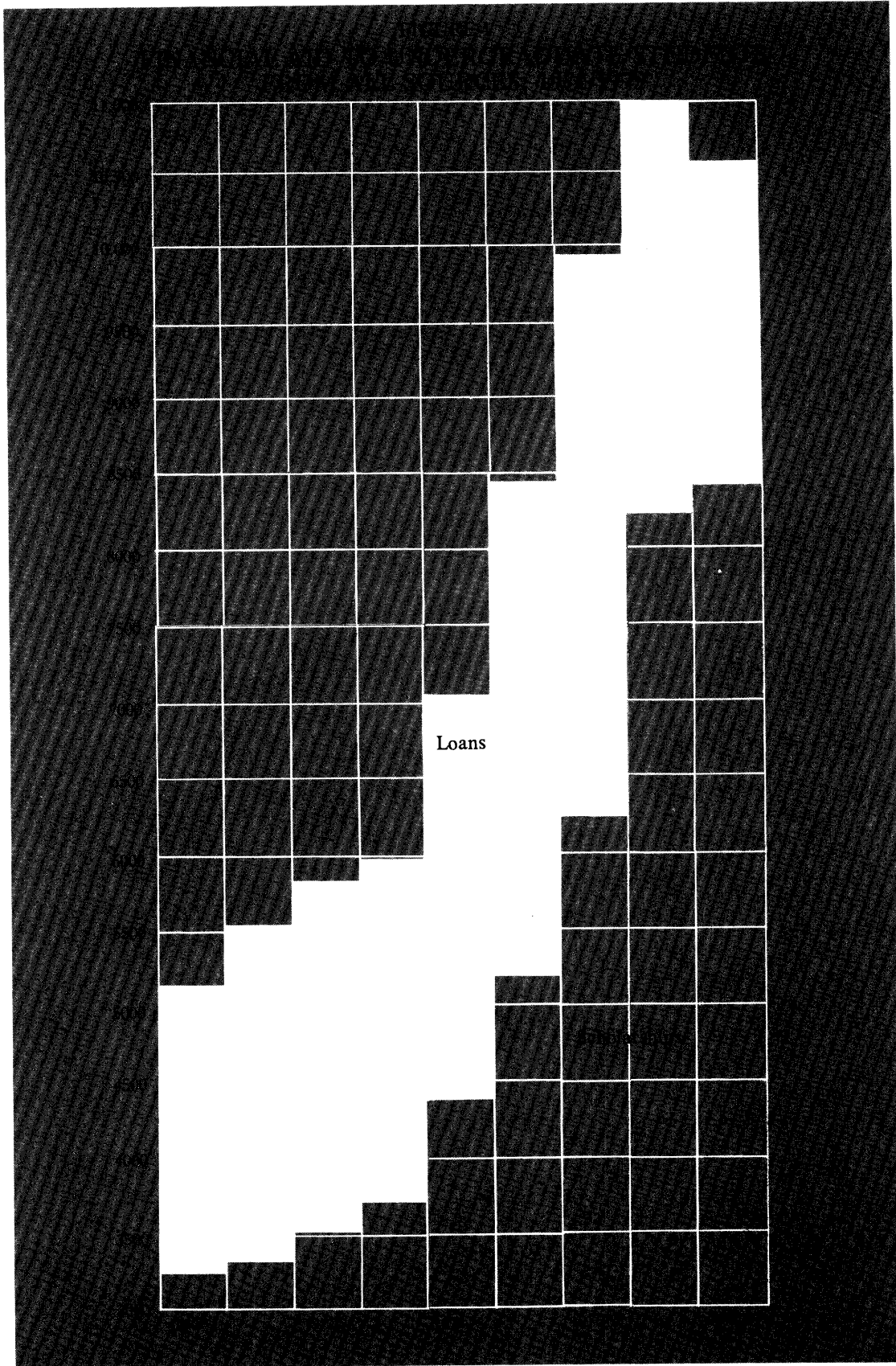
A total of 2,235 undergraduates who demonstrated the need for assistance (49 percent of the enrollment) received \$6,788,761 in scholarship aid and \$2,139,511 in loans. The total \$8,928,272, represents a slight decrease in aid compared with last year. (There was a significant decrease in the amount of M.I.T. loans awarded, and a corresponding increase in loans obtained from commercial sources.)

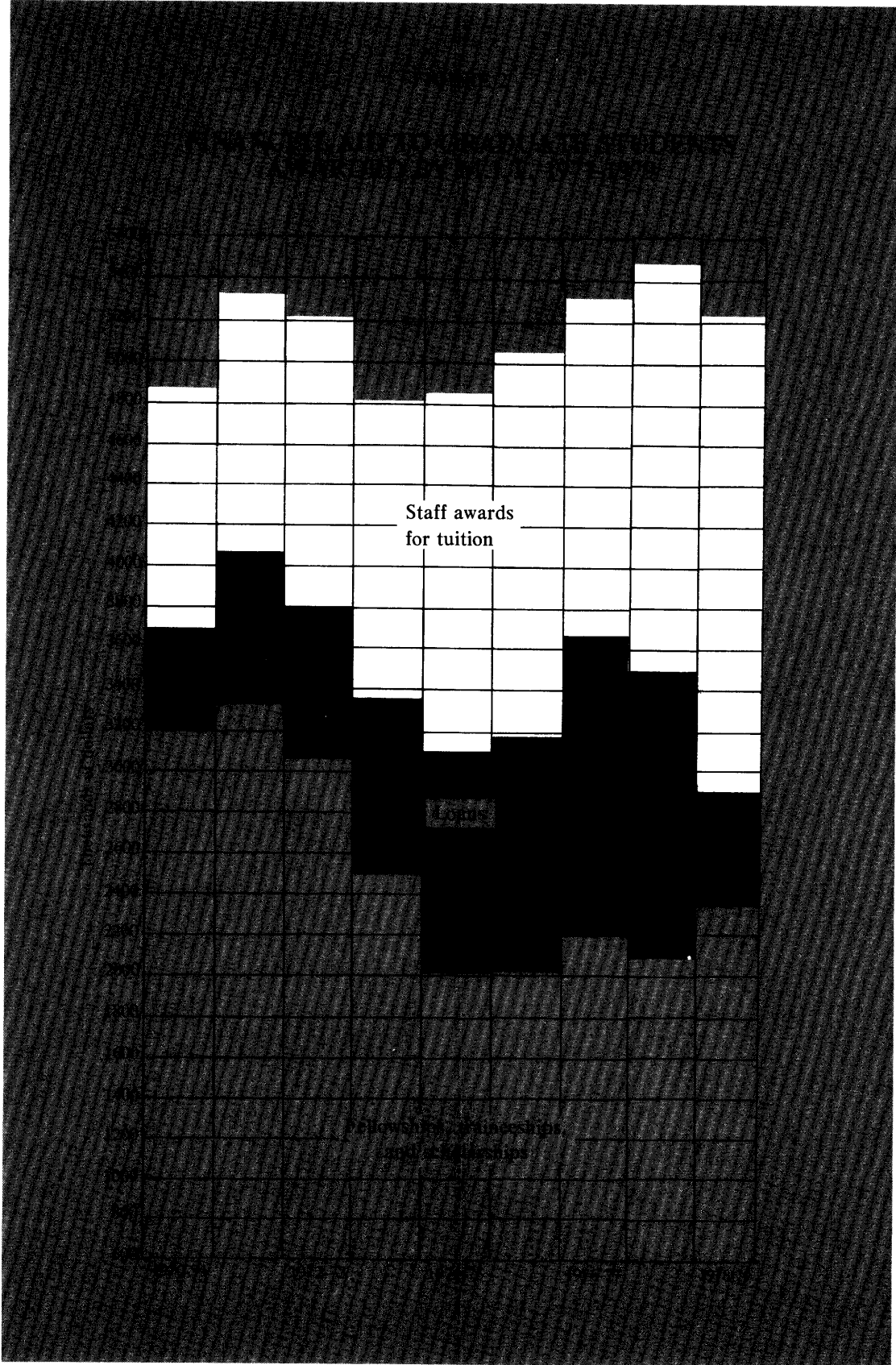
Scholarship assistance was provided by the scholarship endowment in the amount of \$2,262,313, by outside gifts for scholarships in the amount of \$1,028,564, and by direct grants to needy students totaling \$1,651,967 (an increase of 23 percent). Scholarship assistance from M.I.T.'s own operating funds was provided to the extent of \$1,385,000 (a 16 percent increase). The special program of scholarship aid to minority group students represented an additional \$136,925 from specially designated funds. An additional 242 students received direct grants from outside agencies, irrespective of need. The undergraduate scholarship endowment was aided by the addition of new funds which represented an increase of about \$500,000 and which raised the principal of the endowment to \$26,173,000.

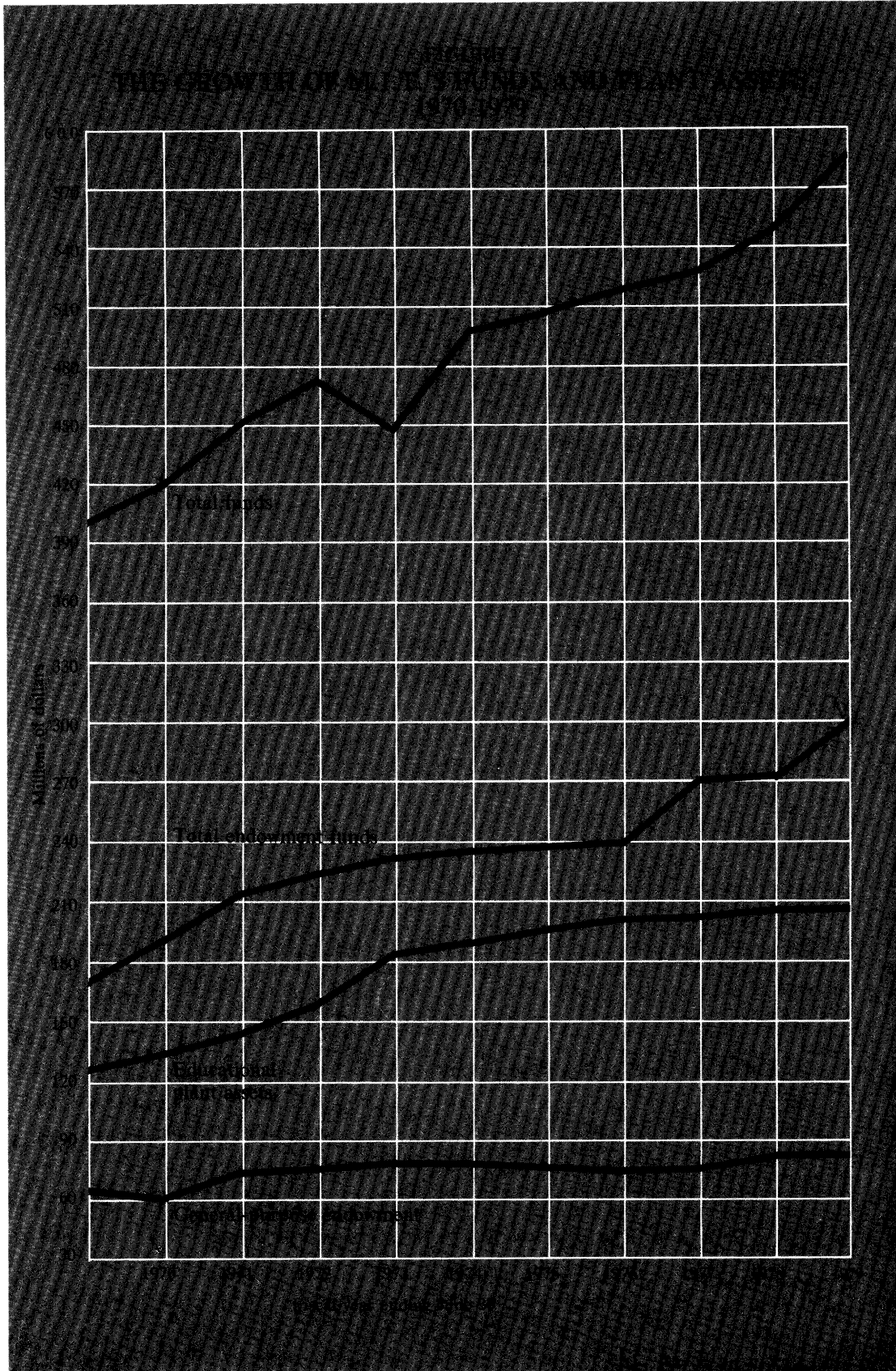
Loans totaling \$2,139,511 were made to needy undergraduates. Of this amount, \$365,351 came from the Technology Loan Fund, and \$1,774,160 from the National Direct Student Loan Program. An additional \$1,929,203 (a 60 percent increase) was obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources.

Graduate students obtained \$538,434 from the Technology Loan Fund and \$429,286 from the National Direct Student Loan Program. The total, \$967,720, represents a 31 percent reduction compared with last year's level, reflecting the wider availability of state-guaranteed student loans. Of this total, \$209,794 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 (\$3,107,231) was a decrease of 26 percent from last year's total.

* Minority students include Blacks (non-Hispanic), Native Americans (including Alaskan Natives), Hispanics, and Asian or Pacific Islanders.







Career Planning and Placement

A quickening demand for the Institute's graduates in engineering and the physical sciences rose to a crescendo in 1978-79, with 416 separate organizations coming to the Career Planning and Placement Office to interview prospective employees. The office was the scene of 8,527 recruiting interviews. In only three years since World War II has the interview count exceeded 8,000. The demand was also strong for graduates of the Sloan School.

Confirming the evidence of interview schedules, starting salaries in many fields went up sharply, exceeding the 7 percent of Washington's wage and price regulations if not the rate of inflation. In electrical engineering, where demand was particularly strong, bachelor's salaries rose 13 percent (beating the rising cost of living by three percentage points). In management, master's salaries jumped 13 to 20 percent. The *median* salary accepted by masters was \$20,400, and the median accepted by doctors was \$25,520. The Sloan School reported an *average* starting salary for its master's graduates of \$28,700 (up from \$23,800 in 1977-78).

In other fields the employment picture was mixed. In architecture, for example, the demand for graduates showed signs of strengthening after several lean years, perhaps reflecting new approaches in the profession to the servicing of clients' needs. Graduate students and post-doctorals in the life sciences came to the office in increased numbers to discuss the alternatives to academic employment.

The high demand for engineering graduates showed itself in the area of Alumni Career Services. Demand was particularly strong for electrical, mechanical, and chemical engineers, as well as for graduates in computer science. Many employers felt the need to come to the office in person to announce their requirements. The increase in employer activity was matched by a drop in the number of alumni requesting placement assistance. Favorable as the market was for job seekers, however, 40 percent of registrants still took six months or more to find satisfactory employment. Compared with 1977-78, this year's registrants were generally older, held higher degrees, and were at higher salary levels. Fifty-seven percent were over 40 and 41 percent earned over \$30,000. Fewer registrants were in manufacturing, and more were in service organizations (consulting, government, teaching, and so forth). A number were engaged in significant career changes, among them faculty members leaving academia and officers retiring from the military.

Finances

As reported by the Vice President for Financial Operations and the Treasurer, the total financial operations of the Institute, including sponsored research, increased from the level of 1977-78. Education and general expenses -- excluding the direct expenses of departmental and inter-departmental research, and the Lincoln Laboratory -- amounted to \$144,069,000 during 1978-79, compared to \$130,928,000 in 1977-78. Reflected in the finances of the Institute was the use in operations of unrestricted funds of \$5,565,000, compared with \$5,875,000 the preceding year.

The direct expenses of campus departmental and interdepartmental sponsored research increased from \$89,736,000 to \$107,521,000, and the direct expenses of the Lincoln Laboratory's sponsored research increased to \$102,279,000 from \$96,595,000 because of an overall increase in government research support.

The construction program of the Institute continued to make progress in 1978-79 with the book value of educational plant facilities increasing from \$205,992,000 to \$208,195,000.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, students' notes receivable, and amounts due from educational plant, had a book value of \$387,463,000 and a market value of \$467,349,000. This compares to book and market values of \$348,481,000 and \$409,603,000 last year.

Gifts

Gifts, grants, and bequests to M.I.T. from private donors increased from \$31,287,000 in fiscal year 1977-78 to \$33,944,000 in fiscal year 1978-79. The latter figure includes unrestricted direct gifts to the Alumni Fund of \$2,021,000 which constituted part of the total of \$5,158,000 reported by the Alumni Fund in 1978-79.

Physical Plant and Campus Environment

Construction of a facility to house a 10-megawatt, superconducting, cryogenic generator adjacent to the High Voltage Laboratory was completed during the year. The generator, driven by a gas turbine engine, will eventually have its output fed into the Cambridge Electric Company system for a 30-day period to test the feasibility of this innovative approach to electric generation.

Other construction projects completed during the year included a 13,000 gross square foot (gsf) Interim Animal Care Facility on Vassar Street; renovations to the Suffolk Building, E38; and construction of three lecture halls of the Sloan School of Management in Building E51.

The following projects are in design: a 122,000 gsf building for the Whitaker College of Health Sciences, Technology, and Management; a 95,000 gsf Medical Services Building; an 111,000 gsf Athletic Facility; an 8,000 gsf Animal Care Facility within Building E18; and a complete renovation program for the Webster Building, E40.

Various facilities studies were conducted during the year and a number of space change renovations and renewal projects were completed. Included among the latter were facilities for the Laboratory for Nuclear Science, Department of Biology, Department of Chemistry, Department of Meteorology, Research Laboratory of Electronics, Department of Architecture, Center for Materials Research in Archaeology and Ethnology, and the Center for Materials Science and Engineering.

In the fall of 1978, after careful study of admissions information, campus housing retention rates, and proposed alternatives to relieve some of the resultant dormitory crowding problems, the decision was made to proceed with the design of a new undergraduate housing facility for 300 students. A "Program Planning Group" consisting of students, faculty, and staff was formed. This group met during the winter and produced a report which is now being used to generate a facilities program. It is planned that construction of the dormitory will begin in March of 1980 with occupancy scheduled for September 1981.

The major maintenance program to upgrade the quality of residential facilities continues with several projects completed or under way. A major project this year is the conversion of the Westgate heating system from an independent boiler to the central steam system. It is expected to be completed before next year's heating season begins and will provide a more efficient and economical system. Major renovations to the graduate residents' facilities in Baker House are also under way. The sprinkler protection system, planned in conjunction with the Safety Office, is proceeding in McCormick Hall public areas and the apartment kitchens in Eastgate.

At the initiative of the Vice President for Operations and the Dean for Student Affairs, the Chancellor appointed a Committee on Campus Dining. The committee was charged to review the existing dining programs and to submit comprehensive recommendations which will enhance the quality of the living, learning, and working environment on campus. It is anticipated that these recommendations will be made early next year.

Personnel Changes

CORPORATION

CHANGES OF APPOINTMENT

Russell DeYoung
Life Member Emeritus

Luis A. Ferre
Life Member Emeritus

Ida M. Green
Life Member Emerita

James R. Killian, Jr.
Life Member Emeritus

Helen F. Whitaker
Life Member

ELECTIONS

Herman R. Branson
Member

Frank T. Cary
Member

Paulette Coleman
Member

Edward E. David, Jr.
Member

S. James Goldstein
Member

Maurice F. Granville
Member

Edward R. Kane
Member

Joe F. Moore
Member

J. Paul Sticht
Member

Emily V. Wade
Member

Thornton A. Wilson
Member

MEMBERS EX-OFFICIO

Claude W. Brenner
President
Alumni Association

Edward J. King
Governor
Commonwealth of
Massachusetts

TERMS EXPIRED

Thomas F. Creamer
Member

Michael S. Dukakis
Ex-Officio Member
Governor of the
Commonwealth

Paul F. Hellmuth
Member

Jerome H. Holland
Member

Wilfred D. MacDonnell
Member

Charles E. Reed
Member

Cecily C. Selby
Member

Jeptha H. Wade
Member

Katrina M. Wootton
Member

DEATH

Henry A. Hill
Member

FACULTY

DEATHS

Gilbert W. Low
Assistant Professor in
Sloan School of Management

Daniel B. Ray
Professor in Mathematics

Louis S. Scaturro
Assistant Professor in
Nuclear Engineering

RETIREMENTS

James M. Austin
Professor in Meteorology

John W. Irvine, Jr.
Professor in Chemistry

Yao-Tzu Li
Professor in Aeronautics
and Astronautics

Robert R. Rathbone
Professor in Humanities

Claude E. Shannon
Professor in Electrical
Engineering and
Computer Science

Isadore M. Singer
Professor in Mathematics

Theodore Wood, Jr.
Professor in Humanities

Henry J. Zimmermann
Professor in Electrical
Engineering and
Computer Science

RESIGNATIONS

Professors

John W. Cahn
Materials Science and Engineering

Personnel Changes

Murray Eden
Electrical Engineering and
Computer Science

Norman Jones
Ocean Engineering

Associate Professors

Franklin F. Alvarez
Ocean Engineering

Michael C. Archer
Nutrition and Food Science

Kenneth Brecher
Physics

Whitney Chadwick
Architecture

Wayne A. Cornelius
Political Science

John W. Devanney
Ocean Engineering

John S. Dickey, Jr.
Earth and Planetary Sciences

Richard G. Donnelly
Chemical Engineering

Dolores Hayden
Architecture

Sidney M. Hecht
Chemistry

Ronald A. Hites
Chemical Engineering

Norberto L.M. Kerzman
Mathematics

Jeffrey E. Mandula
Mathematics

James W. Mark
Mathematics

Edward Y. Miller
Mathematics

Michael Pyatok
Architecture

Stephen J. Vamosi
Architecture

Thomas R. Willemain
Urban Studies and Planning

Assistant Professors:

David M. Camp
Chemical Engineering

Flora Y.-F. Chu
Electrical Engineering and
Computer Science

Raymond Deck
Humanities

Edward M. Graham
Sloan School of Management

Jennifer Humphrey
Humanities

Cyril Leung
Electrical Engineering and
Computer Science

Thomas D. Lockwood
Nutrition and Food Science

Kenneth S. Mericle
Sloan School of Management

Dirk J. Muehlner
Physics

Thomas E. Nutt-Powell
Urban Studies and Planning

Eugene B. Trubowitz
Mathematics

Sean Wellesley-Miller
Architecture

PROMOTIONS

To Professor:

George Boolos
Linguistics and Philosophy

Joan Bresnan
Linguistics and Philosophy

Wit Busza
Physics

Michael S. Feld
Physics

Merrill F. Garrett
Psychology

Jerry Hausman
Economics

Charles E. Holt
Biology

Jonathan King
Biology

Richard C. Larson
Electrical Engineering and
Computer Science

Thomas L. Magnanti
Sloan School of Management

Richard B. Melrose
Mathematics

John W. Negele
Physics

Robert S. Pindyck
Sloan School of Management

Stephen D. Senturia
Electrical Engineering and
Computer Science

Richard L. Schmalensee
Sloan School of Management

Phillip A. Sharp
Biology

Richard P. Stanley
Mathematics

Annamaria Torriani-Gorini
Biology

Erick H. Vanmarcke
Civil Engineering

Roy E. Welsch
Sloan School of Management

To Associate Professor:

Harold Abelson
Division for Study and
Research in Education

Robert C. Armstrong
Chemical Engineering

Tanya M. Atwater
Earth and Planetary Sciences

Raymond M. Baker
Biology

Thomas A. Barocci
Sloan School of Management

President and Chancellor

Michael J. Bevan
Biology

Rafael L. Bras
Civil Engineering

Joel P. Clark
Materials Science and Engineering

Michael P. Cleary
Mechanical Engineering

Lloyd S. Etheredge
Political Science

Christos Georgakis
Chemical Engineering

Dorian M. Goldfeld
Mathematics

David C. Gossard
Mechanical Engineering

Edward M. Greitzer
Aeronautics and Astronautics

Linda M. Hall
Biology

Mujid S. Kazimi
Nuclear Engineering

Stephen J. Kobrin
Sloan School of Management

Steven R. Lerman
Civil Engineering

Raymond E. Levitt
Civil Engineering

Manuel Martinez-Sanchez
Aeronautics and Astronautics

Nathaniel J. Mass
Sloan School of Management

Jeffrey A. Meldman
Sloan School of Management

Philip C. Myers
Physics

Starr Ockenga
Architecture

Derek Rowell
Mechanical Engineering

Edward I. Solomon
Chemistry

Stephen G. Steadman
Physics

Chong S.P. Sung
Materials Science and Engineering

Toyoichi Tanaka
Physics

Harry L. Tuller
Materials Science and Engineering

J. Kim Vandiver
Ocean Engineering

Stephen A. Ward
Electrical Engineering and
Computer Science

Martha W. Weinberg
Political Science

John L. Wilson
Civil Engineering

To Assistant Professor:

David M. Camp
Chemical Engineering

Joshua Cohen
Linguistics and Philosophy
and Political Science

Susan Dickman
Humanities

Frederick Hodgson
Humanities

Harry F. Minor
Urban Studies and Planning

Frank Morgan
Mathematics

Wilburn Williams
Humanities

CHANGES OF APPOINTMENT

George E. Abouseif
Assistant Professor in
Mechanical Engineering

John L. Bassani
Assistant Professor in
Mechanical Engineering

Richard H. Battin
Adjunct Professor in
Aeronautics and Astronautics

Adam C. Bell
Lecturer in Mechanical Engineering

George B. Benedek
Alfred H. Caspary Professor of
Physics

Rafael L. Bras
Gilbert W. Winslow Associate
Professor in Civil Engineering

James D. Bruce
Professor of Electrical Engineering
and Director of Industrial Liaison

B. Shawn Buckley
Lecturer in Mechanical Engineering

Mark A. Cane
Assistant Professor of Oceanography
in Meteorology

Richard L. Cartwright
Professor Philosophy and Acting
Head of Humanities

Patricia Cumming
Research Associate in Humanities

Antonio DiMambro
Assistant Professor in
Architecture

Eric Dluhosch
Associate Professor in
Architecture

Maher A. El-Masri
Assistant Professor in
Mechanical Engineering

Maurice S. Fox
Lester Wolfe Professor of Molecular
Biology

Terry L. Friesz
Visiting Assistant Professor
in Civil Engineering

Alan K. Graham
Research Associate in Sloan
School of Management

Leon B. Groisser
Associate Professor and Acting
Head of Architecture

Personnel Changes

Madhu S. Gupta
Visiting Scientist in
Research Laboratory of
Electronics

Linda M. Hall
Visiting Associate Professor
in Biology

Kent F. Hansen
Professor in Nuclear Engineering
and Associate Dean of the School
of Engineering

David E. Hardt
Assistant Professor in
Mechanical Engineering

Otto K. Harling
Professor in Nuclear Engineering
and Director of the Nuclear
Reactor Laboratory

Neville Hogan
Assistant Professor in
Mechanical Engineering

Daniel J. Kleitman
Professor of Applied Mathematics
and Head of Mathematics

Shimon Levit
Assistant Professor in Physics

Bernard C. Levy
Assistant Professor in
Electrical Engineering and
Computer Science

Francis E. Low
Karl Taylor Compton Professor of
Physics and Director, Laboratory
for Nuclear Science

Douglas E. Mahone
Assistant Professor in Architecture

John D.W. Morecroft
Assistant Professor in Sloan School
of Management

Michael A. Moskowitz
Associate Professor in
Nutrition and Food Science

Charles M. Oman
Principal Research Scientist in
Aeronautics and Astronautics

Ithiel de Sola Pool
Professor and Acting Head of
Political Science

Harilaos N. Psarافتis
Assistant Professor of Marine
Systems in Ocean Engineering

David A. Randall
Visiting Assistant Professor in
Meteorology

Nils R. Sandell
Visiting Scientist in Laboratory
for Information and Decision
Systems

Campbell L. Searle
Professor in Electrical Engineering
and Computer Science

Arthur C. Smith
Professor in Electrical Engineering
and Computer Science and Acting
Director, Office of Minority
Education

Nawal K. Taneja
Principal Research Engineer in
Aeronautics and Astronautics

Michael S. Triantafyllou
Assistant Professor in Ocean Engineering

Bonnie M. Tyler
Visiting Associate Professor in
Biology

Michèle F. Vergne
Associate Professor in Mathematics

Gerald N. Wogan
Professor of Toxicology and
Head of Nutrition and Food
Science

Lothar Wolf
Research Affiliate in
Nuclear Engineering

Ian T. Young
Lecturer in Electrical
Engineering and Computer
Science

NEW FACULTY APPOINTMENTS

Professors:

Edward H. Bowman
Sloan School of Management

Jeffrey P. Freidberg
Nuclear Engineering

Thomas S. Kuhn
Linguistics and Philosophy and
Program in Science, Technology,
and Society

William H. Orme-Johnson
Chemistry

Associate Professors:

Richard P. Bagozzi
Sloan School of Management

Thomas P. Bligh
Mechanical Engineering

John V. Gutttag
Electrical Engineering and
Computer Science

Peter G.W. Keen
Sloan School of Management

Lowell E. Lindgren
Humanities

Ellen B. Voigt
Humanities

Assistant Professors:

Ralph G. Bennett
Nuclear Engineering

Ahmet N. Berker
Physics

Robert A. Brown
Chemical Engineering

Peter Brownell
Sloan School of Management

Richard J. Cohen
Physics and Harvard-M.I.T.
Division of Health Sciences and
Technology

Lewis Erwin
Mechanical Engineering

Michael N. Fardis
Civil Engineering

Elizabeth Garrels
Humanities

Roscoe C. Giles
Physics

President and Chancellor

Timothy L. Grove
Earth and Planetary Sciences

David M. Halperin
Humanities

Robert H. Halstead, Jr.
Electrical Engineering and
Computer Science

Paul K. Houpt
Mechanical Engineering

Emma L. Jackson
Political Science

Robert V. Kenyon
Aeronautics and Astronautics

Bruce M. Kramer
Mechanical Engineering

Roman Krzysztowicz
Civil Engineering

Theodore C. Landsmark
Urban Studies and Planning

Robert B. Litterman
Economics

Kim Molvig
Nuclear Engineering

James B. Orlin
Sloan School of Management

Richard E. Passarelli, Jr.
Meteorology

Christos H. Papadimitriou
Electrical Engineering and
Computer Science

David M. Parks
Mechanical Engineering

Robert P. Redwine
Physics

Rodolfo Rosales
Mathematics

Thomas M. Stoker
Sloan School of Management

Lawrence H. Summers
Economics

Beeke S. Tower
Architecture

Ka Kit Tung
Mathematics

George C. Vergheze
Electrical Engineering and
Computer Science

John Wilkes
Humanities

Clifford Winston
Civil Engineering

M. Anthony Wong
Sloan School of Management

John L. Wyatt, Jr.
Electrical Engineering and
Computer Science

VISITING FACULTY

Visiting Professors:

Prodyot K. Bhattacharya
Mathematics

Elizabeth Bishop
Humanities

George Bluestone
Humanities

Jerome S. Bruner
Division for Study and Research
in Education and Psychology

Paolo Ceccarelli
Urban Studies and Planning

Ranjit K. Chandra
Nutrition and Food Science
and Associate Director,
Clinical Research Center

Antonio P. de Carvalho
Whitaker College of Health Sciences,
Technology, and Management

James Durbin
Sloan School of Management

Merrill L. Ebner
Mechanical Engineering

Dieter Filbert
Electrical Engineering and
Computer Science

Michael Fisher
Physics

William D. Gregory
Materials Science and Engineering

Daniel Greenberger
Physics

John E. Hart
Meteorology

David K. Hsiao
Sloan School of Management

Rosabeth M. Kanter
Sloan School of Management

Paul Kruger
Civil Engineering

André L. Lichnerowicz
Mathematics

Gunter Lorenzl
Center for International Studies

Robert B. McKersie
Sloan School of Management

Manfred R. Michel
Electrical Engineering and
Computer Science

Neville P. Moray
Mechanical Engineering

Adrian V. Polk
Aerospace Studies and
Director of the A.F.R.O.T.C.
Program

Mark Roskill
Architecture

Hasso F. Schreck
Architecture

George S. Springer
Mechanical Engineering

Martin Steinman
Architecture

Christopher A. Sims
Economics

Edvard J. Solnes
Mechanical Engineering

Ezio Tarantelli
Sloan School of Management

Seiya Uyeda
Earth and Planetary Sciences

Personnel Changes

Hertha von Dechend
Program in Science, Technology,
and Society

Eugene Wong
Electrical Engineering and
Computer Science

Visiting Associate Professors:

Hans C. Bjornsson
Civil Engineering

Joan F. Bliss
Division for Study and Research
in Education

Felicia Bonaparte
Humanities

Haim Gershoni
Mechanical Engineering

Bernard R. Gifford
Urban Studies and Planning

Ellis Horowitz
Electrical Engineering and
Computer Science

Nai-Chien Huang
Mechanical Engineering

William R. Keylor
Humanities

Frieder Lenz
Physics

Antonio A. Luraschi
Materials Science and Engineering

Dietrich Naunin
Electrical Engineering and
Computer Science

John M. Ogborn
Division for Study and Research
in Education

Michael Pittas
Architecture

Friedrich Prinz
Mechanical Engineering

Gedaliah Shelef
Civil Engineering

Mahmoud A. Younis
Mechanical Engineering

Hiroaki Wakabayashi
Nuclear Engineering

Edwin Williams
Linguistics and Philosophy

Visiting Assistant Professors:

Mark Adler
Mathematics

Joseph J. Beaman, Jr.
Mechanical Engineering

Christie M. Coffin
Architecture

Thomas R. Copeland
Mechanical Engineering

Judith I. de Neufville
Urban Studies and Planning

Antonio DiMambro
Architecture

Paul R. Krugman
Sloan School of Management

Yuan-chu R. Lam
Humanities

Valerie I. Nelson
Urban Studies and Planning

Kevin W.S. Roberts
Economics

Dan Shneerson
Ocean Engineering

AWARD

Morris Halle
Killian Award Lecturer for
the Academic Year 1978-79

ADMINISTRATION

RESIGNATIONS

Edwin M. Arippol
Industrial Liaison Officer
Industrial Liaison Program

Jurate Barnes
Manager, Computer Resources
Resource Development

Arthur C. Beals
Associate Director
Housing and Food Services

Roxanna S. Billings
Administrative Assistant
Department of Aeronautics
and Astronautics

Burton C. Bluestone
Senior Consultant Trainer
Office of Personnel Development

Mary Jane Burke
Auditor
Audit Division

Peter Büttner
Associate Dean
Dean for Student Affairs

Francis A. Canali
Systems Analyst
Information Processing Services

Suzanne Chen
Senior Applications Analyst
Information Processing Services

Deborah Colaw
Programming Analyst
Information Processing Services

Allen Commeau
Senior Staff Accountant
Comptroller's Accounting Office

Lynn M. Dickey
Administrative Officer
Department of Earth and
Planetary Sciences

Martha S. Draper
Regional Director
Alumni Association

Lisa C. Egbuonu
Assistant to the Director,
Office of Minority Education
Office of the Provost

Eric H. Engberg
Programming Analyst
Information Processing Services

Susanne Fairclough
Editor/Writer
Alumni Association

Martin Frey
Senior Applications Analyst
Office of Facilities Management
Systems

President and Chancellor

Kevan Fulmer
Administrative Officer
Laboratory of Architecture
and Planning

Charna Garber
Administrator
Information Processing
Services

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

Marc S. Gerstein
Assistant Curator
Committee on the Visual Arts

Karen Goode
Senior Staff Accountant
Student Accounts

Guy Guidone
Manager, Food Services
Housing and Food Services

Alan E. Harger
Assistant to the Director
Center for Policy Alternatives

Sharon L. Harris
Financial Administrator
Department of Chemistry

Douglas Hill
Applications Programmer
Information Processing Services

Donald B. Johnson
Director, Development Office
Resource Planning

Marilyn Katz
Administrative Officer
School of Humanities
and Social Science

Andrew Koppel
Co-Manager of In-House
Composition Systems
MIT Press

Florence C. Ladd
Associate Dean
School of Architecture
and Planning

Sally M.R. Leonard
Administrative Dietician
Housing and Food Services

John Lynch
Director, Tutored Video
Instruction
Center for Advanced
Engineering Study

John L. Mack
Associate Director
Admissions Office

Richard McDevitt
Budget Officer
Fiscal Planning and
Budget Office

Cheryl A. Murphy
Assistant Director, UROP
Office of the President
and Chancellor

Sara Neustadt
Managing Editor
Alumni Association

Margaret Norris
Assistant to the Dean
Dean for Student Affairs

Paul A. Palmisciano
Systems Analyst
Information Processing
Services

Janice Phillips
Systems Programmer
Information Processing
Services

James F. Purtell
Manager of Program Development
Information Processing
Services

Wayne Richards
Manager, Computer Facility
Information Processing
Services

Arturo A. Rosales
Assistant Director
Industrial Liaison Program

Richard O. Salmon
Assistant Financial Manager
MIT Press

Sophia M. Sieczkowski
Administrative Assistant
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Zenobia D. Andrus
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Arthur L. Anger
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Dean for Student Affairs

Introduction: A Year of Review

Last fall, following Dean Carola Eisenberg's resignation, Chancellor Paul Gray delegated to me his reporting responsibilities for Student Affairs and asked me to conduct a review and reorganization of the Dean's Office, and to review, as well, the organization of the other student-related responsibilities throughout the Administration. These include the Career Planning and Placement Office, Admissions, Financial Aid, Registrar, Student Accounts and Student Loans, Housing and Food Services, and the Graduate School Office (to the extent that the Office of the D.S.A. would provide services to graduate students). In addition, other areas, such as the Medical Department and Campus Patrol (which are more than student-related services) have close working relations with the Dean's Office, and, of course, the Athletic Department has reported through the D.S.A.

Since the review was a major activity in the work of the Dean's Office last year, we have devoted the first section of this annual report to an account of the review, followed by the traditional reports from each of the Dean's Office sections, assembled by Professor Robert Halfman.

Effective September 1, 1978, Professor Halfman served as Acting Dean with operational responsibilities for the Office; I am grateful to him and to everyone on the staff of the Office of the Dean for Student Affairs for their enthusiastic support of the review during the year and for their hard work and dedication in maintaining the momentum of the Office work and in strengthening communications with students and other student support offices throughout the Institute.

During the fall term, I met with hundreds of students and many faculty members, including all of the relevant groups and committees, with much help from Kathryn Lombardi and David Wiley (my associates in the Analytical Studies and Planning Group of the Office of the President and Chancellor). We listened to a great many points of view, to ideas for improvement, and to critical assessments of the Dean's Office, of student services in general, and of the relations between these services and the academic program. During the month of October we worked also with the Graduate Student Council Executive Committee which prepared presentations for the meeting of the Visiting Committee on Student Affairs on October 26-28.

During January, I participated in the work of the Program Planning Group for the new dormitory. Through its series of intensive meetings, as well as through several meetings with the Interfraternity Conference Executive Committee and the Faculty Housemasters, I learned a lot about the residential program. At the same time, I met with groups of black students and women students, both undergraduate and graduate. Also, we had several sessions with the Housing Office staff, and with several other student-related offices and staffs, in order to begin the review of the services which lie outside the Dean's Office.

Also during January we discussed the progress of the review in some detail with the academic Deans and the Academic Council. Beginning on February 1, we put together our findings and reviewed the summary of observations and needs with several groups, such as the Executive Committee of the Corporation, the academic Department Heads, the Committee on Educational Policy (C.E.P.) and the Housemasters. Our summary was further refined through several iterations in February and March. Appendix A to this report is a copy of a revised outline as it was presented at the faculty meeting on March 21.

Dean for Student Affairs

In response to these findings we began to develop a set of directions of change pertaining to the Dean's Office organization and functions. There is no detailed narrative of these changes, but I met and discussed them with several groups, including the faculty and the Undergraduate General Assembly, both on March 21. Appendix B is a summary of these directions of change in the form of a list of proposed actions and proposed reorganization of the Dean's Office service components.

The General Observations (Appendix A) and the Directions of Change developed in the spring (Appendix B) represent the two principal phases of the review. Our target was to complete, report, and discuss with the community these two phases by the March faculty meeting (which was also the first day of spring) and then move on to the implementation phase.

Phase three began on April 1 with the search for a new Dean and a plan for implementation of the Directions of Change.

Appendix C is the announcement for the Dean's position which appeared in *The Chronicle of Higher Education* and *The New York Times*, as well as other local and national media. On April 4 an Advisory Committee on the selection of the new Dean was appointed by the Chancellor. This Committee has six faculty members, including Anthony P. French, Professor of Physics, as chairman, and four students (two undergraduate and two graduate, including the Undergraduate Association president and the Graduate Student Council president and the chairman of the Interfraternity Conference). The Advisory Committee's role is to assist in the search process and to narrow down the candidates to a short list from whom the senior administration will make the final selection and appointment. We had hoped to name the new Dean by September 1. But completion of the search has been delayed by a large list of applications and nominations (about 350) and several weeks during the summer when the Advisory Committee could not meet because of several members' prior commitments. We now hope to make the appointment of a new Dean in the fall term.

Since the review of areas outside the D.S.A. Office is not completed yet -- and hence the question of reporting responsibilities for student services throughout the Institute is not settled -- the Chancellor has asked me to continue as the senior officer responsible for Student Affairs; the Dean's Office and the Department of Athletics will continue to report through me, until the student-related review is complete and the new concepts in the Dean's Office are implemented.

I have confidence that our approach and the directions we have charted for the Dean's Office are sound, well understood, and supported by the faculty and students who have taken the interest and time to engage in this process. I am less sanguine, however, about securing the resources that will be required to make all of our ideas work out as planned. Furthermore, the space implications, or rather complications, are not minor and may well slow down some of our planned changes. We are now in the midst of the delicate stage of working out the people and money and space plans that will put into place our concept for future operation.

The purpose of this account is to provide a general sense of the process and the course of the review, leaving the communication of the substance of what we accomplished to the shorthand of lists and outlines contained in the two Appendices. Lest they fail to convey the intent of the changes, I should like to summarize here the basic thrust of the review as it relates to the Dean's Office:

The purpose of the Dean's Office is to support and complement the M.I.T. academic program. To accomplish this purpose it is important to bridge all gaps (or perceived gaps, or tendencies to diverge) between the D.S.A. staff and their work to support the students, on one hand, and the faculty and their (academic) work with the students, on the other hand. The Dean's Office reorganization is intended to increase and encourage faculty involvement in the non-curricular aspects of our students' education.

Support services to the students who need them most will continue to be offered in a sensitive and responsive manner, within available resources and with due regard to privacy and other personal considerations. On the whole, here at the Institute and in other universities, we seem to do best in helping students who are in trouble. That work alone may justify the existence of a Dean's Office.

Introduction: A Year of Review

At the same time, there should be increased effort to reach out and *support those students who may not require specific services or counsel*, but whose education and growth in the broadest sense would be enhanced through a variety of new opportunities to engage in academic, intellectual, cultural, or social activities and programs. Career counseling, residential, athletic, and other extracurricular activities are good examples of such programs. Involvement of the faculty in these activities should be encouraged to the greatest extent possible, in order to avoid the dangers of a growing distance between the academic program and the resources whose mission it is to support and complement the academic program.

There is, finally, a *need for prompt and accurate information, and for referral* to the proper sources of help and advice on a myriad of questions that students may have about academics, living arrangements, financial matters, and so forth. Most of the graduate students we have talked with said that such a low key service of a logistical nature is an absolute requirement at M.I.T., because of the tremendous pressures and the time bind that academic work places on all students.

CONSTANTINE B. SIMONIDES

Appendix A

Summary of General Observations - Fall 1978

- D.S.A. services not well known to students or faculty
 - Descriptions on paper abound but are not effective.
 - Perceived need for more personal communication.
- Perceived senseless fragmentation of student services outside D.S.A.
 - "M.I.T. is either confused or out to confuse you."
 - Most frequent examples:
 - Housing Office versus D.S.A. Residence Program
 - Student Accounts versus Financial Aid (and other services)
 - Counseling versus Psychiatric Service (issues of privacy versus need for supportive network)
- Perceived distance between D.S.A. and academic (faculty, departmental) programs and resources.
 - Growing gap over time.
 - Some think by design (D.S.A. as student advocate).
 - General consensus that students suffer from gap.
 - Faculty trust in D.S.A. eroded; do not refer students (no feedback).
- D.S.A. relations more tenuous after the freshman year.
 - Perceived diminishing of connections, cooperation, and support to both students and academic departments.
 - No "lateral reach" available to upperclass students who need advice/encouragement/support (even if it means sending them back to the department).
- Perceived need for more support to undergraduate students in academic/career counseling.
 - Advising not satisfactory (too many complaints). C.E.P. group suggests survey to establish problems and needs.
 - Several levels of career counseling for undergraduates (choice of major, advanced study, professional field, job placement).
- Undergraduate residential program very important but needs support and greater clarity to achieve full potential.
 - Diversity in living styles praised but not clearly understood.
 - Need to attract faculty (non-residents) to associate with Houses.
 - Role of Faculty and Graduate Residents regarded as crucial but (in my judgement) program not developed to full potential.
 - Frats need more support from M.I.T. (w/o endangering independence).
 - Some questions about residence orientation (intensity, abruptness).
- Graduate and International students say D.S.A. not for them.
 - Perceived as undergraduate services, not available to them.
 - Foreign Student Advisor now located in Admissions Office.
 - G.S.O. staff help but not formally responsible for student services.
 - Relations with G.S.C. very tenuous.
- Inadequate assistance/coordination for women's programs.
 - Women students need full-time coordinator Institute-wide for women students' programs and concerns.
- Minorities think D.S.A. not effective for minority programs.
 - Minority students insist academic base crucial for O.M.E.
 - D.S.A. lacks institutional power.

Appendix B

DIRECTIONS OF CHANGE WITHIN DSA

DSA Service Components "SHINGLES"	Services in Response to Needs	Changes/Remarks
*1 Undergraduate Academic Support Office	Strengthen working relations and support to departments and facilitate access to faculty advising and career counseling	
	• Freshman Orientation	
	• Freshman Advising	Departmental Role?
	• Liaison with Undergraduate Departmental Offices, Advising Handbook, other services	Expand/revise CAP guide.
	• Support CAP	Move CAP staff support to this office (but keep separate from counseling section).
	• Support CORE Subjects Group	DSA staff support to Undergraduate Core Subjects Group (chaired by Dean Alberty).
	• Preprofessional and Career Counseling/Graduate Schools (Departmental and Faculty resources)	Work out relations with Placement Office re: career counseling services to students.
	• Surveys and other services	
*2 Student Assistance Services	General emphasis on closer relations with departments and faculty (support network concept)	
	• Personal Counseling Section	Improve access (low threshold); maintain relations with Nightline, Psychiatry, Resident program.
	• International student advisor and staff	Move from Admissions.
	• Graduate student services/information	Strengthen graduate student support throughout DSA and improve information about services.
	• Women student activities coordinator	Institute-wide service.
	• Minority student activities coordinator	Institute-wide service.
**3 Student Activities	• Increased support to Graduate activities	DSA supervision of student government support staff.
	• Review and strengthen orientations	Support to GSC, International Advisor, etc.
**4 Residence Programs	• Increased support to Fraternities	Business Advisor for Fraternities.
	• Describe/explain diversity of living styles (choices, mobility)	
	• Clarify/strengthen adult roles (Faculty/Graduate Residents)	Develop charter of responsibilities.
	• Experiment with new ideas in residence program (e. g., Faculty Associates)	Begin Faculty lunch program in dorm dining rooms.
	• Review residence orientation	
	• Strengthen support to graduate student residence programs.	
**5 Athletics	Continue close program and staff relations with DSA, but Athletic Department will not report formally (i.e., budget, administration, etc.) to the Dean in order to make DSA formal responsibilities more manageable.	

*Proposed new name

** Existing name

Appendix C



DEAN FOR STUDENT AFFAIRS
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

MIT invites nominations and applications for the position of Dean for Student Affairs.

The Dean for Student Affairs articulates and takes initiatives on issues pertaining to the living and learning environment at the Institute; represents the interests and welfare of MIT students; and is concerned with the growth of students both as individuals and as members of the academic community. He or she is a member of the Academic Council, the senior policy-making group of the MIT administration.

The Dean is expected to ensure that the activities of the Office support and complement the academic program and that the staff maintain close working relations with the Institute's departments and faculty as well as with the student body. The Office of the Dean for Student Affairs is organized into four major sections: Undergraduate Academic Support Office, Student Assistance Services, Student Activities, and Residence Programs. The last three sections serve both undergraduate and graduate students. The Dean is responsible for the direction of all programs of the Office, including educational, administrative, and planning functions, as well as the development of the staff.

The Dean is expected to manage the Office with a special concern for enhancing communication and collaborative effort with all other student-related services within MIT.

Qualifications for this position include strong academic orientation; commitment to students and ability to recognize, support and encourage diversity in the student body; and well-established professional stature. Among the personal qualities that are expected in the Dean are: decisiveness, leadership skills, organizational ability, energy, and a sense of humor and self-perspective.

Letter of application, accompanied by curriculum vitae and the names of current references, should be sent to:

Mr. Constantine B. Simonides, Vice President
Office of the President and Chancellor
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

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Office of the Dean for Student Affairs

The character of the past year was shaped early by the unexpected resignation in August of Dean Carola Eisenberg who had served with distinction and sensitivity for six years. Her love for students and her special insights into their needs will ensure her continued success as she carries on in a similar role at Harvard Medical School where her own experience as a psychiatrist will have even greater play. Following the decision by Chancellor Paul Gray to use the opportunity for a thorough review of student services at M.I.T., Vice President Constantine Simonides became deeply involved in carrying out the review and I, as Acting Dean, undertook to maintain the high level of effectiveness of the Office during the interim period. The entire staff responded in an exemplary fashion by carrying on the programs and services despite an increase in demand in many areas, the uncertainties accompanying self-study, and the transitions of a substantial reorganization. The highlights of the year are reported in the following sections but I would like to emphasize a few of the changes.

The new Associate Dean for Residential Programs, Robert A. Sherwood, has proved to be a major factor in the success of the year's efforts. Since arriving in July 1978, he has gained the respect and support of his colleagues and associates in remarkably effective and pleasant fashion.

The counseling duties of Associate Dean James Bishop, who became Dean of Students at Amherst College in the summer of 1978, were ably handled by Assistant to the Dean Margaret Norris who was available only during the fall semester and beginning in March 1979, by Assistant Dean Robert Randolph, who promises to be a valuable addition to the staff. Assistant Dean Alice Seelinger left the Office at the end of the academic year with a unique record of serving in the Office in many capacities over many years. Her contributions reflected a deep concern and sensitivity for effective student service and her flair and perspective will be sorely missed.

The ranks of the faculty residents were greatly enhanced by the addition of Professor Margery Resnick and her husband Stephen Ault at the beginning of the year and diminished at year's end by the resignation of Professor Thomas Lockwood after two years in Random Hall.

Problems of student housing were in the forefront over the past year. Despite relatively constant enrollments, the increasingly tight rental market forced unacceptable levels of crowding in the dormitories and stimulated a planning effort for a new undergraduate dormitory. Fortunately enough, funding became available to permit a commitment to proceed toward completion in fall 1981. As a further step, policy changes have been made to permit very active support of sound efforts to establish physical facilities for new independent living groups. A new fraternity is already benefiting from these efforts. Still needed is a substantially increased program of assisting students, especially graduate students, in finding suitable rental accommodations as the market continues to get tighter.

The full range of graduate student needs and problems came into much clearer focus during the year following the report of an earlier study, and the forum offered by the fall meeting of the Corporation Visiting Committee on Student Affairs. Many changes are being made and are planned which should begin to provide substantial relief in the next few years.

Another major effort which should begin to show substantial results during the next year is the study of dining and its relation to the quality of student life on campus. Controversy as well as social benefits can be expected to accompany the anticipated selective movement back toward a "commons" style of student dining.

Increasingly effective cooperation with alumni through the Alumni Office has led to successful innovations directly affecting undergraduates in a number of ways. Especially promising was a Saturday program on course and career planning which also had the close cooperation of the Placement Office and numerous interested faculty.

Also noteworthy this past year was the successful establishment of "Nightline," a student-run peer counseling and information service with solid connections to related services and resources, which promises to grow into a valued part of the M.I.T. scene.

ROBERT L. HALFMAN

Office of Freshman Advising

This past year has been a time for rethinking the role of the O.F.A. as the D.S.A. review progressed. At the same time we carried on our usual activities about which we report first.

Advising

The primary counseling of freshmen is done by approximately 250 advisors (faculty, staff, and graduate students) who voluntarily provide this important contact with an adult who knows M.I.T., who can help the freshmen find out what they want to know, and who can provide some perspective on the first-year experience. The table below shows the affiliation of the advisors as of July 1979 and compares it with previous years at the same time.

	<u>Faculty*</u>	<u>Staff</u>	<u>Graduate Students</u>
1979-80	123	91	23
1978-79	133	70	26
1977-78	136	72	40
New Advisors (1979-80)	27	25	11

* Includes lecturers and instructors

(These numbers do not include six faculty members who were asked to be advisors by Baker House as an experiment in associating advisors with a specific living group so that the advisors can become more involved in and knowledgeable about the living group activities.)

The table shows a drop in the number of faculty participating in the program; we need to watch this situation closely. The increased number of staff members resulted from more well-qualified applicants, perhaps due to an increased awareness of the D.S.A. as a result of the review process. We continue to have an abundance of undergraduates applying for the "associate advisor" position. Those students are a critical component of the advising system in that they provide current information on the academic and social realities of undergraduate life at M.I.T. to the advisees and to their advisor.

We have continued to counsel individual students who come to our office independently or who are encouraged to do so by their advisors.

Twenty-one freshmen withdrew for a variety of personal reasons during the academic year. Twelve additional freshmen were required to withdraw for at least one term because of unsatisfactory academic performance. The table below summarizes the number of formal warnings of unsatisfactory performance given by the Committee on Academic Performance ("C.A.P. Warning") or the more informal letter from our office suggesting that the student think over his or her performance. Also shown is the number of Required Withdrawals.

Office of Freshman Advising

	<u>Required Withdrawals</u>	<u>C.A.P. Warnings</u>	<u>O.F.A. Letters</u>		<u>Required Withdrawals</u>	<u>C.A.P. Warnings</u>	<u>O.F.A. Letters</u>
January 1979	1	45	38	June 1979	12	63	49
January 1978	3	38	39	June 1978	10	75	41
January 1977	1	30	29	June 1977	17	47	32
January 1976	1	41	36	June 1976	19	68	46

Approximately 18 percent of the class received either an O.F.A. or a C.A.P. Warning letter during the past academic year.

We continued to stress the importance of using the freshman evaluation forms to provide a fuller view of a student's performance to the student and to the advisor. We show below the results of a study of the percent return of the evaluations for a sample of 50 students during the past academic year. We feel that we are probably operating near the practical limit of success in ensuring use of the forms though we shall continue to stress their importance and simplify their usage where we can.

Average Returns from Most Frequently Taken Subjects

<u>Term</u>	<u>Subjects</u>	<u>Mid Term</u>	<u>End of Term</u>
Fall 1978	3.091, 5.41, 8.01, 8.02, 18.01, 18.02	96%	84%
Spring 1979	8.02, 18.02, 18.03	84%	72%

Staff

Members of the O.F.A. continue to serve on faculty committees ex officio: the Committee on Academic Performance, the Committee on Curricula, and the Committee on Undergraduate Admissions and Financial Aid. In addition, a staff member serves as the Dean's office representative to the Committee on Discipline and to the 504 Task Force for the Handicapped. We hold membership on the Faculty/Staff Advisory Committee to the Office of Minority Education, the Upward Bound Steering Committee, and the Community Service Fund. We also attend meetings chaired by Dean Robert Alberty for faculty teaching science requirement subjects taken by many freshmen. Staff members meet regularly with the Committee on Freshman Advising,* which has been a source of wise counsel as they served as a sounding board for new ideas and as they debated issues from different perspectives. We welcome their continued presence and thank them for their involvement.

Barry Newman, Class of 1979, was student coordinator for 1978 Residence/Orientation Week. Eric Sklar, Class of 1981, is in the process of coordinating these efforts for the fall of 1979. A large number of undergraduates volunteer their assistance for this planning.

Four students participated in a *Freshman Handbook* workshop which began during I.A.P. and continued into the spring semester. These students gave their advice on revisions to the book and solicited and selected quotations and essays from students for the new book. Three other students volunteered their efforts for the photography work for the book, and Margo Woodruff was hired as photography consultant.

* Members of the Committee include Karl Frey, Class of 1982; Professor Carl Garland, Chemistry; Jerry Marks, Class of 1979; Professor James Melcher, Committee Chairman, Electrical Engineering and Computer Science; Professor James Munkres, Mathematics; and Professor Stewart Myers, Management.

Lesley Kim Zaugg, Class of 1980, and Daniel G. McDonough, Class of 1981, were hired as student assistants to replace William Harper, Class of 1979, and Roger Goun, Class of 1981. David C. Millman, Class of 1981, was recently hired to replace Mr. McDonough who left in June.

New Activities

A major effort this past spring was put into a course and career selection program which was brought about through the joint efforts of our office, the Career Planning and Placement Office, the Alumni Association, and the Undergraduate Association. The initial phase involved listing and assembling information from each department regarding the principal contact person for freshmen interested in that department's activities and a brief summary of the materials available from that department. The visits to the undergraduate contact in each department were made much more effective through the presence of Mr. Newman and Tim Morgenthaler, Class of 1980, of the Undergraduate Association who gave a sense of student needs. The list of contacts and information available were then circulated to the departments in draft form, which encouraged new ideas; the list was then sent to all freshmen near the beginning of the spring term. These early visits to the departments helped start their planning of open house activities, which were generally well attended.

A symposium on course and career selection, entitled "Trailblazing," was organized. Local alumni from a variety of occupations were asked to come on a Saturday to discuss their current occupations and to give a brief sketch of how they got to that occupation following their M.I.T. undergraduate experience. All the groups mentioned above played major roles in organizing and running the symposium. A group of enthusiastic freshmen under the leadership of Mr. Morgenthaler handled much of the necessary publicity and preparation for the symposium as well as seeing to it that the day went smoothly. They received the Stewart Award in recognition of their efforts.

The alumni were enthusiastic about the experience as were the approximately 175 freshmen who attended. It seemed to be a natural combination of the freshmen's desire for a view of potential career paths and the alumni's desire to help present students. We plan to organize another such symposium this coming year.

In a related area, we tried to obtain a clearer understanding of factors entering a student's choice of department and how interests change during the undergraduate years. We asked freshmen to complete a questionnaire at the end of the spring term, when they made their initial choice of Course. On the questionnaire, they indicated the dominant influences on their selection and when that choice was made. We plan to follow the class through their years at M.I.T. to get a sense of the evolution of their choice of major. A study of the Courses of graduating seniors compared to the Courses they were in at the start of their sophomore years showed that 20 percent of the seniors had changed their Courses. (An additional 10 percent of the class had been undesignated sophomores.) We hope to obtain a better idea of the motivations for these changes in future studies.

Future Directions

The review of the D.S.A. carried out by Vice President Simonides suggested that the O.F.A. broaden its services and become an office which offers academic support to all undergraduates. For students beyond the freshman year, it would support the departmental advising programs through studies as described above. It could also draw together services already used by students. To begin this process, the preprofessional component of the D.S.A. (staffed by Dean Susan Houpt and Eleanor Delaney) will become associated with the new Undergraduate Academic Support office, as will the administrative support for the Committee on Academic Performance, provided by E. Jane Dickson.

The latter addition improves student access to information about academic formalities as well as adding to our office a person with considerable experience in academic counseling. We also anticipate natural ties with the C.A.P. in studies of academic performance. We hope to serve as a resource for Faculty Counselors in all the departments and to provide some exchange of information between departments.

Undergraduate Seminars Program

Our close association with the preprofessional section of the D.S.A. can provide an important component in the student's search for information about course selection, and fits well with the course and career selection program mentioned earlier. We plan to maintain strong ties with the Career Planning and Placement Office as well as the Alumni Association's programs in this area.

A final addition to the office will be responsibility for the undesignated sophomore program.

All these changes will surely tax our imagination and challenge our views of our current program. Clearly any precipitous change in our freshman efforts would endanger a smoothly operating, successful program. We hope to change cautiously as we learn where the problems and opportunities lie.

ALAN J. LAZARUS
BONNY S. KELLERMANN

Undergraduate Seminars Program

The Undergraduate Seminars Program showed declines in the number of offerings in both the fall term (from 60 to 47) and spring term (from 39 to 37). However, the large number of students who choose to participate in this program would seem to indicate that undergraduate seminars continue to provide an important addition to M.I.T.'s curriculum.

A total of 824 students (609 of whom were freshmen) participated in a fall seminar; 438 students (of whom 226 were freshmen) participated in one of the seminars in the spring.

A major concern for the Seminars Program in the future will be to continue encouraging faculty to contribute their time to and departments to be supportive of this activity.

Professor Michael Driscoll has continued as Faculty Chairman of the Undergraduate Seminars Program and Dean Bonny Kellermann has continued as Executive Officer, with secretarial support from Deborah Andrew.

The Undergraduate Seminars Program will continue to be administered through the Dean for Student Affairs Office as a part of the newly created Undergraduate Academic Support (U.A.S.) Office.

BONNY S. KELLERMANN

Undesignated Sophomore Program

Continuing the downtrend of recent years, about 30 percent fewer sophomores chose to use the undesignated category rather than declare departmental affiliation in this past academic year as compared to the previous year. Only 40 volunteer advisors drawn from faculty, staff, and graduate students were needed to provide a reasonable match of interests with the 109 undesignated sophomores at the beginning of the fall term, and the 60 in the spring. Five years ago, 68 advisors were needed for the 237 sophomores in the fall and 135 in the spring.

ROBERT L. HALFMAN

Preprofessional Advising and Education Office

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

In September, meetings with freshmen acquainted them with the advisory services of the Pre-medical and Prelaw councils as well as services available at the Preprofessional Advising and Education Office. Later that month, Dr. Thomas Lentz, Assistant Dean of Admission at the Yale University School of Medicine, spoke with medical school applicants about the nature and format of the medical school interview. In February, sophomores were told of the planning necessary for a medical education. That same month, members of the Council met with students who will be attending medical school next year. Discussion focused on criteria for selecting medical schools. In March, a session was held to acquaint M.I.T. students with the Medical College Admission Test (MCAT). In April, there were two meetings for those students who will apply for admission to medical or law school for the class entering in September 1980.

Representatives from two medical schools and 12 law schools visited M.I.T. during the year. They met with students as well as members of the Advisory Councils. These sessions benefit the Advisory Councils and the students as well as the professional schools in that they provide a source of helpful information.

Professor Bernard S. Gould and Dean Susan Haigh Houpt attended the meeting of the Northeast Association of Advisors to the Health Professions held in Cambridge in April. Professor Gould was asked to be a member of a panel discussion on preparation for the MCAT. The comments which he elicited from M.I.T. students about the examination will no doubt have some influence on those who are responsible for the preparation of the MCAT. Dean Houpt also participated in the annual meeting of the Northeast Association of Prelaw Advisors at Connecticut College in New London in June. The contacts made at these meetings, both with other advisors and with representatives of professional schools, will provide an opportunity for mutual support.

During Independent Activities Period (I.A.P.), the Preprofessional Advising and Education Office sponsored or co-sponsored a number of offerings. These included "So You Want to be a Lawyer," co-sponsored with Professor Lawrence Bacow of the Department of Urban Studies and Planning; "A Brief Introduction to the Law," co-sponsored with Professor Jeffrey Meldman of the Sloan School of Management; and "Animal Physiology: An Interdisciplinary Field," with Professor Gould (Department of Biology).

In an effort to continue to provide M.I.T. applicants to medical and law school with as much information as possible about these academic programs, we again mailed a questionnaire to the alumni who are presently enrolled. In the case of law students, we also included in our mailing those who had graduated from law school within the past two years. Fifty percent of the more than 400 alumni who received the medical school questionnaire and 41 percent of the 234 law school alumni returned their responses. They represent 67 medical schools and 32 law schools. This information continues to be invaluable to both the students who plan their professional studies and the members of the Advisory Councils.

The Preprofessional Advising and Education Office sponsored one of the members of the Association of Black Premedical Students to attend the annual meeting in April of the Student National Medical Association at U.C.L.A. Medical College. The students benefit from the experience of meeting with minority medical students and physicians at these conferences.

During this past year Dean Houpt assigned 73 members of the Class of 1981 to members of the Premedical Advisory Council. It is anticipated that several more members of the Class will be assigned to advisors in September. Last year at this time, 87 individuals of the Class of 1980 had been assigned to advisors; at the present time, that number has grown to 143.

Dean Houpt wrote letters in support of 52 applicants to law school. Law schools often require a letter from M.I.T. attesting to a student's citizenship while he or she was registered as a student. Dean Houpt wrote 31 letters for currently registered students and 21 letters for former students.

PREMEDICAL AND PRELAW STATISTICS

During the year, 35 undergraduate and graduate students and 16 M.I.T. alumni who graduated between 1965 and 1978 applied to law school for admission in 1979. They submitted 274 applications to 41 law schools. The students submitted an average of six applications; the alumni submitted an average of five applications.

Three of the students who were accepted to law school have decided not to attend. Two students and one alumnus have received deferrals for one year.

We received 83 LSAT scores for 69 individuals. This includes scores for 25 individuals who did not apply to law school. Nine LSAT applicants repeated the LSAT; they showed an improvement of 19 to 192 points. The average improvement in score was 79 points. The mean scores are 702 for students who applied to law school and 685 for alumni who applied.

During the year, a total of 150 individuals applied to medical and dental schools for admission in 1979. Admission to at least one school was obtained by 85 (83 percent) of the 103 S.B. candidates and 27 (57 percent) of the additional 47 applicants.

Altogether the 150 applicants submitted 2,119 applications to 111 medical schools, a mean of 14 per student.

This year, 110 applicants received acceptances from 74 medical schools. The mean number of acceptances was 2.2 among the students who received acceptances. The ratio of acceptances to applications was 8.7 percent.

Four citizens of foreign countries applied to medical and dental school in the US; two were admitted.

Forty-two (38 percent) of the accepted applicants were accepted to only one school. Twenty-two of these were accepted only by their state school (20 percent of the total number of applicants accepted).

One hundred seven are attending 53 medical schools. Three have decided not to pursue a medical career.

Five second- and third-year students applied to medical school without their M.I.T. degrees. Three were admitted.

Twenty-one of the applicants had failed to gain admission to medical school in a previous year; 8 were admitted this year (38 percent).

Twenty-three M.I.T. alumni applied to medical school through the Preprofessional Advising and Education Office. Ten (43 percent) were admitted. Of the 11 alumni who applied to medical school for the first time, eight were admitted (72 percent).

SUSAN HAIGH HOUP T

Minority Support Activities

Minority support activities are planned to enrich the social and educational experiences of minority students at M.I.T. The operational objectives are first, to help prevent crisis situations, and secondly, to define and develop social attitudes and behavior that influence the development of a positive self-image and achievement motivation. The resultant objectives are to decrease the attrition rate; to increase grade point averages; to increase social awareness and involvement in campus activities; to decrease the number of interpersonal conflicts in the dormitories and elsewhere on campus; to increase cultural awareness in the university and local community; and to increase contact with highly motivated minority and other concerned persons as role models and resources.

Club Latino, a Spanish student organization, presented "The Puerto Rican Question Lecture Series." Speakers addressed questions on the independence, statehood, or republic status for Puerto Rico. The Alpha Kappa Alpha Sorority, a student service organization, sponsored tutorial sessions on the Preliminary and Scholastic Achievement Tests for local high school students; a lecture series for minority women students at M.I.T., Wellesley, and Harvard; and a holiday service for the M.I.T. community. The Black Christian Fellowship sponsored several retreats for students and faculty. The M.I.T. Gospel Choir presented its annual concert in conjunction with several local and out-of-state college choirs. They joined with other religious campus groups in Bible distribution to the M.I.T. community.

The Minority Discussion Group and Rap Sessions continued to provide a format to express community and personal reactions, interactions, perspectives, perceptions, and attitudes experienced by the minority student. Myra Rodrigues, Social Worker in the M.I.T. Medical Department and Mary Hope, Assistant Dean for Student Affairs, served as staff assistants. The Problem Sessions which address specific topics of concern for individual minority women continued by student request. The Office of the Dean for Student Affairs continues to sponsor student attendance to off-campus conferences. Departmental groups such as the Black Pre-Medical group, Mechanical Engineers, and Electrical Engineers continue with student leadership and faculty advisement. The student Black Caucus which includes all presidents or chairmen of minority activities was organized to improve coordination of activities and facilitate communication.

Lisa Egbonu, Class of 1979, the first minority woman to be inducted into the M.I.T. Chapter of Phi Beta Kappa in May, also received the scholastic award for outstanding woman student in the North Atlantic Region of the National Sorority of Alpha Kappa Alpha Incorporated.

The Albert G. Hill Prize awarded to the minority student who has made continued contributions to the improvement of the quality of life for minorities at M.I.T. while satisfactorily progressing academically was awarded to Ms. Egbonu and to Laura May Robinson, Class of 1980.

Students' academic progress continued to be monitored. Students were commended for excelling or counseled and referred to appropriate resources for academic assistance.

The number of minority undergraduates to receive degrees at Commencement in June 1979 is indicated in the attached tables. Undergraduates obtained meaningful summer jobs through the D.S.A. and the Office of Career Planning and Placement.

MARY O. HOPE

Minority Support Activities

TABLE I
Minority Students Admitted and Registered

	<u>Fall 1975 - Class of 1979</u>				
	<u>African Americans</u>	<u>Mexican Americans</u>	<u>Puerto Ricans</u>	<u>Native Americans</u>	<u>Total</u>
Graduated	18	3	4	0	25
Withdrawn	6	2	0	0	8
Transferred	1	0	0	0	1
Continuing	7	5	3	0	15
TOTAL	32	10	7	0	49

TABLE II
Minority Graduates - Class of 1979

<u>Departmental Programs</u>	<u>African American</u>		<u>Mexican American</u>		<u>Puerto Rican</u>		<u>Total</u>
	<u>Male</u>	<u>Female</u>	<u>Male</u>	<u>Female</u>	<u>Male</u>	<u>Female</u>	
School of Architecture and Planning	0	1	0	0	0	0	1
School of Engineering	12	2*	2	0	2	0	18
School of Humanities and Social Science	0	0	0	0	0	0	0
Sloan School of Management	0	0	0	0	0	0	0
School of Science	0	3	1	0	2	0	6
TOTAL	12	6	3	0	4	0	25

* One student, Class of 1978

Women's Program

The desired thrust of programs for women students has been under scrutiny this year as have all the student services provided by the Office of the Dean for Student Affairs. To aid in this endeavor Dean Holliday Heine presented a report to the Academic Council in December summarizing the strengths and weaknesses in M.I.T.'s support of its women students. As a result of the self-examination this year, a stronger program will be forthcoming with more coordination among the various individuals currently counseling or advising women students.

The activities occurring this year have been quite varied. In December, Dean Heine sponsored with the Radcliffe Forum a conference for women on careers in biology as alternatives to medicine. This one-day conference gave 275 young high school and college women a chance to meet women scientists in fields such as business, publishing, marine biology, and bioengineering -- fields one can enter with a biology background.

The Ad Hoc Committee on Women's Admissions again sponsored a telethon in the spring to call admitted women students. About 20 faculty, staff, and students attended a "warm-up" dinner and then telephoned the recently admitted students, answering their questions and encouraging them to come to M.I.T. Preliminary results from last year's telethon show that such personal contact does produce an increase in the number of women who choose M.I.T.

An admissions project carried out solely by students is that organized by the Committee for the Michigan Project at M.I.T. These dedicated young men and women from the state of Michigan have spent a year in contact with 450 high school juniors from the state of Michigan. They are encouraging these young women to think about careers in science and engineering and hope to see equal numbers of male and female freshmen entering M.I.T. from Michigan.

The activities undertaken by women undergraduates through the Association for Women Students continue to be integral to the women's admissions program.

The Margaret Cheney Room is a suite reserved for the exclusive use of women students. This year, the Cheney Room Committee sponsored several lunches for women students and an Open House for the M.I.T. community. In addition, the Association for Women Students provided donuts and bagels for busy students during the last week of classes.

A new women's residence, the Women's Independent Living Group, has just completed its first full year of regular activity. This new member of the Interfraternity Conference is providing an alternative for those women who would like to control their living environment and live in close cooperation with other women students.

We continue to seek ways to involve more M.I.T. women students in the M.I.T.-Wellesley Exchange. Wellesley faculty members were guests this year at a meeting of the M.I.T. women faculty to discuss these concerns. This will be one of the points of emphasis of the Exchange in the coming year.

Undergraduate and graduate women have succeeded this year in organizing the first M.I.T. chapter of the Society of Women Engineers. The students have been very active, holding on-campus meetings and attending national conferences.

The cooperation among women students from various parts of the campus is on the increase this year. The Residence/Orientation program planned for the fall is a singular example: Dorms are no longer "competing" as much for incoming women students, with greater emphasis on helping them make informed choices. An extensive Big Sister/Little Sister program also is planned to keep this cooperative spirit intact throughout the year.

HOLLIDAY C. HEINE

Advising and Counseling

The counseling of individual students, which often includes contact with friends, advisors, and parents, is a major activity for four deans, and a supplementary responsibility for the rest. Over the past academic year the four had nearly 2,400 substantial conferences with students, an increase of more than 30 percent over 1977-78. Although part of the increase is related to a somewhat higher level of available resources throughout the year, an increase in student demand was the dominant factor.

A significant fraction of the conferences concerned possible interruption of the undergraduate program or a return from time away, as increasing numbers of students find adequate reason to believe that keeping the nose continuously to the academic grindstone may not be the best way to gain a good education. About 300 undergraduates were readmitted to M.I.T. during the past academic year after at least one term away, taken, in most cases, voluntarily.

In order to focus attention of students, advisors, and student service staff on this developing attitude, Dean Holliday Heine in April moderated a community meeting, "Taking Time Away from M.I.T." Approximately 100 faculty, staff, and students attended, with many participating in the discussion. As a result, two projects are under way this summer: one to review current Institute policies affecting students who take time off and to make recommendations for study or change where appropriate; and the other to prepare a booklet to guide students (and their parents) in making this difficult decision.

Buoyed by the success of this effort, we are planning future programs to highlight other problem areas which are not the direct responsibility of a particular group and yet are of concern to the community as a whole.

After months of planning and gathering resources, the student-initiated peer counseling service "Nightline" started operation in the early fall. About 40 students, supported by advisors from the psychiatric and social work staffs as well as from the Dean's Office, operated a telephone information and listening service from 7 pm to 7 am each night throughout the academic year. Patterned on successful services at other schools, Nightline provided a low threshold opportunity for students to talk with concerned and experienced peers with complete privacy at convenient times. The advisory support ensured that referrals were suggested when appropriate and that the Nightline team learned well from their experiences. As part of the operation, Nightline tries to be a current accurate source of information on many topics of personal or social interest to the student community. The telephone operation is being carefully supplemented by a drop-in mode as Nightline goes into its second year in its central West Campus location adjacent to Ashdown House. It is expected that use of Nightline will grow gradually as it becomes a better known and trusted community resource.

During the past academic year, Dean Bonny Kellermann has acted as a facilitator to meet special needs of students who have been disabled permanently or temporarily. She assumed this role when responsibility was shifted from the social service section of the Medical Department in September 1978. She participated in the 504 Evaluation Task Force, and has fielded inquiries from prospective students, visitors to campus, and other schools about services at M.I.T. for the handicapped.

ROBERT L. HALFMAN

Student Community Affairs, Student Activities, and Governance

For the third successive year, the twin themes of student social interaction and the quality of student life continued to dominate the concerns of the Student Activities and Governance section. This circumstance is partly in response to sensitive student leadership and to the felt needs and aspirations of individual students who sense that community life somehow could be more productive for themselves as persons.

Improving community life was the substance of five ad hoc meetings of representatives of undergraduate student leadership who discussed this theme from the perspectives of pride in M.I.T., belonging to M.I.T., well-being, personal growth, and community association. Many of these same concerns were addressed by graduate students through "the Dober Report on M.I.T. Graduate Student Life," (*The Graduate*, December 1978), and the Corporation Visiting Committee on Student Affairs whose agenda at its October 1978 meeting focused on graduate student concerns.

Social events flourished during the year, and one was conscious of increased "visiting" during the intermissions of drama and musical programs, while waiting for the Lecture Series Committee movie, or for Lobdell and Walker to open for the 5 pm serving. In looking ahead, it is not clear what effect the increase in the Massachusetts drinking age to age 20 will have, if any, on these general propensities for socialization, but there is no doubt but that it will impact severely for a time on certain social functions, and present new challenges to social committees and social program planning. Nevertheless, the Kaleidoscope picnic in May with fried chicken and hotdogs was a rousing success.

The Graduate Student Council and the Undergraduate Association had productive tenures. The successive presidents of the Graduate Council, Karl S. Horlitz and Fernando Cruz-Villalba, and the U.A.P.-U.A.V.P. team of Barry A. Newman, Class of 1979, and Timothy Morgenthaler, Class of 1980, gave impressive leadership. Both governance units broke new ground while consolidating gains. Particularly outstanding was Feedback '79, initiated by Charles F. Irwin, Class of 1980, Chairman of the Nominations Committee of the Undergraduate Association. At this special meeting, the Committee for the first time reported to the student constituency, and issues were also considered by a number of the standing committees of the faculty and presidential committees. Also outstanding were the efforts of J. David Germany and the ad hoc committee of the G.S.C., which prepared the program of presentation to the Visiting Committee.

In yet another area, the Undergraduate Association leadership together with representatives of the Classes of 1978, 1979, 1980, and 1981 met throughout the summer with Nancy Wheatley and Bonnie Jones of the Alumni Association staff to develop some possible programming within the classes, specifically to assist the freshman class soon after its arrival to organize for programming and association. This latter objective was fruitfully accomplished under the leadership of the U.A.V.P., while the Class of 1979 pioneered in organizing and presenting the first "all-class" talent show.

The number of recognized student activities continues at about 100, the same as previously, but we have noted this year increased programming by international student groups and religious activities. In December, we discussed international groups and the use of facilities with a group of Boston-area student affairs deans and advisors to international students, comparing notes about space use practices and reciprocity in hosting intercollegiate international programs. In the main, student activities continue, as formerly, to provide responsible outlets and opportunities for service, association, programming, and the cultivation and development of general interests and skills.

Space utilization continues to be a major concern of the Student Center Committee Scheduling Officers, the Association of Student Activities Executive Committee, and the Graduate Student Council Activities section. Program space in Kresge Auditorium, the Stratton Student Center, Walker Memorial, and Burton-Conner Dining Hall continues, in most cases, to be scheduled at prime time capacity. Thanks to the good will and understanding of the community of users, and the beyond-duty efforts of the Physical Plant operating staff, most projected programs can be accommodated, although frequently with compromises. The closing of Kresge Auditorium for a six-month period beginning March 3, 1980 will impact severely on a number of program events, and steps have been undertaken to accommodate these programs in other Institute facilities where feasible.

The M.I.T. Chapel was in use for 11 memorial services, 67 weddings, 5 christenings, 384 scheduled religious services, and 43 musical and theatrical programs. The Reverend Jessica Crist, previously a student intern, has been appointed Lutheran counselor. We look forward to her service of installation in the fall. At this writing, the Conference of the World Council of Churches on "Faith, Science and the Future" has just begun with about 1,000 delegates, consultants, and accredited visitors in attendance. Judging from preliminary comments, it would appear to be an exciting, historic event.

ROBERT J. HOLDEN

Residential Program

INSTITUTE HOUSES

This year's Residence/Orientation week found students experiencing perhaps the worst housing shortage in M.I.T.'s history. The number of available off-campus apartments was significantly down from previous years, resulting in a higher number of upperclass students staying in the Institute Houses. Transfers, re-admits, and graduate students had extreme difficulty finding a place to live off campus, resulting in a higher than expected number of transfers pledging fraternities before they filled up with freshmen. The freshman class size of 1,058 thereby resulted in the record-setting number of 151 crowded rooms in the House system. This number eventually reduced to 132, but still taxed the system, and the morale of the residents, to the ultimate limit.

When these circumstances became apparent, an Ad Hoc Committee on Undergraduate Housing was formed to study the situation and recommend alternative solutions. After several weeks of study, the Committee submitted its report to the Chancellor, the Academic Council, and the Executive Committee of the Corporation.

The Executive Committee approved the concept of constructing a new 300-bed residence west of New House; a group of 30 faculty, students, and staff -- referred to as the Program Planning Group -- immediately was formed under the leadership of Dean Robert A. Sherwood and H. Eugene Brammer, Director of Housing and Food Services. This Group, working in consultation with Richard Dober and Associates, met during an intensive period over I.A.P., held open forums in Houses, talked with previous architects and planners of M.I.T. houses and scholars from other universities, and presented their final report at the end of January. Thereafter, due to a scarcity of capital from the Leadership Campaign for the new residence, the Executive Committee put a hold on the construction of "Next House." However, Dean Sherwood, Mr. Brammer, and Campus Architect Harry Portnoy continued to work on the next stage of facilities planning. As this second stage was being completed, President Wiesner announced at Commencement the receipt of a \$2 million anonymous gift for Next House. Immediately, the facilities planning was completed, and the architectural firm (Sert, Jackson and Associates) and construction firm (Turner Construction Company) were selected and directed to proceed full-steam ahead under a "design-build" concept with the Sherwood-Brammer-Portnoy client team. The target date for occupancy is September 1981. The House will accommodate 300 single undergraduates, will include a central dining room, and will be designed as a horizontal corridor-style House (unlike the six separate houses in New House).

During the past year a Coed Study Group met to advise the Dean's Office on coed housing and language house expansion. After considerable discussion and some controversy, the following decisions were made, to take effect in September 1979. Fenway House was granted provisional coed status. East Campus was allowed to expand its current coed housing to an additional floor. New House was allowed to create an all-female floor in Desmond House. Spanish House was approved as the newest language house and assigned to a limited section of Lawrence House.

In response to a desire for more personal contact with members of the faculty, several new residential programs were instituted during the year, including a Faculty Associates Program in McCormick Hall, a Faculty Guest Program in Baker, MacGregor, and Walker dining halls, and a Faculty Advisors Dinner Program in Senior House.

Baker House celebrated its 30th anniversary with a very successful party for residents and alumni. This kicked off the formation of a group called "Friends of Baker House" which will work with the current undergraduates on a fund drive to raise alumni donations for a Baker House Renovations Fund which will be used to help defray the costs of necessary repairs, renovations, and furnishing replacements.

On a larger scale, the Alumni Office staged a successful telethon raising funds for the Campus Residence Development Fund, which will be distributed through an allocation board similar to the Independent Residence Development Fund.

Renovations to Graduate Resident (Tutor) apartments were studied, and the decision was made to start work this summer on Baker House tutor quarters. This is an on-going program which will require funding from the housing budget each year.

The Dean's Office maintained and enjoyed an excellent working relationship with the Dormitory Council and House governments during the year, meeting regularly to discuss common concerns, policy changes, living conditions, residence programs, rental rate review, judicial procedures, and room assignment procedures.

The advent in April of the new minimum drinking age in Massachusetts (raised from 18 to 20) caused great consternation among students both on and off campus. However, after a series of information-sharing sessions and open forums, revision of the alcohol-party application form, and with good faith in the high level of maturity and responsibility of our students, the transition was made almost without notice.

The Dormitory Council and Interfraternity Conference maintained a very positive relationship this past year, highlighted by reciprocal dinners and social hours sponsored for all House presidents and Dean's Office staff members.

FACULTY AND GRADUATE RESIDENT PROGRAM

The continued excellence of M.I.T.'s Residential Program is due in great part to the dedicated group of Faculty and Graduate Residents who unselfishly devote so much of their professional and personal lives to our resident students. This year, we were extremely fortunate in appointing Professor Margery Resnick, Director of Modern Languages, and her husband, Stephen Ault, as Faculty Residents in McCormick Hall. Margery and Stephen's contributions were acknowledged in an unprecedented letter to President Wiesner from the graduating women of McCormick enumerating the significant ways in which they creatively and effectively enhanced the personal growth of the residents. Other Houses also expressed their heartfelt appreciation to their Faculty and Graduate Residents in a variety of ways, each equally gratifying.

We will be very sorry to see Thomas Lockwood, Assistant Professor of Nutrition and Food Science, leave his position of Faculty Resident in Random Hall. Tom has done an excellent job in the past two years in developing and maintaining a unified House that was so quickly added to the housing system in 1977. We hope to find someone to fill his post before the start of the fall term.

An expanded two-day orientation program for Faculty and Graduate Residents was held before R/O Week and was further supplemented by a week-long program during I.A.P. and monthly meetings with each House during the year. With the assistance of Vice President Constantine Simonides, who reviewed student services this year, the Faculty Residents met each month to draft a charter of responsibilities describing the philosophy and objectives of their position. These monthly meetings, as well as subgroup meetings, were very stimulating and helpful in advising the direction of the Residence Program in particular and the Office of the Dean for Student Affairs in general.

One persistent concern of the Program is the decreasing number of applicants each year for the Graduate Resident vacancies. We certainly need to improve our recruitment and publicity campaign, but also need the assistance of the faculty who could effectively encourage their graduate students to work in this important capacity.

FRATERNITIES AND INDEPENDENT LIVING GROUPS

The Intrafraternity Conference enjoyed a very productive year starting with a successful rush during R/O Week. However, the vacancies which existed during the spring term are a concern which needs to be addressed in the future. Several programs were sponsored by the Residence Program staff during I.A.P., including Leadership Training Workshops for dormitories and fraternities and Rush Workshops for fraternity members.

Zeta Psi, the latest fraternity added to the system, gained "colonization status" during the year. Zeta Psi will be accommodated temporarily during the 1979-80 year in a series of adjacent apartments on Main Street in Cambridge.

Partly due to the difficulty that Zeta Psi's Alumni Corporation and National Office had in locating a permanent house, M.I.T., upon the advice of the I.F.C. and the A.I.F.C. Executive committees, changed its policy with regard to acquisition of Independent Residences. Henceforth, M.I.T. will actively assist new and/or current independent living groups to locate, purchase and renovate permanent housing off campus. This new policy should serve to facilitate and support fraternities and independent living groups in acquiring real estate which is becoming increasingly difficult to locate and afford.

The Independent Residence Development Fund continues to assist fraternities in need of renovations and repairs. This past year it awarded funds to several more Houses which will be installing sprinkler systems, as well as to Student House which will undergo a substantial renovation this summer.

The Alumni Interfraternity Conference was not particularly active this past year; yet whenever individual House Corporation Alumni Officers were contacted to help with specific problems with their Houses, they were very responsive and supportive.

The executive officers of I.F.C. were very effective in carrying out their responsibilities and developing programs, such as Freshman Symposium, A.I.F.C.-I.F.C. Fraternity Day Symposium, Northeast Interfraternity Conference, meeting with the Back Bay Neighborhood Association and Representative Barney Frank, community service projects, and I.A.P. workshops. Mark Bye, a graduate intern in the Office of the Dean for Student Affairs, and Merrick Leler, Assistant to the Treasurer, were very helpful to the on-going success of the fraternity programs.

Based upon the recommendation of the I.F.C., Vice President Simonides approved the creation of the full-time position of business advisor to fraternities and independent living groups, effective August 1979. This position will expand upon the responsibilities previously held by Merrick Leler, such as Secretary to the A.I.F.C. and liaison with the Real Estate, Physical Plant, Safety, Treasurer's, and Alumni Association offices. It will entail long-range planning for the fraternity system as well. We look forward to working with Stephen D. Immerman, who will serve in this capacity next year. Steve will be a member of the Residence Program staff of the D.S.A., and we are confident that the excellent relationship which has existed between the independent living groups and the Institute will continue. We are especially looking forward to working with Barbara Hill, the I.F.C.'s first chairwoman, and her excellent team of executive officers for 1979-80.

DINING REVIEW

Over the past 12 months, a major exhaustive study led by Professor John G. Kassakian has been made of the campus dining program. Several staff members of the D.S.A. were on the Committee on Campus Dining and its three Working Groups. The recommendations of the Committee should have a significant effect on the Institute House system and the residence programs. Next year will be a very important one in educating the community about the benefits of the recommended changes and implementing the new programs which should add a considerably new and improved dimension to the residential/dining system.

PERSONNEL CHANGES

It is with a great sense of loss that we announced the departure of Alice Seelinger from the Residence staff of the Dean's Office. Alice has contributed a great deal to the Institute residence system and the D.S.A. over the past several years. We wish her the best of luck in her future pursuits.

Likewise, Lisa Kunstadter's departure will be widely felt. Lisa had such a unique ability to calmly organize all of the confusion during R/O Week and the rest of the year and to make sure that everyone was properly assigned to a room. We wish her success at Columbia Graduate School of Business.

We welcome Robert Randolph, who will be dividing his time between the Counseling Section and the Residence Section starting in the fall, as well as Barbara Chuck who has joined us as the Administrative Assistant on our Residence Staff. Also as mentioned above, Stephen Immerman will be joining the staff as Business Advisor to Fraternities and Independent Living Groups. I would also like to highly commend Beth Gardner Faried for being the glue which keeps the whole staff together and always the cheerful, warm person to help any student in need.

ROBERT A. SHERWOOD

RESIDENTIAL DISTRIBUTION OF M.I.T. STUDENTS

Fall Term 1978-79

UNDERGRADUATES

<u>Institute Houses</u>	<u>MEN</u>	<u>WOMEN</u>	<u>TOTAL</u>
Single Sex Housing	805	235	1,040
Coed Housing, but not Coed Floor	153	-	153
Coed Housing	917	321	1,238
	<hr/>	<hr/>	<hr/>
TOTAL INSTITUTE HOUSES	1,875 (49.3%)	556 (70.4%)	2,431 (52.9%)
<u>Fraternities and Independent Residences</u>			
Boston - Single Sex (20)	779	-	779
Coed (1)	21	10	31
Cambridge - Single Sex (7)	272	42	314
Coed (2)	37	39	76
Brookline - Single Sex (1)	63	-	63
Coed (1)	20	13	33
	<hr/>	<hr/>	<hr/>
TOTAL FRATERNITIES, ETC.	1,192 (31.3%)	104 (13.2%)	1,296 (28.2%)
<u>Married Student Housing</u>	22	4	26
TOTAL "ON-CAMPUS"	3,089 (81.2%)	664 (84.1%)	3,753 (81.7%)
<u>OFF-CAMPUS</u>	715 (18.8%)	126 (15.9%)	841 (18.3%)
<u>TOTAL UNDERGRADUATES</u>	3,804 (100%)	790 (100%)	4,594 (100%)

Talbot House

UNDERGRADUATE RESIDENTIAL DISTRIBUTION

1969-1978

Year (Fall Term)	Undergraduate Enrollment ¹	Dorm Occupancy ²		Crowding	Fraternity Occupancy ³		Off Campus ⁴	
		#	%		#	%	#	%
1969	4,074	1,866	45.8		1,250	30.7	958	23.2
1970	4,120	1,908	46.3		1,250	30.3	962	23.3
1971	4,137	1,926	46.6	28	1,250	30.2	961	23.2
1972	4,183	2,009	48.0	78	1,250	29.9	924	22.1
1973	4,113	1,963	47.8	39	1,250	30.4	900	21.8
1974	4,136	2,045	49.4	56	1,250	30.2	841	20.3
1975	4,433	2,272	51.3	55	1,252	28.2	909	20.5
1976	4,468	2,315	51.8	96	1,301	29.1	852	19.0
1977	4,547	2,407	52.9	108	1,344	29.6	796	17.5
1978	4,594	2,431	52.9	134	1,296	28.2	867	18.9

¹Source = Registrar's Reports

²Source = D.S.A. records

³1969-74 estimated; 1975 and later from D.S.A. records

⁴Subtract (2) and (3) from (1). (Undergraduates in M.I.T. married student housing appear in this number even though they do not live off campus. For 1978, that number was 26.)

Talbot House

Talbot House has continued to enjoy popularity with a variety of groups from the M.I.T. community. During 1978-79, 57 different groups composed of 1,158 individuals stayed at Talbot House. These groups can be categorized as academic groups (32), living groups (8), clubs (8), and recreation groups (8).

With the exception of the month of December when there were two free weekends, Talbot House was occupied every weekend of the year. During I.A.P. nine different groups took advantage of the accommodations. Efforts to encourage weekday visits to Talbot House have continued to meet with little success.

Because of escalating costs, the price structure was adjusted again in January. We expect to have to raise prices annually to keep Talbot House's income consistent with actual costs.

Two major renovation projects were undertaken this year. The exterior of Talbot House was painted. This along with some newly planted spring bulbs made the house a most attractive and colorful sight this spring.

In order to cope with high energy costs we made several changes in the heating system. With the consultation of George West, Manager of Mechanical Services, a sixth zone was added to the boiler supply to heat the faculty host's bedroom; insulation was added to the attic; and the safety covers were removed from the thermostats so that guests could regulate the temperature. We experienced a 13.8% savings in fuel used for heating purposes. We plan to consider additional ways in which we can conserve energy.

SUSAN HAIGH HOUPT

Foreign Study Office

The Junior Year Abroad program continues, on a relatively small scale, to be an excellent opportunity for undergraduates. It is also beneficial to M.I.T. as an incentive to prospective freshmen and as an opportunity to increase the cultural awareness of the student body as a whole. The number of participants remained nearly the same as the previous year's with 14 students going abroad, three for the full academic year, three for the fall term, and eight for the spring term. The countries represented were Australia, Austria, England, France, West Germany, Israel, Lebanon, and Scotland.

The number of student inquiries about foreign or domestic study also seemed to remain stable at approximately 500 student visits to the Foreign Study Office. Foreign study personnel no longer issue International Student Identity Cards, but approximately 250 applications and explanations were given out.

Six students participated in the domestic year away program this year; one for the full year, two for the fall term, and three for the spring term. The schools attended were: University of Arizona at Tucson; University of California at Berkeley; Brown University; Harvard University; Vassar College; and University of Wisconsin at Madison. Although the number of participating students continues to be small, the program greatly benefits many upperclass students whose M.I.T. goals are further defined by having made a thoughtful comparison of M.I.T. study with that at another school.

ROBERT L. HALFMAN

Disciplinary Concerns

Student disciplinary problems are handled in a variety of ways. Most often, the parties involved deal with the situation themselves within their own living groups. The Dean for Student Affairs Office may be contacted for advice on how to deal with a situation or to mediate a problem. Referral to the Dean's Office is also made if the offense is considered serious enough to warrant keeping a record of the incident. The most serious cases are referred to the Committee on Discipline.

The staff of the Dean for Student Affairs Office dealt with approximately 50 complaints during the 1978-79 academic year. The Chairman of the Committee on Discipline was involved in discussions on a number of these cases and four cases were brought before the Committee on Discipline. In addition, the residence section of the Dean's Office dealt with approximately 35 complaints from neighbors of fraternities and many other minor problems in the dormitories.

The most frequent problem (15 complaints) handled within the Dean's Office involved hacking which got out of hand in terms of safety, property damage, or abuse of an individual. Other problems which came up repeatedly included academic dishonesty (six times), theft (four times), and personal injury or abuse (four times).

The situations which were handled by the Committee on Discipline included the following: one student who was in possession of a departmental master key; two students who were accused of invasion of privacy and severe harassment of others; one student who was believed to have fabricated research data; and one student who was in possession of dangerous chemicals in his dormitory room. As a result of these hearings, one student was acquitted, one student was reprimanded, two students were placed on formal probation, and one student was suspended.

Disciplinary Concerns

Eight of the cases handled by the Dean's Office resulted in Dean's Office probation. These involved incidences of cheating, physical injury to others, selling drugs, and vandalism. In addition, two students were required to leave the dormitory system because of pranks which were very disturbing to other individuals and/or resulted in property damage or created safety concerns; one student was required to leave the dorm for selling drugs. Students were required to pay for damages they caused. The remaining situations resulted in discussions, verbal reprimands, or notations in the Dean's file.

In addition to dealing with specific disciplinary problems, Deans Robert Sherwood and Bonny Kellermann met on a regular basis in the spring term with dormitory JudComm chairmen. During these meetings we began revisions of the Uniform Judicial Code and reviewed problems which had come up during the year. The problems most frequently dealt with by dormitory JudComms were to mediate complaints about excessive hacking and noise. Members of JudComm often act as mediators to facilitate communications where no further action is necessary. Hearings were held by various dorms for issues including defacing or damaging property, throwing things out of windows, and violent behavior. These have generally resulted in warnings or dormitory probation. In some cases, recommendations were made to the Dean's Office to place the student on Dean's Office probation.

BONNY S. KELLERMANN

Provost

Accreditation Review

One of the traditional rites of the academic world is the accreditation review, which takes place every 10 years. For M.I.T., this process began in the summer of 1978 and culminated with a visit to the campus in April 1979 by a visiting team under the aegis of the New England Association of Schools and Colleges (NEASC). The preceding accreditation review had taken place in 1969 during a period of turmoil on the campuses of the nation. M.I.T. was reaccredited even though that year's annual report, preoccupied with more pressing matters, makes no mention of the event.

The reaccreditation process had evolved during the ensuing decade, and we found that Dr. William J. MacLeod (Director of Evaluation for NEASC) welcomed our suggestion that instead of a more standard presentation of M.I.T.'s educational offerings and programs in the natural sciences and the humanities and social sciences¹ we would prepare several self-studies that might help M.I.T. in coming to grips with important educational issues.

We charged a steering committee with the overall task of preparing ourselves for the visit and discussed within that committee the most appropriate topics for the self-studies. We agreed on the following themes: 1) the basic educational requirements in M.I.T.'s undergraduate curricula; 2) the evolution of institutional forms with particular emphasis on interdisciplinary and interdepartmental laboratories, centers, and programs; 3) the role of computers and computation in undergraduate education at M.I.T.; and 4) career expectations and career paths of M.I.T. students and alumni.

A task force was established to study and prepare a report on each of these themes. The four task force reports, together with an unusually complete collection of M.I.T. publications and a comprehensive report assembled by steering committee members Kathryn W. Lombardi and John M. Wynne (with the assistance of Susan I. Shansky of the M.I.T. Bulletin office), were designed to give an overview of the structure of educational programs, facilities, finances, and general operations of the Institute. Those materials constituted the written information sent in advance to the visiting team. In addition, the following timetable conveys the diversity and intensity of the visiting team's personal interactions with faculty, students, staff, Corporation members, and the M.I.T. administration.

Schedule for NEASC Visiting Team

Sunday, April 8, 1979

3:30 pm	Tour of M.I.T. campus
6:30 pm	President's reception and dinner (with Howard W. Johnson, Dr. Jerome B. Wiesner, Dr. Paul E. Gray, Professor Walter A. Rosenblith)

Monday, April 9, 1979

8:00 am	Breakfast with Steering Committee
9:30 am	Subgroup meeting with Task Force on Evolution of Interdisciplinary Forms

¹ The School of Engineering, the School of Architecture and Planning, and the Sloan School of Management were all recently accredited by the appropriate professional bodies.

Provost

9:30 am Subgroup meeting with Task Force on Basic Educational Requirements

12:00 noon Lunch with Academic Deans

2:00 - 4:30 pm Subgroup meeting with Task Force on M.I.T. Education and Computers

Subgroup meeting with Task Force on Career Paths and Expectations of M.I.T. Students and Alumni

7:00 pm Dinner meeting

Tuesday, April 10, 1979

8:00 am Subgroup meeting on Affirmative Action with John M. Wynne, Professor Walter A. Rosenblith, Dr. Mary P. Rowe, Dr. Clarence G. Williams

8:00 - 9:30 am Seven individual or group meetings between visiting team members and faculty from departments throughout the Institute

9:30 am Subgroup meeting with selected group of students

11:00 am Subgroup meeting with joint group of faculty and students

Individual meeting with Dr. Mary P. Rowe, Special Assistant for Women and Work

Subgroup meeting with women students

12:00 noon Visiting team lunch with selected members of the Committee on Educational Policy (faculty and students)

2:00 pm Subgroup meeting with combined student-faculty groups from Undergraduate Research Opportunities Program (UROP); Experimental Study Group (ESG); Concourse Program; and Office of Minority Education

Subgroup meeting with selected faculty from the Committee on Humanities, Arts, and Social Sciences Requirement; the Program in Science, Technology, and Society; the M.I.T.-Wellesley Exchange Program; and the Independent Activities Period (I.A.P.) committee

4:00 pm Subgroup meeting with women faculty

Subgroup meeting with minority faculty

Subgroup meeting with minority students

6:00 pm Visiting team meeting and dinner with members of the M.I.T. Corporation

Wednesday, April 11, 1979

7:30 am Subgroup breakfast with officers from Financial Aid and Admissions

Subgroup breakfast with officers from Student Affairs

Subgroup breakfast with women graduate students

8:45 am Visiting team executive session

Provost

11:00 am Visiting team meeting with Steering Committee
12:00 noon Continuation of executive session and meeting with
President Wiesner, Chancellor Gray, and Provost Rosenblith

Following its visit to the campus, the visiting team wrote an extraordinarily perceptive report which it forwarded to the Commission on Institutions of Higher Education of NEASC.

This whole effort was skillfully orchestrated by Joel Orlen, Executive Officer in the Office of the Provost. It was he who handled schedules and logistics, interacted with the visitors and the members of the M.I.T. community, and saw to it that these few days were managed so as to be incredibly informative and yet not too frustrating. It is a pleasure to acknowledge his superb performance.

Membership of NEASC Visiting Team

Chairman

Dr. H. Guyford Stever
Chairman, Assembly of Engineering
National Research Council

Members

Dr. Edgar F. Beckham
Dean of the College
Wesleyan University

Dr. Henry Rosovsky
Dean of the Faculty of Arts and Sciences
Harvard University

Dr. Rita Colwell
Professor of Microbiology
University of Maryland

Dr. Adele Simmons
President
Hampshire College

Mr. William R. Driver, Jr.
Managing Partner, Retired
Brown Bros. Harriman and Co.

Dr. Walter H. Stockmayer
Albert W. Smith Professor of Chemistry
Dartmouth College

Dr. Helene Moglen
Dean of Humanities and Arts
University of California at Santa Cruz

Dr. Oliver E. Williamson
Professor of Economics
University of Pennsylvania

Dr. David Pines
Professor of Physics
University of Illinois

Steering Committee

Professor Michael L. Dertouzos, Electrical Engineering and Computer Science; Director, Laboratory for Computer Science; Chairman, Task Force on M.I.T. Education and Computers

Professor Robert I. Hulsizer, Jr., Physics; Chairman of the Faculty; Task Force on Basic Educational Requirements

Kathryn W. Lombardi, Manager, Campus Information Services; Associate, Analytical Studies and Planning Group; Task Force on Career Paths and Expectations of M.I.T. Students and Alumni

Jay Lucker, Director of Libraries

Professor Elting E. Morison, Senior Lecturer and Professor Emeritus, Humanities and Social Science; Chairman, Task Force on Evolution of Interdisciplinary Forms

Professor Barbara S. Nelson, Associate Director and Assistant Professor of Education, Division for Study and Research in Education; Task Force on M.I.T. Education and Computers

Joel Orlen, Executive Officer, Office of the Provost

Provost

Professor Hartley Rogers, Jr., Mathematics; Associate Provost; Task Force on Basic Educational Requirements

Professor Walter A. Rosenblith, Provost; Institute Professor; Chairman, Steering Committee for NEASC Accreditation Review

Professor Edgar H. Schein, Sloan School of Management; Chairman, Task Force on Career Paths and Expectations of M.I.T. Students and Alumni

Constantine B. Simonides, Vice President; Task Force on Career Paths and Expectations of M.I.T. Students and Alumni

John M. Wynne, Vice President, Administration and Personnel; Task Force on Career Paths and Expectations of M.I.T. Students and Alumni

Advisory Committee of Deans

Dean Robert A. Alberty, School of Science

Dean Harold J. Hanham, School of Humanities and Social Science

Dean William L. Porter, School of Architecture and Planning

Dean William F. Pounds, Sloan School of Management

Dean Robert C. Seamans, Jr., School of Engineering

Dean Kenneth R. Wadleigh, Graduate School

Accreditation Task Forces

Task Force on Evolution of Interdisciplinary Forms

Martin Deutsch, Professor, Physics, Director, Laboratory for Nuclear Science; Peter Elias, Professor, Electrical Engineering and Computer Science; Kenneth M. Hoffman, Head, Mathematics; J. Herbert Holloman, Professor, School of Engineering, Director, Center for Policy Alternatives; Paul L. Joskow, Professor, Economics; Margaret L. MacVicar, Associate Professor, Physics, Director, UROP; Elting E. Morison, Professor Emeritus, School of Humanities and Social Science; Lawrence E. Susskind, Head, Urban Studies and Planning.

Task Force on Basic Educational Requirements

Richard B. Adler, Associate Head, Electrical Engineering and Computer Science; Harold J. Hanham, Dean, School of Humanities and Social Science; Robert I. Hulsizer, Professor, Physics, Chairman of the Faculty; Hartley Rogers, Jr., Associate Provost, Professor, Mathematics; Ascher H. Shapiro, Institute Professor, Mechanical Engineering; Edwin F. Taylor, Senior Research Scientist, Physics.

Task Force on M.I.T. Education and Computers

Michael L. Dertouzos¹, Professor, Electrical Engineering and Computer Science, Director, Laboratory for Computer Science; Robert M. Fano, Professor, Electrical Engineering and Computer Science; J.C.R. Licklider, Professor, Electrical Engineering and Computer Science; Arthur P. Mattuck, Professor, Mathematics; Joel Moses, Associate Head, Electrical Engineering and Computer Science; Nicholas P. Negroponte, Associate Professor, Architecture; Barbara S. Nelson, Assistant Professor and Associate Director, Division for Study and Research in Education; Ithiel de Sola Pool, Professor, Political Science; John F. Rockart, Senior Lecturer, Sloan School of Management, Director, Center for Information Systems Research; Joseph Weizenbaum, Professor, Electrical Engineering and Computer Science.

¹ Chairman of Task Force

Task Force on Career Paths and Expectations of M.I.T. Students and Alumni

Lotte Bailyn, Associate Professor, Sloan School of Management; Lisa Egbuonu, Student, fourth year, Biology; Steven Felsher, graduate student, Management; Kenneth Keniston, Professor, School of Humanities and Social Science; Kathryn W. Lombardi, Associate, Analytical Studies and Planning Group, Manager, Campus Information Services; Peter H. Richardson, Director, Admissions; Edgar H. Schein¹, Professor, Sloan School of Management; H. Dany Siler, Assistant to the Director, Admissions; Constantine B. Simonides, Vice President; Benson R. Synder, Professor of Psychiatry, Director, Division for Study and Research in Education; Linda Stantial Yenawin, Coordinator, Alumni Career Services; James R. Thompson, Student, fourth year, Architecture; Robert K. Weatherall, Director, Career Planning and Placement; John M. Wynne, Vice President, Administration and Personnel.

Urgent Needs for Instructional and Research Equipment

Last year, this report commented on certain aspects of the Institute's "space crunch." While these problems have in no way abated, they have been joined by another source of increasing frustration: the obsolescence of the Institute's equipment used for laboratory teaching. The amount of general funds that are available are hardly sufficient to cover even a small fraction of the equipment that needs to be replaced. This lack of up-to-date equipment -- both for instructional and research purposes -- represents a serious handicap in the education of young engineers and scientists. Both inflation and the increasing sophistication of scientific and technical equipment have seriously weakened the ability of research universities to provide up-to-date training and to remain in the forefront of experimental research.

Science and Decision Making, 1979

In 1976, Bernard Gregory (Ph.D in Physics, 1950), who was then Director of the French CNRS (Centre National de la Recherche Scientifique), and the M.I.T. Provost agreed to conduct a joint exploration by staff members of the CNRS and faculty members at M.I.T. of the role of scientific knowledge in societal decision making. We set up several joint working groups on both sides of the Atlantic, in the hope of gaining significant insights by comparing how new scientific findings and technical developments were translated into societal realities by industry and governmental institutions in the two countries. (This agreement followed upon an earlier initiative of another M.I.T. alumnus, the late Maurice Barthalon [Mechanical Engineering, 1949]. His particular interest had been in examining the role which academic institutions play in bringing about innovation in the US and France, and in exploring whether we could meaningfully forecast how progress in science and technology would shape the last two decades of this century.) Throughout the two-year period of the study, the Paris Club of M.I.T. Alumni manifested a sustained interest in the CNRS-M.I.T. project and assisted in a multitude of ways.

The areas in which the working groups were set up were the following: energy (more specifically conservation, co-generation, and district heating), urban systems (in particular, housing and transportation), health and lifestyle (with emphasis on smoking), and comparative studies of the telephone and railroads -- areas in which there have been significant differences in performance in our two countries in the recent past.

Each working group was led by two co-chairpersons (one each from France and M.I.T.). The M.I.T. chairpersons were Dean Robert C. Seamans, Jr. (energy), Dr. Irving M. London (health), Professor Alan A. Altshuler (urban systems), and Professors Elting E. Morison and Ithiel Pool (railroads and telephone). Each working group was composed of roughly a dozen participants. On the American side, practically all came from M.I.T.²; on the French side, there was a mixture of staff members from CNRS, INSERM (comparable to the National Institutes of Health), several universities, certain "grandes écoles," and the civil service.

¹ Chairman of Task Force

² With the notable exception of Alfred Chandler, Strauss Professor of Business History from the Harvard Graduate School of Business Administration.

The working groups met several times during the two-year period to discuss papers that their members had prepared. The topics did not lend themselves to a standardized methodology of inquiry, and yet there emerged from this effort not only a set of acquaintances and friendships but also the conviction that out of such collaboration came new questions and insights that would have been difficult to gain in either country by itself.

This two-year long effort culminated in a major symposium entitled, *Science et Décision*, held on February 1 and 2, 1979, at the Paris House of Unesco. It was dedicated to the memory of Bernard Gregory, who had unfortunately passed away in the interim. Several hundred participants -- in the main, French, but also from the United States and several European countries -- attended.

The conference included major addresses by key academic and governmental figures from both countries, separate meetings in which the reports of the several working groups were discussed, as well as panels, plenary sessions, and opportunities for general discussion among the participants. Following the conference, on February 3, more than a dozen M.I.T. faculty members reported the deliberations of the symposium to about 100 French and other European alumni. They tried to communicate how, in an increasingly man-made world, the results of technological progress demand rapid adaptation by individuals and societies if the risks and detriments are not to tear the fabric of our culture. The time scale of evolution and the time scale of decision making under uncertainty are obviously orders of magnitude apart. Whether the issue be nuclear energy, new chemicals, food safety, a new vaccine, or recombinant DNA, there is never enough knowledge to make a decision that can weigh with precision and accuracy the attendant risks and benefits. And yet without the contributions of science and technology, most of our societal problems can neither be analyzed completely, nor solved. Hence, there is a need to develop, within the framework of our democratic institutions, procedures that will take advantage of the rationality of science in the allocation of resources. This is a terrain where little theory exists; therefore, it appeared to us a worthwhile experiment to contrast and compare the ways of our two countries, for identical natural laws give rise to dissimilar technological realities in different historical, educational, economic, and political contexts. It is these interactions that we need to explore if we are serious about inventing better futures.

These are not issues over which any scientific discipline can claim a monopoly. What is needed are communicative encounters between men and women from all sectors of society -- industry, government, and academic -- natural and social scientists, engineers, historians, industrial and governmental decision makers, and technically literate citizens concerned for the common weal.

WALTER A. ROSENBLITH

¹ In addition to special publications, the symposium proceedings are being published in the *Progres Scientifique*; M.I.T.'s participation in the symposium was supported by Arthur D. Little, Inc, Schlumberger Horizons, Inc., and the Phillippe Foundation, Inc.

Artificial Intelligence Laboratory

The primary goal of the Artificial Intelligence Laboratory is to understand how computers can be made to exhibit intelligence. Two corollary goals are to make computers more useful and to understand certain aspects of human intelligence. The research program includes work on computer vision and manipulation, intelligent personal assistants, English-language understanding, learning and automatic debugging, common-sense reasoning, expert engineering problem solving, manufacturing productivity, computer architecture, human development, and human education.

Professor Patrick H. Winston is responsible for the general direction of the Laboratory and for work on learning. This year, Professors Berthold K.P. Horn and David C. Marr led work on computer vision, and Professor Horn also supervised work on computer-controlled, multiple-joint manipulators and other problems in manufacturing productivity. Professor Randall Davis began research on distributed problem solving. Professor Carl E. Hewitt investigated new programming models and developed the ACTOR language. Professors Marvin Minsky and Seymour A. Papert worked on the development of general theories of artificial and natural intelligence. Professor Gerald J. Sussman worked on programs that reason about electronic circuits, and Professor Sussman and John Holloway began work on the problems of integrated circuit design. Richard D. Greenblatt, Thomas F. Knight, and Mr. Holloway led work on computer systems including the development of a high-performance processor oriented toward the symbol manipulation required by intelligent programs.

The Laboratory's 83 members include a total of 11 faculty, 34 research and support staff, and 38 graduate students. They are involved in research activities which were funded during the past year by the Defense Advanced Research Projects Agency, the Office of Naval Research, the National Science Foundation, and the International Business Machines Corporation.

Image Understanding

Professor Horn's group has spent a considerable part of the past two years working on the automatic understanding of aerial photographs. In particular, Professor Horn has devised a representation called *the reflectance map* to describe how reflected intensity is controlled by surface material, surface orientation, and light-source position. Reflectance maps enable the generation of synthetic high-altitude images from terrain models. Correlating a real image with a synthetic one can establish the proper registration of the real image with a terrain model in preparation for various sorts of automated cartography and improved crop forecasting. To keep computational time within reasonable bounds, blurred real and synthetic images are first correlated in translation, rotation, and scale space to give approximate registration, and then the process is repeated with high resolution images to achieve high accuracy.

Once the registration problem was under control, Professor Horn proceeded to make the first images in which intensity is determined by the ratio of real image intensity to synthetic image intensity. These albedo maps offer a new way of doing crop analysis inasmuch as intensity varies only with ground cover and not with changes in ground slope or sun position.

Synthetic images that are to mimic real images obtained from spacecraft require attention to the fact that the atmosphere attenuates visual signals, scatters spurious light into the viewing port of the satellite, and illuminates the ground as a large, diffuse light source. During the past year, Professor Horn has begun to study these effects in order to make better synthetic images.

The particular problem of atmospheric effects is quite complex and mathematically intricate. The literature of remote sensing, atmospheric science, geophysics, and space science is filled with detailed reports on absorption, transmission, radiance, complete tabulations of wavelength-dependent behavior, and sophisticated models of particle scattering. However, the emphasis always has been on the degradation of visual signals passing through the atmosphere. The

little research on the contribution of sky luminance to the imaging process has been restricted to flat areas of the earth's surface, either agricultural lands or the ocean. Professor Horn, working with Dr. Robert J. Woodham, has shown that, at least in the shorter wavelengths, sky illumination is not negligible in LANDSAT multispectral scanner images. Part of this is due to the relatively low sun elevation (about 9:30 am local time for LANDSAT 1 and 2) which puts a large portion of rugged terrain in shadow. For these areas, the sky is the only light source (ignoring such things as mutual illumination of one side of a valley by the opposite side). Work is under way to investigate the interaction of sky radiance and surface reflectance in areas of rugged topography.

Natural Vision

Believing that an overall theory of vision must rely on explicit descriptions at the right levels, Professor Marr has concentrated on three representations: the *primal sketch* which records information about intensity changes and local two-dimensional geometry; the *2 1/2-D sketch* which is a viewer-centered representation of the depth and orientation of visible surface and includes contours of discontinuities in these quantities; and the *3-D model* representation, which makes information about shape explicit.

During the past year, the original structure of the primal sketch computation has been put aside, in favor of a better theory. In developing a new structure, Professor Marr and his student, Ellen C. Hildreth, have shown that the intensity changes at a particular scale in an image are best detected by locating the zero-crossings of the Laplacian of the image after convolution with a 2-D Gaussian distribution. The smallest operator usable in practice has a diameter of nine picture elements in the central, positive region, with an overall support of roughly 1,000 picture elements. Interestingly, this is roughly the size of the smallest channel found in early human vision. The zero-crossings are then represented by a set of oriented primitives called zero-crossing segments, each describing a piece of the contour whose intensity, slope, and local orientation are roughly uniform.

In combining information from the separate channels, it is useful to note that intensity changes in an image arise from surface discontinuities, or from reflectance or illumination boundaries, which all have the property that they are spatially localized. This observation led to the spatial coincidence assumption, which states that if similar information concerning the presence of an intensity change is found across a set of adjacent channels, then all channels likely describe the same physical intensity change, so their descriptions may be integrated into a single description of an edge. The final raw primal sketch contains a binary map specifying the position of the original zero-crossing contours, together with the symbolic description of the intensity changes obtained from the separate channels.

The work on zero crossings was stimulated by the development of a stereo algorithm that provides a theoretical framework for most existing psychophysical and neurophysiological data about stereopsis. The algorithm consists of the following steps: each image is filtered with Gaussian masks of three sizes; after taking the Laplacian, zero-crossings are localized; for each mask size, matching takes place between pairs of zero-crossings of the same sign (results with one mask controls the matching at the next smaller scale); and when a correspondence is achieved, it is written into a dynamic buffer, the *2 1/2-D sketch*. During the past year, this new stereo algorithm has been the subject of considerable experimentation by Professor Marr, working with his student, W. Eric Grimson.

Expert Problem Solving

Traditional automated synthesis techniques for circuit design are restricted to small classes of circuit functions for which exact mathematical methods exist. Professor Sussman and his group have developed computer-aided design tools that can be of much broader assistance.

It is an obvious idea to determine component values by solving the set of equations and inequalities which result from matching a symbolic analysis of the circuit with the given design criteria. Unfortunately, this is algebraically infeasible in general. A complete symbolic analysis of even simple circuits containing nonlinear components is usually difficult. But even for circuits whose behavior is linear in voltages and currents, the equations are badly nonlinear in the component parameter values.

Professor Sussman's synthesis aid is based, instead, on analysis by propagation of constraints. This analysis method guides the use of symbolic algebraic methods in combining constraints which describe circuit elements and their interconnections to determine the behavior of a circuit. He has shown how propagation analysis can be inverted to determine constraints on the individual parts from the desired behavior of the circuit. The method is based on the observation that locally, analysis and synthesis are very similar: the problem of finding the resistance which permits a given current flow at a given potential is equivalent to the problem of determining the current that flows given a resistance and a potential.

Computer Systems Development

Intelligent information processing places unusual demands on computers. Consequently, Messrs. Greenblatt, Knight, and Holloway and their colleagues, have designed a computer that gives its users more symbol-manipulation and list-processing power than ever available before. The processor's features include hardware-data types, interleaved processing and garbage collection, a very large address space, and a very general microcode that enables, among other things, a uniquely powerful function-calling instruction.

During the past year, five LISP (list processing) machines were built. Four more will be built during the remainder of 1979 under existing contracts. After those are completed, the current plan is to build six machines for the Department of Electrical Engineering and Computer Science, two for the Research Laboratory of Electronics (R.L.E.), and one for the Division for Study and Research in Education (D.S.R.E.).

All of the existing machines are linked together to demonstrate that collections of inexpensive, connected "personal" computers in local networks are superior to large, expensive time-shared machines. The linking is through an eight-megabit packet-oriented cable system known as the CHAOSNET. At the moment the CHAOSNET links five LISP machines, and four other computers, on .65 miles of cable. The technology is such that the system can support as many as 100 communicating computers before reaching intolerable performance deterioration.

In large part, this work on hardware was possible because of the development of total design environments that transfer much of the burden of design bookkeeping and simple design checking to a computer working as a partner with a human designer.

Large-Scale Integrated Circuit Design

During the past year, a major new effort was begun in response to a national need for design tools that can help human designers cope with the enormous complexity of very large-scale integrated circuit design. Three factors make this new research area particularly attractive technically: first, the relevance of the work of Professor Sussman and his associates on expert problem solving in the domain of analog electronics; second, the experience of Mr. Holloway and his associates on the creation of total design environments, such as the one used in the development of the LISP machine; and third, the general abundance of problems of importance to other laboratory people, which can be solved only by the development of integrated circuit design technology.

At this moment, Professor Sussman and Mr. Holloway are working hard on a design for a chip to run the language SCHEME, a derivative of LISP, as a way of exploring what tools to develop first. Most of the other work so far has been oriented toward laying out a five-year program in cooperation with Professor Jonathan Allen's group in R.L.E. and with the Department of Electrical Engineering and Computer Science.

Basic Theory

Professors Minsky and Papert are attempting to combine some ideas from developmental, psychoanalytic, and cognitive theories with ideas from artificial intelligence. In the *society of mind* theory, intelligence emerges from the interaction of large "societies" of rather simple individual "agents," in a parallel computational structure. Because each agent is relatively simple, communication between agents must be very restricted, both in amount and in complexity.

It is hoped that the approach may illuminate the psychological theories of Piaget and Freud, as well as the coherence of artificial intelligence theories, which have not previously attempted to consider the kinds of problems that must be confronted by a whole "personality." The limitations of inter-agent communication make it necessary for the mind to develop hierarchies of control structures that we may be able to identify with developmental stages. The censors and critics of the hierarchy must settle conflicts by referring to early-developed self-images.

Whether or not the theory is psychologically productive, the work has already suggested new ways to organize very large knowledge-based computer programs. Recently, it has produced some novel ideas about building large, active computer memories. These new memory structures may turn out to be very useful for the representation of kinds of common-sense knowledge that have been hard to deal with in conventional systems. Several students are implementing computer models of their own versions of the theory.

Manufacturing Productivity

To advance the state of the art in automation, Professor Horn is doing long-term research in computer vision, computer-controlled manipulation, and high-level programming languages.

Professor Horn and his students have developed a technique for recovering shape and identifying objects using only one camera position together with multiple light sources. Normally, the intensity of a point in an ordinary black-and-white image is not sufficient to determine the surface normal at that point. There is constraint, however, and using multiple light sources, two or more separate curves in reflectance-map space are obtained. Their intersection gives the surface normal unambiguously.

During the past year, Professor Horn has shown that it is possible to work with the specular surfaces of metallic objects by using distributed light sources, rather than concentrated ones.

Manipulator control also has been a major concern. Some time ago Professor Horn solved the intricate problem of calculating the forces needed to move a six-joint arm along a prescribed trajectory using the Euler-Lagrange approach, but the resulting formulas are much too large to use in real-time control. One alternative that Professor Horn has explored is to combine table look-up with some real-time computation. Professor Horn calls the method configuration-space control. It correctly deals with Coriolis forces, varying inertia, and link interaction, predicting the forces required to follow a prescribed trajectory.

During the past year, Professor Horn's student, Brian G. Schunk, has married configuration-space control with the feedback suggested by modern control theory. Success in simulation has led to a current effort aimed at tests with a real manipulator.

Education

The LOGO Group, under the direction of Professor Papert, concentrates on enhancing education through the application of both theoretical and technological developments in computer science. Most of the group's activities involve collaboration with the D.S.R.E. Details on the LOGO group's project involving the use of computers in classrooms at the Lamplighter Elementary School, and their project on incorporating computer technology into M.I.T.'s undergraduate curriculum, can be found in the "Research" section of the report of the Division for Study and Research in Education.

PATRICK H. WINSTON

Cell Culture Center

The Cell Culture Center at M.I.T. has been established and funded by the Human Cell Biology Program of the National Science Foundation. It is intended to serve as a facility and resource for cell biologists primarily, but not exclusively, in the northeastern part of the United States; applications from other parts of the country, however, are welcomed.

The Center is headed by Professor Phillips W. Robbins of M.I.T., Dr. Richard L. Davidson from Harvard Medical School and the Massachusetts General Hospital, and Donald J. Giard, Director. The mission of the Center is to produce cells and viruses on a large scale in order to allow scientists to conduct novel and important experiments in basic cell biology that could not be accomplished with the materials and resources in the investigator's own laboratory. The Center works directly with individual scientists on basic research problems and, in addition, conducts an active program in the development of new techniques for large-scale cell and virus production.

Production

During the period January 1 to December 31, 1978, the Cell Culture Center provided cells and/or virus material to 38 research projects in New England as well as other parts of the country. Examples of projects completed during this period include: 160 liters of HeLa S-3 cells for M.I.T.; 220 liters of CEM cells for the Sidney Farber Cancer Center, Boston; 183 roller bottles of RAG cells for Children's Hospital Medical Center, Boston; 2,374 roller bottles of SV-3T3 cells for Massachusetts General Hospital, Boston; 1,818 roller bottles of SV-80 cells for Sidney Farber Cancer Center; 3,696 roller bottles of SV-80 cells for the University of Illinois at Urbana; and 900 roller bottles of Cl-1 cells for MuLv production for M.I.T.

Cost Apportioning Program

The Cost Apportioning Program continues to be a successful operation. Under this policy, all users are required to pay for the cost of all consumable materials used for their projects. The Center is receiving nearly 100 percent return on all expendable materials billed.

Research and Development

The Cell Culture Center has continued its active program in microcarrier applications research. These studies fall into two main areas:

Use of microcarriers for on-going projects: Significant progress has been made in improving conditions for growth of many different cell types including human diploid fibroblasts on microcarriers. The transfer of this new technology has been slow for a number of reasons. The problem of efficiently removing cells from the microcarrier surface, with the aid of enzymes, has not yet been satisfactorily resolved. Low MuLv and Sindbis virus yields on a per-cell basis in microcarrier culture has made it impractical at this time to use the microcarrier system for virus production runs.

In-coming projects, however, continue to be screened for applicability to the microcarrier system. One such project being conducted by Roslyn Orkin of Massachusetts General Hospital involves the study of the mode of action of hyaluronidase (HAse), an enzyme which is secreted into the culture medium by chick embryo fibroblasts. We tested microcarrier-grown chick fibroblasts for ability to produce HAse and found them to be excellent. We have switched to 1-liter microcarrier cultures for this project, and are producing the equivalent of 75 roller bottles of HAse with each 1-liter microcarrier run.

Interferon production: Feasibility studies on the use of microcarriers to grow human fibroblast cells for interferon have continued and clearly demonstrate that microcarriers have great potential for large-scale interferon production. Small-scale studies on the optimization of parameters for interferon production are nearing completion and during the next year, large-scale studies are planned.

Education

The Cell Culture Center sponsors a Master's Program in Animal Cell and Tissue Culture Sciences being offered under the auspices of the Interdisciplinary Science Program in the School of Science (Course XXV). The program offers course work in the Departments of Biology, and Nutrition and Food Science, and laboratory experience in the Cell Culture Center. The program provides students with excellent preparation for vocations that require a broad knowledge of the techniques of cell culture and animal virology. During the past academic year, two students successfully completed the program and two are enrolled for next year.

PHILLIPS WESLEY ROBBINS

Center for Advanced Visual Studies

Centerbeam

The academic year 1978-79 followed a summer-long celebration of "Centerbeam DC" on the National Mall in Washington, DC with an estimated half million spectators and participants at evening performances that included 25 sky events and the premiere of the sky opera "Icarus." C.A.V.S. served approximately 170 students from M.I.T., Harvard University, Massachusetts College of Art, and the Museum of Fine Arts School through its offering of 12 fall and nine spring subjects respectively. Professor Otto Piene and Elizabeth Goldring taught the lecture and investigation series on the history, theory, and practice of environmental art ("Art and the Environment"). The course addressed the emerging field of sky art with lectures by Professors Harold Edgerton and Walter Lewin and the Reverend Scott Paradise, as well as student presentations on a variety of sky art topics. In Professor Piene's studio, "Advanced Visual Design," students developed projects in interactive media, environmental sculpture, and large-scale celebrations.

Educational Activities

Nishan Bichajian, Harel Kedem, and Mira Cantor Piene taught "Life Drawing" and "Still Life" to more than 80 students during the past year and Ms. Piene's subject "Advanced Figure Drawing" has been established as a continuing M.I.T. subject beginning with the fall 1979 term. Nishan Bichajian's "Basic Photography for Architects" familiarizes students with techniques in black and white photography for architectural models. During the fall term Peter Campus offered a video studio which concentrated on individual student assignments and videotapes. Aldo Tambellini's "Video Image Process and Communication" has continued as a successful collaboration between C.A.V.S. and the Center for Advanced Engineering Study for the past three years. Mr. Tambellini also co-taught a film course with Yvonne Rainer, "Film as Medium" during the spring term. Through a series of presentations, Mr. Tambellini concentrated on the history of film, and Ms. Rainer presented her own work and other contemporary artistic films.

Harriet Casdin-Silver and Don Thornton offered "Holography as an Art Medium" both terms. Student holograms were created in the C.A.V.S. student holography laboratory and 180° integrations were executed as group projects.

Antonio Muntadas' media studio "Videotape as a Communication Tool and Environmental Medium" was directed toward an exploration of the possible uses of technologies as means to improve human communication.

During this past year the Master of Science in Visual Studies was awarded to Tom Sansone (Installations and the Conditions of Vision), Don Thornton (Multi-Color Holographic Art: Imaging from one Helium-Neon Laser), Ellen Kozak (Information Space), Nina Frankenheim (Environmental Kodolith), Martha Lozano (Typography and Architectural Environments), and Mike Naimark (Spatial Correspondence: A Study in Environmental Media). All of the graduating students have been appointed junior research Fellows at the Center.

Exhibitions and Fellows' Activities

"5 Artists/5 Technologies" (June-July 1979) was a group exhibition at the Grand Rapids Art Museum, Grand Rapids, Michigan, comprising five environmental chambers by Professor Piene (indoor inflatables and three sky events), Ms. Casdin-Silver (integram and hologram), Paul Earls (laser space), Mr. Campus (photo projection), Alejandro Sina (kinetic gas discharge sculptures), and a documentation gallery by Ms. Goldring. To complement the exhibition, Professor Piene flew his Carousel and Brockton Flower from Calder Plaza on three days of the Grand Rapids Arts Festival.

The Center was invited to participate in the Vienna Biennale for Graphics and Visual Art, which was organized around the theme "Expansion." Ms. Goldring's documentation room described selected Center projects and individual works by Center Fellows over the past 10 years. Ms. Casdin-Silver exhibited three holograms. Dr. Earls and Professor Piene collaborated to produce indoor and outdoor performances and sky events involving laser-scanned imagery, electronic music, and Professor Piene's inflatable sculptures. Professors Piene and Gyorgy Kepes participated in the opening symposium on "Art, Technology, and Science." Our participation in both exhibits is detailed in the accompanying catalogues.

Individual Fellows' work included one-person exhibitions, group shows, performances, events, and video screenings/installations.

The traveling show "Dreamstage," in its second year, was installed in St. Louis, Missouri and Seattle, Washington. Principal artist for the exhibition is Dr. Earls (with Harvard University neurophysiologist Allan Hobson and photographer Ted Spagna). Dr. Earls' work in music included "Doppelgaenger" with Nora Post at the Harbor Festival of the University of Massachusetts; a solo concert at the Portland Community College, Portland, Oregon; and the music and sound installation for Ms. Cantor's "Centerbeach" exhibition.

"Centerbeach" (April 1979), an installation of 25 life-size soft sculptures at C.A.V.S., simulated a beach scene. Ms. Cantor also exhibited soft sculptures, drawings, and lithographs at the Gallery Loehrl, Dusseldorf, Germany. She designed and executed costumes for the Jassin Dancers, for a performance at the Berklee Center for Performing Arts in Boston, and has received several commissions for soft sculptures.

Piotr Kowalski showed models and sculptures and presented the book *Kowalski, Espaces, Epreuves* (Kowalski, Spaces, Proofs) by Baatsch, Bailly, and Dyck at Claude Givaudan, Geneva, Switzerland. He had a one-man show at the Feldman Gallery in New York City.

Mr. Muntadas' video installations/screenings during the past year took place at the Vancouver Art Gallery, Vancouver, Canada; the Alberta Art Gallery, Calgary, Canada; the Centre Georges Pompidou (the Beaubourg) in Paris where he presented "Journées Interdisciplinaire;" and the Museum of Modern Art in New York City where "Subjectivity/Objectivity: Private/Public Information" was screened.

Mr. Tambellini presented "Two Way Live," a video installation at the Boston Film and Video Foundation. He participated in "Alternative Imaging Systems," a group show at the Everson Museum of Art, Syracuse, New York and was invited as guest artist to a colloquium on "Aesthetics and Technology" of the Institute of Design of Offenbach am Main, West Germany.

Paul Matisse exhibited a large kalliroscope at the Museum of History and Technology, Smithsonian Institution, Washington, DC and at the exhibition of Cyril Smith's "Aspects of Art and Science" at the Compton Gallery, sponsored by the Committee on the Visual Arts. He also built a large kalliroscope for the Boston Museum of Science as part of their new energy exhibit installation.

Mr. Sina participated in the two group shows: "Energy into Art," at the Memorial Art Gallery, Rochester, New York and a traveling exhibition of kinetic sculptures of the Asahi Shimbun, Tokyo, Japan, which was titled "Museum of Fun." William Parker also participated in the latter exhibition with electrical discharge pieces. Mr. Sina received commissions from the National Shopping Centers, Rye, New York for outdoor kinetic participatory works and the Best Western Hotel, Danvers, Massachusetts for a computer-controlled neon grid installation.

Frank Smullin, a Research Fellow since January 1979 on sabbatical leave from Duke University, Durham, North Carolina, placed his sculpture "Labyrinth" on the Boston University campus. The cor-ton steel sculpture was designed with the use of a computer program.

Harel Kedem, artist and architect, designed the Peles residence and farm in Galilee, Israel as well as the Paddock Restaurant in Hyannis, Cape Cod. He also built a monument for the new City Hall in Quincy, Massachusetts.

Carl Nesjar finished a large photo mural in Moss, Norway, and is working on an all-season park in Moss and on a fountain for the Lake Placid Winter Olympics.

Elon Goitein collaborated with several departments at M.I.T. to produce Henry Brant's "Spatial Concerto" with the M.I.T. Symphony Orchestra. The two-inch videotape will be aired on national television as a one-hour program. The collaborating departments were the Music Section of the Humanities Department, Educational Video Resources, the Film/Video Section of the Architecture Department, and C.A.V.S. Encouraged by this successful venture, Elon Goitein has proposed two projects of the same scale for the coming year.

The Dutch artist Peter Struycken, recommended to the Center by Professor John Habraken, developed computer programs for his work using the Architecture Machine (headed by Professor Nicholas Negroponte) and Professor Walter Lewin's group in the Department of Physics.

Participants in the C.A.V.S. presentation series included artist/Fellows Antoni Miralda, who showed slides and films of ceremonials, rituals, and events; Lowry Burgess, who presented "The Quiet Axis" Part II, a conceptual project in the Pacific Ocean south of Easter Island; and Ms. Rainer, who read parts of a new film script and showed excerpts of her latest film, *Journeys From Berlin/1971*.

Ms. Casdin-Silver and Ms. Rainer were appointed Rockefeller Fellows during this past year and both fellowships will continue. Next year's much appreciated grant to C.A.V.S. from the Rockefeller Foundation will provide fellowships, project money, and administrative support for the coming year. C.A.V.S. also received a fellowship grant from the National Endowment for the Arts' Visual Arts Program.

Professor Piene, Ms. Goldring, Dr. Earls, and Joan Brigham were commissioned to develop a portfolio of ideas for celebrative outdoor events and spectacles for the 1980 Lake Placid Winter Olympic Games. The "idea album" of large-scale day and night performances was executed in partial fulfillment of a phase one contract with the Lake Placid Olympic Organizing Committee.

Individual grants and prizes were awarded to: Frank Smullin, from the Alcoa Foundation, Pittsburgh, Pennsylvania; Mr. Muntadas, who received financial support from the Sumner Foundation, Madrid, Spain for his book *On Subjectivity*; Mr. Kowalski, who was awarded a prize at the International Art Competition, Winterthur, Switzerland for a large-scale environmental sculpture; and Ms. Piene, who received the Artist's Foundation Grant in drawing from the Commonwealth of Massachusetts for works in an exhibition at the Rose Art Museum, Brandeis University.

Several C.A.V.S. Fellows worked during the past year on books that have been published or are forthcoming. Mr. Muntadas' book *On Subjectivity* is a collaborative effort between this Center and the Visible Language Workshop. Mr. Matisse continued work in Paris on a publication of Marcel Duchamp's last notes, to be published by the Centre National d'Art et Culture, Georges Pompidou. Ms. Brigham (on sabbatical leave from Emerson College) collaborated in Paris with Mr. Matisse on the Duchamp publication. Other projects during her year's residence in France included research in early steam technology at the Conservatoire Nationale des Arts et Métiers, where she presented seven finished works in glass for an exhibit scheduled for summer 1980. Furthermore, she has plans for a project with Corning, France for a kinetic, glass, steam, and water installation at the Palais de la Découverte.

Center for Cancer Research

Professor Piene's personal work concentrated on sky events, exhibitions, and writing. After his "Centerbeam" DC contribution he contributed the 230-foot inflatable "Milwaukee Anemone" to First Night (December 31, 1978) in Boston. With a C.A.V.S. team, he made pieces such as "Iowa Star" for Iowa State University and "Carousel" with 12 human figures in a circular arrangement. Both large sculptures also were used several times at the Vienna Biennale. His one-man exhibitions of paintings and light sculptures included "Sterne" (Stars) at Galerie Heseler, Munich, and "Sky Art" at the Basel Art Fair.

The Zurich Museum organized a retrospective exhibition at the Kunsthaus, "Zero-Bildvorstellungen ciner europaeischen Avantgarde" (Zero-Image Concepts of a European Avantgarde) around the earlier work of Yves Klein, Lucio Fontana, Otto Piene, and other Zero artists of that period. Professor Piene contributed to numerous publications, notably his new essay, "Technology for Art" (Grand Rapids Art Museum and Vienna Biennale catalogues). A substantial new C.A.V.S. publication, "Centerbeam," is in the final stages of preparation.

Institute Professor Emeritus and Director Emeritus, Gyorgy Kepes accepted the distinguished Walker Ames Professorship at the University of Washington in Seattle for the fall term, followed by a visiting professorship at the University of Cincinnati. During the spring term he taught a course at Harvard University which explored the role of the artist in contemporary society. He showed paintings at the University of Washington, the Saitenberg Gallery in New York City, and the Alpha Gallery in Boston, and photographs at the Vision Gallery, Boston. He lectured at the Hungarian Artists' Association in September 1978. Translations of his books, *New Landscape* and *Language of Vision*, were published in Budapest, Hungary, this spring.

The Center's involvement with its outstanding large kinetic group sculpture, "Centerbeam" has come to a tentative conclusion with *Centerbeam*, a film by Professor Richard Leacock and former C.A.V.S. fellow Jon Rubin, and a videotape by Professor Leacock, Mr. Rubin, Professor Piene, and Glorianna Davenport. The documentation was sponsored by the US International Communications Agency which will distribute tapes through its international network.

OTTO PIENE

Center for Cancer Research

In the academic year 1978-79 a great deal of research in the Center for Cancer Research continued to concentrate on the identification of genes and gene products responsible for the transformation of normal cells into cancer cells. Substantial progress has been made this year in the study of tumor-inducing components of murine tumor viruses and adenovirus. Extensive application of recombinant DNA methods has greatly increased the refinement of these experiments. The nature of tumor viruses that exist unrecognized in various strains of mice and that can be activated by a variety of methods has been explored. These viruses serve as models for tumor viruses that may be present in the human genome. The study of glycoproteins that distinguish tumor cells from normal cells has proceeded rapidly at the biochemical level, where specific differences have now been identified. An exciting discovery was the identification of the role of the thymus gland in impressing upon different lymphocytes the specificity with which they will act in killing foreign or cancer cells. This represents a major advance in understanding the mechanism of lymphocyte action in the body's defense against cancer.

Collaborative research by virologists, cell biologists, and immunologists has expanded. A "retreat" held in Woods Hole on April 12 and 13 brought out the extent of progress, evidenced also by over 300 publications from the Cancer Center.

Members of the Cancer Center led I.A.P. activities which attracted many undergraduates. Over 20 M.I.T. undergraduates worked in the Center for one or two semesters.

Again this year several distinguished scientists spent their sabbatical leaves as our guests. Associate Professor Phillip Sharp was promoted to full professor. Associate Professors Nancy Hopkins and Robert Weinberg received tenure in the Department of Biology. Assistant Professors Raymond Baker and Michael Bevan were promoted to associate professors.

SALVADOR EDWARD LURIA

Center for Cognitive Science

This report constitutes the first annual report of the Center for Cognitive Science, formally established in February 1979 at M.I.T.

The professional concerns of cognitive scientists are necessarily broad. They include the formal description of mental faculties, the evaluation of mechanisms by which those faculties might be implemented, the conduct and critical discussion of experimental research, and the study of the biological bases of cognition. The initial and continuing education of such a scientist requires an intensive interdisciplinary program of training and postdoctoral study. By the same token, research in cognitive science is usually carried out in an atmosphere of cross-disciplinary inquiry and critical discussion.

During the past decade individual scientists working at M.I.T. have established a special tradition of excellence for research in such fields as linguistics and philosophy, psychology, artificial intelligence, speech production and perception, and education. Drawing on this history of outstanding inquiry in the sub-fields of cognitive science, a new interest in the field, directed particularly toward an interdisciplinary approach to the understanding of cognition, has rapidly accelerated the growth of cognitive science at M.I.T. This activity culminated in the establishment of the Center for Cognitive Science.

The formation of the Center marks the official emergence of an emphasis on cross-disciplinary collaboration in cognitive science at M.I.T. and in the field at large, and provides an intellectual and administrative focus for such research within the Institute's scientific community. Special purpose facilities for much of this research have already been developed within the Institute and at other medical and research institutions with which formal contacts have been established. In addition, the Center itself will provide general purpose experimental facilities, staff support, and assistance in the development of new installations as they are required by specific research projects.

A program of workshops and visiting scholars in Cognitive Science, supported by the Alfred P. Sloan Foundation, has significantly aided the effort to bring together related aspects of research at the Institute, and it has invaluable broadened communication among scholars throughout the field. Presently, a grant from the Sloan Foundation has been made to the Center to support its Program of Visiting Scholars, as well as a program of predoctoral study in the cognitive sciences. This support will extend through 1982.

At M.I.T., programs of research include an investigation of the relationship between formal grammars of language, parsing algorithms, and psycholinguistic processes; the interaction of developmental and maturational components in cognitive development; an examination of the normal processes of understanding and producing sentences and their breakdown or failure in cognitive disorders; algorithms for visual processing and their relationship to the neurophysiology of vision; studies of the comprehension of written, spoken, and pictured concepts; speech recognition and production; the formal relation of grammars, processors, and the neurological basis of language; a comparison of conceptual change in development and in science; and basic research in linguistics, the philosophy of language and mind, psychology, artificial intelligence, and neuroscience.

EDUCATION

Training in cognitive science is coordinated by the Interdisciplinary Committee on Cognitive Science working in conjunction with the relevant committees of the faculty. The members of this committee, which includes representatives from the Departments of Linguistics and Philosophy, Psychology, Electrical Engineering and Computer Science, and the Division for Study and Research in Education, are developing an interdisciplinary curriculum in cognitive science. In addition, a curriculum guide is now being prepared which lists all subjects relevant to cognitive science taught at the Institute. This guide will be distributed in the fall of 1979. The Committee also will coordinate the staged development of a mature graduate program in cognitive science to parallel the program which has been developed for undergraduate study. This formal program in Language and Mind, in operation since 1976, provides curriculum guidance to those undergraduates who seek concentrated training in cognitive science.

RESEARCH

Workshops

During the past year, M.I.T. conducted a series of workshops on cognitive science. Over 200 scholars have participated in these workshops, either by presenting papers for discussion or through commentary from the audience. The first workshop, organized by Professor Jerry Fodor of the Department of Linguistics and Philosophy, was on the topic "Mental Representation" and was held in January 1978. The second, organized by Professor Susan Carey (Psychology), was entitled "Maturational Factors in Cognitive Development." And the third, organized by Professor Noam Chomsky (Linguistics and Philosophy), was on "The Biological Basis of Language." The second and third workshops were held concurrently in June 1978 to take advantage of the overlapping interests of the panelists and those attending. These workshops were preceded by a public lecture by Dr. John C. Marshall, Catholic University, Nijmegen, entitled "Toward a Unified Theory for Neurolinguistics." A fourth workshop on "Conceptual Change," organized by Professors Carey and Daniel Osherson, (Psychology) was held on January 26-28, 1979.

The success of these workshops has been in no small part due to the informal atmosphere of the facilities of Endicott House. The brief but intensive exposure to the participants' various points of view has proved extremely fruitful to both the formal and informal scholarly exchanges in the workshops. An anthology of the presented papers from the workshops on Maturational Factors and The Biological Basis of Language, including supplementary material and commentary from the audience, has been edited by David Caplan, M.D., a conference participant and holder of a doctoral degree in linguistics from M.I.T. This volume will be published in 1980 by the MIT Press under the title "Biological Studies of Mental Processes."

The last workshop in this series was organized by Professor George A. Miller (Linguistics and Philosophy). This workshop, which was held June 1-2, 1979, summarized the work of the preceding workshops and the continuing research of the members of the Center for Cognitive Science at M.I.T. Professor Miller's remarks, entitled "A Very Personal History of Cognitive Science," have appeared as the first of a series of *Occasional Papers in Cognitive Science*. Participation in this final workshop was limited to members and affiliates of the Center in order to examine in depth the alternatives for future collaborative research in cognitive science brought forth by the program of workshops, the visiting scholars program, and current research at M.I.T.

Joint Seminar on Cognitive Processing

In the spring term 1978 a joint seminar was established to facilitate the discussion of topics of mutual interest among cognitive scientists in the M.I.T. research community. The seminar, now in its second year of successful operation, has served not only to make a variety of viewpoints on recent work from several disciplines familiar to its more than 40 members, but also has broadened their acquaintance with colleagues at other academic and research institutions. The seminar also has provided an appropriate means of introducing Visiting Scholars in cognitive science at M.I.T. to that broader community.

Visiting Scholars in Cognitive Science

The Visiting Scholars Program has brought to the M.I.T. community a group whose expertise and research interests extend or complement those of the scientists at the Institute. Visiting Scholar appointments provide for longer and more extensive interaction among individuals than is possible under the Workshops on Cognitive Science program or the Joint Seminar. The Program thus serves to build both personal and intellectual bridges between permanent members of the Center for Cognitive Science and cognitive scientists working in related fields at other institutions. The program also acquaints scholars at M.I.T. with the important work being carried out in other areas of research overlapping the interests represented by the members.

During the tenure of their visits, the Visiting Scholars participate in the Joint Seminar, the Continuing Research Workshops, and the M.I.T. Workshops on Cognitive Science where the research interests of the Working Group coincide with those of the visitors. The program of Visiting Scholars thus has had a mutually beneficial function, and it is hoped that the patterns of collaborative research which arise or are fostered during the scholars' visits will continue after their appointments have ended.

Continuing Research Workshops

Research support for the program of research on cognitive science at M.I.T. is presently provided under individual and departmental grants, programs, and contracts within the resident departments of the Working Group members. On August 1, 1978, a program of Continuing Research Workshops on Cognitive Science was begun under the direct control of the Working Group. The members of this group have themselves committed personal research time and laboratory facilities to support this program of research.

These research workshops have pursued in depth several of the avenues of inquiry generated by the M.I.T. Workshops on Cognitive Science, the Joint Seminar, the Visiting Scholars Program, and the continuing interaction of the members of the Working Group on Cognitive Science. The projects have attracted the participation of three young Visiting Scholars who are especially well qualified in the areas of research under study. Where appropriate, Visiting Scholars, Joint Seminar members, and advanced graduate students have also been invited to take part in the Workshop projects.

Presently, two research proposals and a proposal for a laboratory computer facility have been developed within the Center. The first, for which funds are pending under a joint program of the National Science Foundation and the National Institute of Education, is entitled "Conceptual Change in Children and Adult Scientists." The principal investigator of this proposal, Professor Carey, will attempt to establish the thesis that the kinds of conceptual change that have been important in the development of scientific theories, especially during scientific revolutions, are also important in conceptual development in children. This work is of special interest as Professor Thomas Kuhn will be joining the Department of Linguistics and Philosophy in the fall of 1979; the overlap of the project with Dr. Kuhn's work on change in science is substantial, and the cooperation between Professors Kuhn and Carey promises to give rise to a unique interpretation of the subject.

A second proposal to the National Science Foundation has been submitted by Professor Joan Bresnan. The intellectual core of this proposal, entitled "Grammatical Representation and Grammatical Processing," is the development of an explicit and explanatory model of the cognitive processes involved in comprehending natural language.

The third proposal, with Dr. Edward Walker as principal investigator, requests funding from the National Science Foundation for a laboratory computer to support collaborative research among the members of the Center. The equipment requested will provide both a general purpose research tool and a central facility for controlling experimental apparatus in individual laboratories.

This program of Continuing Research Workshops thus has expressed concretely the commitment of the members of the Working Group to fostering interdisciplinary research and training in cognitive science at M.I.T. Furthermore, we anticipate that these research workshops will

Center for International Studies

continue to provide an important resource for developing proposals for future funding of research within the Center. The research environment and the topics considered also serve as a practical means for collaboration among the cognitive scientists now working in various administrative units within M.I.T. Thus, the Continuing Research Workshops have been a major unifying and productive focus for research in cognitive science at the Institute.

The efforts of the Center for Cognitive Science to recognize and bring together scholars and scientists engaged in research and training in cognitive science at M.I.T. have met with considerable success during the past year. The programs we have described represent important milestones in our intellectual commitment to the interdisciplinary approach to cognitive science. With the formation of the Center for Cognitive Science, the advent of an extensive new program of postdoctoral and predoctoral training, and the inception of funded research within the framework of the Center, we look forward to further consolidation of the work now in progress at the Institute. We hope that our efforts to provide a stable and nurturing institutional atmosphere for the conduct of work in cognitive science at M.I.T. will continue to prove as rewarding as they have in the past year.

SAMUEL JAY KEYSER

Center for International Studies

The programs and activities of the Center for International Studies during the past year focused on studying and assessing the increasing impact of science and technology on society, both internationally and in the United States. Under its Director, Professor Eugene B. Skolnikoff, the Center continued to play an active role in stimulating and focusing the attention of M.I.T. faculty, students, and staff, whether social scientists, engineers, or natural scientists, on important technology-related issues.

These efforts were aided on an institutional level by the Center's move to new headquarters on the sixth and seventh floors of the Suffolk Building, which promoted a greater sense of community and coordination for faculty, students, and staff, and by the appointment of a new Administrative Officer for the Center, Charles Ellis.

Arms control and defense studies remained a major program focus of the Center. The quality of the program was recognized by the award of a major five-year endowment grant of \$1 million from the Ford Foundation. The grant will enable continuation of research and seminars, and in particular will support the otherwise unsupported curriculum development aspects of the program. The Center has been able to attract an outstanding group of S.M. and Ph.D. students to the program and, with the assistance of the Ford support, will be able to fund additional students in the future. The educational, research, and seminar activities were also enhanced by the drawing together from scattered areas of the campus of faculty, students, and staff at the new Center headquarters. Professor Jack Ruina (Department of Electrical Engineering and Computer Science) is Director of the program. Also associated were Professor George Rathjens (Department of Political Science and, for the current year, Deputy US Special Representative for Non-Proliferation Matters), Professor William Kaufmann (Department of Political Science), Professor Bernard Feld (Department of Physics), Professor Skolnikoff, Dr. Kosta Tsipis (Research Associate, Center for International Studies), and Dr. Amelia Leiss (Assistant Director, Center for International Studies). Professor Ted Greenwood, on leave with the US Office of Science and Technology Policy, is expected to return in the fall of 1979.

The Center's principal research and seminar activities emphasized current issues in nuclear arms control and weapons policy, including the impact of science and technology on defense and arms control. The national concern about SALT was a particular focus throughout the year for research and an extensive seminar series. Other issues included the long-term military and strategic significance of new technologies, the role of arms control agreements in the strategic weapons procurement policies of the United States and the Soviet Union, the control of nuclear proliferation, limits on nuclear testing, conventional weapons technology and its impact on force

structure and doctrine, the rationale and allocation of the US defense budget, and the international trade in conventional arms and the arms acquisition process. The program also helped sponsor the Technology and Culture series on arms control at M.I.T. The Program in Science and Technology for International Security was directed by Professor Feld and included Dr. Tsipis and Dr. Michael Callaham (Postdoctoral Fellow, Center for International Studies). This Program completed its experimental year with Ford support and moved its focus from the Center to the Department of Physics.

The closely related range of issues associated with the international and domestic implications of nuclear energy continued to play an important role in the Center's work. Professor Henry Jacoby (Sloan School of Management), Professor Paul Joskow (Department of Economics), and Professor Joel Yellin (School of Humanities and Social Science, on leave at the Kennedy School of Government at Harvard) continued their study, funded by the Ford Foundation, on various long-term aspects of nuclear energy generation, including nuclear power plant siting, uranium supplies and markets, and economic and environmental impacts.

Energy-related problems between the United States and Canada also were examined by several members of the Center. Professor Greenwood continued his study, supported by the World Peace Foundation, of uranium supplies in the two nations and the implications of government restrictions on its trade.

The Center, with the support of the Sloan Foundation, jointly participated with representatives of the British Government in a study on multinational arrangements for the nuclear fuel cycle. Sessions during the year at M.I.T. and in London addressed the political, economic, and technical feasibility of adapting and developing multinational arrangements for the ownership, control, or management of nuclear fuel cycle facilities, with the aim of reducing or restricting the probability and fear of nuclear proliferation. Professor Lincoln Bloomfield (Department of Political Science) and Professor Skolnikoff were closely involved. A final report is being prepared for publication.

In cooperation with Harvard, the Center also continued an important series of bilateral conferences on nuclear energy policy. Two were held with Japan (following similar conferences with West Germany) at which participants from government, industry, and universities discussed the background and objectives of the nuclear policies of the United States and Japan; explored existing data and future policy options; and established new working relationships. Professor Skolnikoff for the Center, together with Harvard's Center for Science in International Affairs and the Japan Industrial Forum, coordinated these conferences, and the Ford Foundation provided financial support. A third conference is being planned at the suggestion of our Japanese colleagues, and a similar one with India is being developed.

During the past year, the Center undertook several other initiatives to foster international collaboration on various technology and policy issues. A program of joint studies with the French government was explored at a major conference, resulting in plans for continued joint work. A program of collaborative research is being developed with the University of Tokyo on a series of issues including communications, energy, and science policy. The Center also participated in hosting several sessions with visiting dignitaries from the People's Republic of China during which we explored a substantial collaborative relationship in a number of policy areas (strategic studies, energy policy, science policy, and economic planning and management).

The Center, supported by the Rockefeller Foundation, the Andrew W. Mellon Foundation, and the United Nations Environment Program (UNEP), continued its work on international environmental policy and the environmental effects of various technologies. The Program on International Environmental Issues (I.E.I) focused on the current concern over rising carbon dioxide levels in the atmosphere, reflecting both staff and sponsor interest in this topic. Other work during the year concerned trans-frontier pollution problems and the general question of devising methods of policy analysis useful in dealing with long-range global environmental issues (such as CO₂). Various seminars were held, and on the basis of a previous seminar series organized by Dr. Saul Friedlander (Professor of History, Tel Aviv University) exploring the historical, philosophical, and literary aspects of society's response to earlier ideas of apocalypse, plans were initiated to publish a book on the image of catastrophe or holocaust in Western thought. Editorial direction will be provided by Dr. Friedlander, Professor Skolnikoff, Professor Gerald Holton (School of Humanities and Social Science and Program in Science, Technology, and Society), and Professor Leo Marx (School of Humanities and Social Science). I.E.I. is directed by Professor Rathjens and involves Professor Skolnikoff and Dr. Howard Margolis (Research Fellow, Center for International Studies).

The Center's research on new communications technology and its impact on international communications policy continued and broadened, as part of M.I.T.'s Research Program on Communications Policy. Professor Ithiel de Sola Pool (Department of Political Science) directed the Center's work in this area in collaboration with the faculty members and staff in the Center for Policy Alternatives, the Center for Advanced Engineering Study, the Electronic Systems Laboratory, and the Laboratory for Computer Science, and with the support of the Markle Foundation, American Telephone and Telegraph, International Business Machines, Hughes Aircraft Corporation, and the National Science Foundation.

Work during the year included the study of capital mobilization for communication utilities in France, Britain, Japan, and the US; joint study with CNRS in France comparing the US and French telephone and railroad systems; joint study with the Institute of Communication Research, Keio University, Japan, of the amounts, kinds, and psychological effects of violence on Japanese television; joint study with the University of Cairo on the use of advanced communication technology in village communications in developing countries; and examination of the exporting of US television programs and its impact on programming. The group also sponsored a regular series of seminars on various aspects of communications policy, including such topics as commercial satellite communications, capital needs for communications development, and the role of telecommunications in developing countries. *A New Guide to Federal Cable Regulation* by Steven Rivkin was published by the MIT Press.

The implications of internal and interstate migration on political, social, and economic development remained an important focus of the Center's research. Various members of the M.I.T. Migration and Development Study Group headed by Professor Myron Weiner (Department of Political Science), studied internal migration in India, including the following topics: the impact of antimigrant policies, organization, and movements (Professor Weiner); the process and impact, both within Mexico and on the US, of rural outmigration in Mexico (Professor Wayne Cornelius, Department of Political Science); the economic, social, and political effects on host and donor countries of the Middle East, and on the region as a whole, resulting from skilled manpower flows in the Middle East (Professor Nazli Choucri, Department of Political Science); the effects on the economy and the development process of rural-urban migration in Indonesia and Kenya (Professor John Harris, Research Associate, Center for International Studies); the migration experience of Yugoslav migrants in Austria and its effects on their attitudes and ability to adjust to modernization (Dr. Rosemarie Rogers, Research Associate, Center for International Studies). Dr. Cornelius' work in Mexico proved to be of great significance with respect to the growing problem of Mexican migration to the US. Support for the program was provided principally by the National Institute of Child Health and Human Development with additional research support for Professor Weiner's work from the Ford-Rockefeller Foundation Studies Program.

The Center's collaboration with the Department of Nutrition and Food Science continued over the past year on an ongoing multidisciplinary program of research, graduate education, advanced training, and advisory services in food nutrition policy and planning and various aspects of implementation and evaluation. In early 1978 the International Nutrition Policy and Planning Program and the Harvard School of Public Health established the M.I.T.-Harvard International Food and Nutrition Policy Program (I.F.N.P.) to enhance their mutual disciplinary and research offerings. I.F.N.P. soon became an associated institution of the United Nations University in its World Hunger Program (UNU/WHP).

Studies under way during the year included examination of the potential application of high technology in speeding food relief in international disasters; market-related policies that affect production and consumption of staple foods in poor countries; domestic-international intersections in US food policy; current practices and trends in breastfeeding worldwide, their scientific basis, and implications for developing countries; nutrition interventions in developing countries; and international population initiatives.

A conference was held at the Center for the UNU/WHP, drawing those professionals engaged in nutrition planning and policy making around the world to assess the state of the art. Several books in the International Nutrition Policy Series were published by the MIT Press, including the widely regarded *Fish Protein Concentrate: Panacea for Protein Malnutrition?* by Ernst R. Pariser (Associate Director for Education, Sea Grant Project), Mitchel Wallerstein (Ph.D. candidate, Department of Political Science), Norman Brown (National Academy of Sciences), and Christopher Corkery (then working for an advanced degree in the International Nutrition Program).

Provost

Supported by the Agency for International Development, the Rockefeller Foundation, the National Science Foundation, and Community Systems Foundation, the program is headed by Dr. Nevin S. Scrimshaw. Also associated were Professor Skolnikoff, Professor Barbara Underwood (Department of Nutrition and Food Science and Resident Coordinator, I.F.N.P.), Professor Lance Taylor (Departments of Nutrition and Food Science and Economics), Dr. William Dietz (Nutrition and Food Science), Dr. Martin Diskin (Anthropology/Archaeology Section of the Department of Humanities), Dr. John Gordon (Nutrition and Food Science), Dr. William Rand (Nutrition and Food Science), Dr. Noel Solomons (Nutrition and Food Science), Dr. John Stanbury (Nutrition and Food Science and Director, International Population Initiatives), and Dr. Wallerstein.

Reflecting its involvement in food-related development issues, the Center will coordinate M.I.T.'s relationship to the Title XII program of the US government. This program is aimed at strengthening US initiatives in their ability to attack central problems of hunger in developing countries. Professor Skolnikoff served as Title XII coordinator at M.I.T. this year.

A seminar for promising United States journalists and other media professionals on "Idealism versus Pragmatism in American Foreign Policy" explored the place of values and ideals in American foreign policy in a four-week program at the Center. Topics covered included recurring moral dilemmas, the roots of contemporary debates on human rights, redefinition of US security, interdependence of dilemmas, and the ethics of modern defense. Sponsored by the National Endowment for the Humanities, the sessions were directed by Professor Bloomfield, who is also Consultant to the US State Department's Policy Planning Staff).

In addition to the major themes and program areas discussed above, several other projects have continued under Center auspices. Professor Bloomfield (also on half-year leave at the Graduate Institute of International Studies, Geneva) studied various aspects of the American foreign policy-making process. Professor William Griffith (Department of Political Science and consultant to the National Security Council) continued his study of Communist and radical movements around the world with the support of the Earhart and Carthage Foundations. Professor Douglas Hibbs (Political Science) worked with National Science Foundation support on models of inflation as a political phenomenon. Professor Hayward Alker (Political Science) with National Science Foundation support began study and development of reflective logical procedures for resolving collective insecurity dilemmas. Professor Charles Sabel (School of Humanities and Social Science) and Professor Michael Piore (Department of Economics), supported by the German Marshall Fund, began research on the connection between plant-level collective bargaining and rates of unemployment and inflation in the United States, Great Britain, Italy, France, West Germany, and Spain. Emeritus Professor Harold Isaacs (Political Science) continued with Ford Foundation support to draw together his work on questions of racial, ethnic, and family identity. Professor Steven Kobrin (Sloan School of Management) continued his study supported by the International Business Project of how political risk is assessed and evaluated by US firms as well as his study of the history of nationalization of industry. Professor Daniel Holland (Sloan School of Management), also with the support of the International Business Project, studied ways to measure the rate of return to capital in different industrial societies.

The Center's contribution to M.I.T.'s educational program continued to be important, not only in providing research and financial support to faculty and students but also in broadening and enriching research opportunities and subjects by taking into account the increasing linkages between domestic and international issues as they are affected by science and technology. Complementing its other activities, the Center also sponsored an extensive program of seminars for the M.I.T. community and the Cambridge and Boston academic communities. These sessions ranged in subject matter from scholarly topics to subjects of current international interest. Major series continued on technology and international security, international nutrition, communications policy, environmental issues, African affairs, and migration, all subjects of substantial Center research interest. Cooperating closely with the Political Science Department and its Public Policy Program, the Department of Linguistics and Philosophy, and the International Nutrition Program, the Center also sponsored a coordinated program of I.A.P. seminars. The Center published a number of papers and research reports in its own monograph series, and sponsored the commercial publication of several books on the results of its projects.

A number of visiting scholars, both US and foreign, worked on problems relating to the Center's research areas during the year. Among them, Dr. Herbert Dordick, Associate Director and Senior Research Associate, Center for Communications Policy Research, Annenberg School of

Center for Materials Research in Archaeology and Ethnology

Communications, University of Southern California, worked on communications technology, policy, and planning and contributed considerably to the Research Program on Communications Policy. C.V. Narasimhan, retired Under Secretary-General for Inter-Agency Affairs and Coordination at the United Nations, began a study on the New International Economic Order. Col. Wolfgang Samuel, US Air Force, completed a study on precision guided missiles and Col. Robert Clewell, US Army, studied US doctrines on strategic defense. Dr. Michael Handel of Tel Aviv University examined the impact of new conventional weapons technology and its impact on arms control. Omi Marwah of Harvard's Kennedy School of Government investigated the proliferation risks of spent nuclear fuel storage. Professor Alden Speare, Chairman, Sociology Department, Brown University, continued his work on urbanization in East Asia. And Hartojo Wignjowijoto of Indonesia examined the financial aspects of long-term macroeconomic energy models and the relation of public finance and economic growth.

The Center received support during the past year from the Sloan Foundation for its core administrative costs, complementing the generous support from the Institute.

EUGENE B. SKOLNIKOFF

Center for Materials Research in Archaeology and Ethnology

The Center for Materials Research in Archaeology and Ethnology (C.M.R.A.E.) was established in 1977 by nine Boston-area educational and cultural institutions* for the purpose of developing educational programs and basic research in the new field of materials science of archaeology and related disciplines. M.I.T. took the initiative in forming the C.M.R.A.E., and continues as its lead institution. Professor Heather Lechtman of M.I.T.'s Department of Humanities and Department of Materials Science and Engineering is the director.

The Center's teaching programs are supported for an initial three-year period by a \$200,000 grant from the Education Division of the National Endowment for the Humanities (NEH). The grant supports a new graduate teaching laboratory located at M.I.T., which was opened for student instruction this past November. A separate grant from the Kress Foundation allowed us to add a photography laboratory which will be available for use this September. The teaching laboratory is the main facility for a four-year cycle of seminar/laboratory courses that cover all the major classes of materials -- metals, stone, ceramics, and floral and faunal materials -- encountered by archaeologists. Begun in 1975, the first four-year cycle has already been completed, and a second cycle will begin this year with a revised syllabus on "Metals in Ancient Society," organized by Professor Lechtman. A new and fifth topic, "Mathematics and Computers in Archaeological Data Analysis," to be taught by Professor George Cowgill of Brandeis University, will be added this year.

The research endeavors of the C.M.R.A.E. initially will be based on the separate research projects of individual faculty members. A planning grant of \$50,000 from the Research Division of NEH is aimed at increasing coordination and planning for the sharing of research resources among the nine C.M.R.A.E. member institutions. Initial efforts under this grant during the year included an inventory of resources, personnel, equipment, and requirements among the member institutions, and a start on the development of standard reference collections, beginning with phytoliths and ceramics. The first step toward common use of equipment was taken this year; an atomic absorption spectrophotometer was acquired by the Center with the help of a grant from the National Science Foundation. This instrument allows precise quantitative determinations of groups of elements present even in only trace concentrations (ppm-ppb), and it is particularly needed for research on inorganic materials such as metals and ceramics. It will be housed in the Central Analytic Laboratory of M.I.T.'s Center for Materials Science and Engineering, and it will be operated and maintained by the staff of that Laboratory. It will be available for use by the staff and students at all C.M.R.A.E. member institutions.

* Boston University, Brandeis University, Harvard University, M.I.T., Museum of Fine Arts of Boston, Robert S. Peabody Foundation for Archaeology, Tufts University, University of Massachusetts, and Wellesley College.

An ambitious C.M.R.A.E. proposal to establish five research laboratories, each equipped to handle a different major class of materials, was not funded, and has had to be set aside for the time being. As an interim measure, we are seeking funds to support several postdoctoral appointments as a means of increasing the number of persons systematically pursuing laboratory research in the relevant fields.

HEATHER LECHTMAN

Clinical Research Center

Several important developments combined to make the past year highly significant for the Clinical Research Center. Approval was obtained for the development of previously unoccupied space adjacent to the C.R.C. as well as for renovations of existing space within the Center. Construction commenced in early March and is expected to continue through the end of the year. The new facilities will house an ambulatory care unit, expanded administrative offices, a fellows room, waiting rooms, examining rooms, and a medical records room. The renovated areas will provide needed space for equipment used in testing patients involved in research investigations.

There were substantial changes among the personnel in the C.R.C. administration, core laboratory, nursing staff, and metabolic kitchen. Professor Nevin S. Scrimshaw, principal investigator of the C.R.C. since its inception in 1962, will assume the position of Program Director of the C.R.C. in July 1979 replacing Dr. Jack Burke who will become chairman of the Executive Committee. In addition, Dr. Melvin H. Rodman, Medical Director of the Medical Department, became co-principal investigator of the C.R.C. and chairman of its Policy Committee. Dr. Robert M. Suskind, Associate Program Director, resigned in July 1978 to become Director of Pediatrics at the University of South Alabama. Maureen Quirk became Research Dietitian in November, and Hilary Spence assumed the position of Administrative Coordinator in December 1978.

Physician fellows in the Ph.D. Clinical Nutrition Training Program were associated with the Clinical Research Center, with six of them funded by a National Institutes of Health Clinical Nutrition Training Grant. Extensive work on examining the ways in which human body protein metabolism adapts to alterations in dietary protein intake was initiated under the supervision of Drs. Scrimshaw and Vernon Young. Dynamic stable isotope techniques were applied to examine total body nitrogen turnover, protein synthesis, and protein catabolism. These techniques also were applied to a new method for dietary amino acid requirements based on functional criteria.

Investigators from the Department of Psychology have expanded their use of the Clinical Research Center. Dr. Suzanne Corkin and her colleagues have been active in their research on behavioral aspects of brain lesions in humans and on the effects of cingulotomy. New testing space earmarked for use by Professors Alan Hein, Emilio Bizzi, and Richard Held will provide these researchers with the experimental facilities needed to expand their clinical investigations.

Dr. Melvin Chalfen has continued his long-range collaborative study of persons with internal depositions of alpha-ray emitting radioactive substances. These quantitative studies of radium patients are the basis for the international radiation protection standards for internal emitters such as radium and plutonium.

Work on the dietary precursor of neurotransmitters has continued under the direction of Dr. John Growdon and Professor Richard Wurtman. Their most recent focus has been the effect of choline or lecithin on a variety of parameters in human subjects hospitalized at the C.R.C. Investigations of the effect of choline or lecithin administration of various neurologic disorders are in progress.

Committee on the Visual Arts

During the past year the C.R.C. has experienced a significant increase in research activity in both inpatient and outpatient divisions. With an average occupancy rate of 102%, a total of 3,731 patient care days and 958 outpatient visits, the Center has been operating at maximum capacity. The new, enlarged ambulatory facilities for treatment and testing of subjects will expand the Center's resources significantly, and permit investigations of new technology within the C.R.C.

NEVIN S. SCRIMSHAW

Committee on the Visual Arts

COMMITTEE ACTION

The Committee on the Visual Arts (C.V.A.), a faculty and student committee established in 1966, sponsors a growing number of non-curricular, arts-related activities for the M.I.T. community and the general public. The Committee sets policy governing the acquisition and care of the Permanent Collection; the development of educational projects which promote an understanding of the historical precedents of and salient movements in contemporary art and architecture; and the operation of the Hayden Gallery and Hayden Corridor Gallery exhibitions program. In addition, the Committee serves as an advisory body to the staff, which is responsible for the planning and administration of the exhibitions, publications, and education programs as well as for the registration, siting, and conservation of the Permanent Collection and the two Student Loan Collections. The staff is assisted by student interns from regional educational institutions and by volunteers.

The Committee met nine times during the 1978-79 academic year. Several meetings were devoted to the formulation of the following acquisitions policy:

The M.I.T. Permanent Collection is designed to enhance the visual environment, increase the general aesthetic appreciation of the M.I.T. community and general public, and support teaching and research in the visual arts. The acquisitions policy of the Committee on the Visual Arts is consistent with these goals. The major focus of the Permanent Collection continues to be on contemporary and avant-garde movements with consideration for earlier art which had a strong, generative influence on these movements.

This emphasis is designed to complement several excellent regional collections of period art open to the Boston community. By concentration on art of the present and recent past, the Institute seeks to build a unique body of reputable work by promising as well as established artists through gifts, solicitations of desired works, and funds available through the M.I.T. One-Percent for Art Policy.

Works of art at M.I.T. are displayed throughout the campus rather than housed in the controlled environment of a museum. Therefore, considerations of the appropriate environment for works of art are part of acquisitions procedure. This is especially true for works which are fragile in technique or material, or of exceptionally large or small size. Acquisitions of sculpture must be made with consideration for appropriate siting, including security, maintenance, and public safety.

We also seek preliminary sketches, drawings, maquettes, and in the case of sculpture, engineering or fabrication plans, for the Reference Collection. This Collection, which illuminates the creative process and illustrates technical means by which works of art come to completion, will be housed in a Study Archives and is a part of the Permanent Collection.

Another important function of acquisitions is to provide material for the Student Loan Programs. Contemporary works on paper including prints, artist-designed posters, and photographs of modest cost continue to be acquired.

By clarifying the intention of the Collection and by acquainting prospective donors with its parameters, it is anticipated that the number of less suitable works offered will decrease while donations of more desirable works will increase. The Committee agreed that works in all media should be judged by the same standards.

Along similar lines, the Committee agreed to establish a subcommittee composed of the C.V.A. chairman, Projects Director, and two Committee members to work with four representatives of the Council for the Arts at M.I.T. in further defining a list of works desired for the Collection and guidelines for contacting prospective donors to solicit these works. While all actions will be reviewed and approved by the C.V.A., the members of the subcommittee will be empowered to contact prospective donors. The subcommittee also will develop potential sources for funding programs and publications.

Among the other important issues discussed were the One-Percent for Art allocation available for the purchase of work for the Alumni Association Offices; artists' proposals for the Animal Care Facility sculpture competition; the need to expand the Student Loan Collections in order to satisfy student demand; the programmatic, spatial, and budgetary considerations related to a proposed arts and media facility; and the potential of expanding programs such as seminars and internships through the summer months as a possible means for generating income.

PERMANENT COLLECTION

The M.I.T. Collections, consisting of the Permanent Collection and two Student Loan Collections, includes more than 1,000 works of art. The primary focus is on contemporary sculpture, painting, and works on paper.

Acquisitions

During the 1978-79 academic year, 54 works were acquired through gift, purchase, or extended loan. Among these works were *Descending Ochre* (1974) by Helene Aylon, oil stained through paper under plexiglass; *Untitled* (1976-77) by Robert Grosvenor, wood and creosote; and *Kathy* (1979) by Chuck Close, a 20 x 24 inch Polaroid color print. Theodore Roszak loaned a significant number of working drawings, preparatory models, castings, and architectural renderings for the Bell Tower on M.I.T.'s Chapel; this will enable students and scholars to trace one artist's creative process.

New Installations and Sitings

Several major works from the Permanent Collection were sited during the past year. Among them were: *The Iceberg and its Shadow* by Bell, in the lobby of the Vannevar Bush Building; *City Red* by Hopkins, in the headquarters of the Center for Advanced Engineering Study; and *Detail Study for M.I.T. Belltower* by Roszak, in the Dean of Engineering's Conference Room.

An important work by sculptor Isaac Witkin, *Angola* of 1968 in corten steel, was installed on the lawn on the Memorial Drive side of the Hayden Memorial Library Building on December 11, 1978. The sculpture, given to M.I.T. by a member of the Council for the Arts at M.I.T. in May 1978, complements the Calder and Nevelson works by its variation on the shared idea of making free-standing, metal sculpture by the constructive method. Witkin's *Angola* is an excellent example of the sculpture which emerged in England during the 1960s and which was influenced by the ideas and achievements of the British sculptor Anthony Caro.

Loans to Other Institutions

Larry Bell's *The Iceberg and its Shadow* was returned to M.I.T. in September by the Federal Reserve Bank in Boston where it had been on exhibition since April of 1978. Three paintings from the Permanent Collection -- *Magic Number* by Jules Olitski, *Grayling* by Harvey Quaytman, and *Greenhouse Counterpoint* by Joel Janowitz -- also were loaned to the bank for "New England Connections," a major survey of contemporary art. The works were displayed from November 28, 1978 through January 31, 1979. Janowitz' painting is currently on loan to and included in a retrospective at the University of Connecticut at Storrs' Jorgensen Gallery; it will be returned in July.

Storage

Expanded and reorganized Hayden Gallery storage and work space was completed for use in early spring. This space supplements various ad hoc storage arrangements that had been in use since the previous fine arts storage space in Room 7-020 had to be given up in spring 1978.

Conservation

The Registrar of the Permanent Collection and the Hayden Gallery Manager attended conservation seminars sponsored by M.I.T. Historical Collections and an intensive two-day conservation workshop given by the staff of the Fogg Art Museum for conservation and technical studies.

Because of increasing recognition of the need for a conservation program to maintain the Permanent Collection, a proposal entitled "Fine Arts Conservation Support for M.I.T. Committee on the Visual Arts Activities" was submitted to the Institute of Museum Services, Education Division, US Department of Health, Education and Welfare. A decision on the application will be made in August.

The Registrar presented a conservation report to the Committee on the Visual Arts and to some members of the Council for the Arts' Acquisitions Committee in May. It is anticipated that a conservation policy and recommendations for action will be completed in the fall.

Vandalism and Theft

In February of this year, the first International Symposium on Art Security was held and the *New York Times*, reporting on the comments of curators and administrators from major American museums, stated that art thefts had risen 35 to 40 percent in the last two years. M.I.T., a pioneer in the museum-without-walls concept, has experienced increasing difficulty in monitoring a collection designed to bring the community as well as the general public into direct and daily contact with original art works. A number of thefts of works of art from the Permanent Collection and from temporary exhibitions were reported this year. A drawing by Frances Barth and a mask by Ursula Schneider were registered as missing with the Art Dealers Association of America's notification system. A print by M.C. Escher (stolen during academic year 1977-78) was also registered. This is the first year the Committee on the Visual Arts has made use of this service.

Even more disturbing is the problem of vandalism. Indelible ink, poured through the top of three Hayden Corridor display panels, destroyed three prints from the Catherine N. Stratton Student Loan Collection. Several works in the Permanent Collection sited in populated public spaces were vandalized or perhaps accidentally damaged during the past year. Among them were two modules of Larry Bell's glass sculpture *The Iceberg and its Shadow*, and paintings by Katherine Porter, Richard Smith, Paul Reed, and Bruce Boice. Because of the extent of vandalism to paintings sited in open public spaces, no more works will be hung in unmonitored public spaces until the problem can be fully considered. Works of art will continue to be placed in public areas such as conference rooms, reception areas, libraries, and hallways that can be locked during times when the spaces are not monitored.

EDUCATIONAL PROGRAMS

The Committee strives to integrate its special projects and exhibitions programs. The intention is to broaden the public's awareness of the artist's creative methods and professional concerns as well as to increase understanding of the historical roots of and salient issues in contemporary art.

List and Stratton Student Loan Collections

One hundred and twenty-one prints and posters from the Catherine N. Stratton Collection of Graphic Art and the List Student Loan Program were exhibited in Hayden Gallery from September 5 to September 15, 1978. As a result of the publicity and the success of the program in the previous year, over 750 students entered choices for a lottery of the works held at the close of the exhibition.

Winners were announced on September 15 at a Hayden Gallery student party organized by the C.V.A. and supported by the Dean for Student Affairs office. When the works were returned in May 1979, students were asked to comment on the program. All of the responses received were overwhelmingly enthusiastic. One student's response mirrors the others received: "To say I enjoyed the Lindner print *Arturo VI* would be a gross understatement. For the last two semesters it was the centerpiece of my room, a constant source of beauty in an otherwise mundane setting. To view art in a museum one passes by hundreds of paintings and sculptures, many completely unrelated to one another. By enabling me to have the Brecht in my personal possession, I was able to appreciate art in a way I was never able to before. Privately and for a long period of time. I sincerely commend and congratulate whoever is in charge of the program. It is 'just' one more way my education at M.I.T. has been enriched."

Little problem was encountered in collecting the works and all were returned in good condition. Expansion of these Collections remains an important priority. A gift from Catherine N. Stratton was used to frame works in storage, thus adding seven works to the Stratton program for the coming year. In October, a gift of three prints was made to the List Program by the Albert and Vera List Collection. Two additional prints by minority artists were acquired recently and assigned to these programs.

ArtFacts Meetings

At the beginning of this academic year, Artfacts was organized as an informal discussion group designed to offer an ongoing forum for members of the M.I.T. community to consider the direction of the Hayden Gallery program and of the Permanent Collection, including problems of acquisitions, siting, and maintenance. Its intent also was to bring the community into direct contact with art-world professionals and to focus on questions concerning contemporary art, including the functions and operation of art museums and commercial galleries. The meetings were attended by groups of people averaging 15, most of whom were students. Topics for the meetings included highlights from the Permanent Collection; the policy, place, and problems of contemporary art at a university museum; the care and restoration of works of art on paper; and the role of the dealer in contemporary art, including the dealer's responsibilities both to artists and to the art public.

Artist-in-Residency Project

The Committee on the Visual Arts received a National Endowment for the Arts grant to support "Focusing on Faces," a three-week artist-in-residency project involving Jim Dine, Chuck Close, and Joel Janowitz -- painters who, while sharing an interest in the aesthetic and psychological qualities of portraiture, utilize the photographic medium for different purposes. The project, undertaken with assistance from the Polaroid Corporation, consisted of three components: 1) the creation of original works by each artist and members of the Creative Photography Lab and the Visible Language Workshop, utilizing Polaroid's experimental 20 x 24" format camera; 2) daily two-hour discussions with the artists and technical staff on the possibilities offered by the camera's recent development; and 3) an informal exhibition in Hayden Gallery of works-in-progress. The educational context was threefold: 1) the opportunity to create an unlimited number of large-scale color prints (in 90 seconds) encouraged the exploration of a new medium fostered by a new technology;

Committee on the Visual Arts

2) turning Hayden Gallery into a studio space allowed visitors to observe firsthand the artist's working processes, promoted the interaction of artist and audience, and tied those experiences to the appreciation of the work produced; and 3) the chance to support artists' use of experimental equipment prior to commercial distribution allowed for the refinement of the "tool."

The project was an unqualified success for all participants. Each artist made over 100 photographs which were viewed by more than 4,000 visitors.

Independent Activities Period

In addition to the exhibition and activities included in the "Focusing on Faces" project, the Committee on the Visual Arts sponsored a number of lectures in conjunction with I.A.P. A lecture by Dr. Samuel Edgerton entitled "The Renaissance Artist as Quantifier" was given to augment the Hayden Corridor Gallery exhibition, "Man and Machine." Professor Boris Magasanik, Chairman of the C.V.A., and an avid collector of African art for many years, presented a series of three illustrated lectures entitled "African Tribal Art: A Personal View." Professor Magasanik's lectures were presented informally at noon with time for questions and conversation, and were well received by students and staff. Partial support for these activities was received from the I.A.P. Activities Fund Committee.

Lecture Series

During April and May, the C.V.A. sponsored a series of four public lectures by prominent professionals representing a variety of fields and orientations in the visual arts. The series, "Confrontations with Contemporary Art," was made possible by a grant from the Council for the Arts at M.I.T. Designed to fulfill an educational function, the general topic of the series was "The Role of Contemporary Art in Society." Invited speakers dealt with the ways in which contemporary art and artists respond to and affect their social, political, and environmental milieux. Lucy Lippard, prominent critic, talked on "The Artist's Role in Society," in particular on recent art with social and political roots and content. Michael Fried, renowned critic of contemporary art and Professor of Humanities and the History of Art at Johns Hopkins University, spoke on "The Case for Abstract Art," countering the idea that recent art must deal overtly with social and political questions. James Melchert, Director of the Visual Arts Program of the National Endowment for the Arts, discussed the role of Federal, state, and local government in "Fostering Art in Public Places." Lastly, Hans Haacke, an artist whose work involved political, social, and environmental systems, presented his own work and spoke on how he engages significant political and social issues in his art. The attendance at all four lectures was excellent, twice filling lecture hall 9-150 to capacity and once filling the Bush Room. The morning following the lectures of Messrs. Fried and Haacke, informal gatherings were held over coffee for discussions between the speakers and members of the M.I.T. community. Informal gatherings involving the speakers and curators and administrators from regional institutions such as the Institute for Contemporary Art, the Massachusetts Arts and Humanities Foundation, the School of the Museum of Fine Arts, and the Massachusetts College of Art also were organized.

Tours and Gallery Talks

In order to acquaint both the M.I.T. community and the general public with the range and quality of the M.I.T. Permanent Collection, tours and slide lectures of the Permanent Collection were given this year by the staff. These activities introduced some of the important art works permanently installed at or on extended loan to the Institute. Tours were given in the fall of 1978 to sculpture classes from the School of the Museum of Fine Arts, a seminar group from the Council for the Arts at M.I.T. at their annual meeting, and in conjunction with the Hayden Gallery exhibition "Drawings for Outdoor Sculpture." During the spring of 1979, tours were given to a large group of M.I.T. employees and their families on Employees Open House Day, to participants in the Acoustical Society of America's annual meeting, and to two smaller groups. Slide talks on the Permanent Collection were offered to the M.I.T. Wives Group in February 1979 and to members of ArtFacts at its first meeting in November 1978. Additional lectures were given further afield by the Assistant Curator to audiences at the University of Colorado and at Lafayette College. The Permanent Collection also was the object of study by the graduate seminar on American art 1900-1950 at Boston University.

Walking Tour/Catalogue

A Walking Tour/Catalogue documenting the development of M.I.T.'s built and landscaped environment as well as its Permanent Collection moved from the planning stages to organization and writing. As editor, Silvia Sutton was asked to write an essay on the history of the architecture and a walking tour of the campus. The Assistant Curator worked on a history of the visual arts at M.I.T. and on individual texts highlighting several works from the M.I.T. Permanent Collection. A volunteer curatorial assistant assembled a complete chronological catalogue of the Permanent Collection which will be featured in the publication.

The Walking Tour/Catalogue is funded by grants from the National Endowment for the Arts and the Council for the Arts at M.I.T. Its purpose is to make information about M.I.T.'s art and architecture more accessible by offering visitors as well as the M.I.T. community a guide to the Institute's aesthetic environment. The Walking Tour/Catalogue will be published in the fall of 1979.

Internships

For the second year in a row, an intern from Wheaton College assisted the Registrar and the Compton Gallery Director during January as part of the college's Career Exploration Internship Program. For the first time, the C.V.A. participated in Bennington College's Non-Resident Term by accepting an intern for full-time work during January and February. The student assisted the Registrar with an inventory of the M.I.T. Permanent Collection, and also assisted the Hayden Gallery manager with the expansion of Hayden Gallery storage and with the installation of a major exhibition.

Since February, a part-time volunteer has assisted the Registrar in preparing background information on artists represented in the Permanent Collection. This information will be distributed to staff members and students who have works from the Permanent Collection sited in their areas.

In responding to the professional yet informal learning environment fostered by the C.V.A. staff, these volunteers provided the program with invaluable support; it is anticipated that the internship program will be expanded in the coming years.

Use of Video Resources

Educational use was made of video for two exhibitions this year. "Metamorphosis: Totems, Masks and Objects" was accompanied by two daily screenings in Hayden Gallery of videotaped interviews with the four participating artists; the interviews were conducted by guest curator Whitney Chadwick, Associate Professor of Art History in the Department of Architecture. The production and editing were supported by grants from the Sloan II Fund. In conjunction with the Hayden Corridor Gallery exhibition "Carol Beckwith, African Journal: Color Photographs," an interview with the artist was conducted by the Projects Director, Assistant Curator, and Leigh Passman (Class of 1981), a C.V.A. member. The color videotape was made at the Center for Advanced Engineering Study and was screened numerous times over the five-week course of the exhibition on M.I.T.'s cable television channel. It is hoped that each exhibition will be accompanied by a video interview with the artist in the near future.

Publications and Public Information

In support of the Hayden Gallery and Hayden Corridor Gallery exhibitions, various educational publications were produced by the C.V.A. in order to facilitate and maximize the exhibition audience's appreciation and understanding. Extensive explanatory wall texts and artists' statements were posted prominently for each of the 13 exhibitions, and catalogues were produced for three Hayden Gallery exhibitions: *Ger Dekkers: New Dutch Landscape*, the first US publication of the artist; *Two Views/Two Sculptures: Peter Berg/Ed Rothfarb* consisting of in-depth interviews with the artists; and *Processes in Architecture: A Documentation of Six Examples*, published jointly by the C.V.A. and the School of Architecture and Planning as an issue of *PLAN* magazine. "Metamorphosis: Totems, Masks and Objects" was accompanied by an essay printed on the verso of the exhibition poster by guest curator Whitney Chadwick.

Press releases were prepared by members of the C.V.A. staff both as publicity and educational support for the Hayden and Hayden Corridor galleries exhibitions. Posters, mailers, or postcards designed by M.I.T. Design Services for C.V.A. activities are mailed to approximately 3,000 individuals and institutions throughout the country. Calendar listings and press releases are sent to all the major newspapers, magazines, radio and TV stations in the Boston area. Coverage in the Boston area was received this year not only in the Institute publications *Tech Talk*, *The Tech*, *Women's League Bulletin*, and *M.I.T.-Wellesley Review*, but also by Robert Taylor in the *Boston Globe*, by Kenneth Baker in the *Boston Phoenix*, in the *New Boston Review*, *Boston Ledger*, *Cambridge Chronicle*, *Sojourner*, and suburban papers. The touring Richard Smith show organized by the C.V.A. was reviewed in the *New York Times*, *Artforum* magazine, the *Riverdale Press*, *Gannett Westchester News*, and *Westchester Weekend*.

Posters and catalogues designed for C.V.A. by Jacqueline S. Casey, Director of M.I.T. Design Services, were singled out in a number of awards, exhibitions, and publications. In particular, the "Drawings for Outdoor Sculpture" poster has been acquired for the New York Museum of Modern Art's Graphic Design Collection.

EXHIBITIONS PROGRAM

The gallery program focuses on innovative, experimental work by established and promising artists and architects of national and international significance. Through its association with arts organizations such as the Cambridge Arts Council and the Massachusetts Arts and Humanities Foundation, the Committee attempts to establish an exhibition program which also addresses local and regional concerns. The Hayden Gallery is open seven days a week from 10 am until 4 pm, and Wednesday evening from 6 to 9 pm. Each exhibition opens with a public preview; the participating artists usually attend.

Schedule for 1978-79

List and Stratton Student Loan Collection, Hayden Gallery and Hayden Corridor Gallery, September 1-15. More than 100 works on paper from the Catherine N. Stratton Collection of Graphic Art established in 1966 and from the List Student Loan Program begun in 1977 were displayed. The purpose of both collections, consisting of signed prints and art posters by outstanding artists, is to offer students direct and daily contact with original works of art.

Metamorphosis: Totems, Masks and Objects, Hayden Gallery, September 29-November 3. This exhibition of 25 new works by San Francisco artists Phil Pasquini (icons, reliquaries, and monstrosities), Ivan Majdrakoff (box-like totemic environments filled with artifacts of the 50s and 60s), Ursula Schneider (life-size masks of invented physiognomies), and Elin Elisofon (fetish objects) examined the mingling of surrealist, funk, and assemblage elements which characterize a significant and persistent strain of Northern California art.

Carol Beckwith, African Journal, a series of color photographs depicting African tribal lifestyle and culture, in Hayden Corridor Gallery, September 29-November 3.

Drawings for Outdoor Sculpture 1946-1977, Hayden Gallery, November 15-December 22. This broad survey of 58 sculptural drawings by 20th-century masters consisted of work done in a number of media including watercolor, oil paint, india ink, and pencil. Some of these drawings could be "read" as diaries of the working process; all the works graphically represented the artists' sculptural intention and sometimes illuminated issues which the completed project only suggested.

Drawing Made Material, Hayden Corridor Gallery, November 15-December 22. This exhibition featured new works on paper by Frances Barth of New York, Sandi Slone of Boston, and James Ford of San Francisco. A variety of media including cray-pas, pencil, acrylic and oil on paper, plaster on matboard and paint mixed with gel were represented. These works were not made as preparatory studies for paintings but as self-contained pieces which explore the specific qualities of drawing as distinguishable from those of painting.

On Subjectivity, A Project Presentation by Muntadas, Hayden Gallery, December 21-29. Media analyst and video artist Antonio Muntadas prepared an exhibition documenting the processes through which his book and videotape *On Subjectivity* came to be.

Focusing on Faces, Hayden Gallery, January 3-24. Three artists interested in various aspects of portraiture were invited to explore the qualities and potential of the Polaroid Corporation's experimental 20 x 24" format camera. Hayden Gallery was turned into a studio space, open to the public for two hours each day.

Man as Machine, The Development of Scientific Illustration in Renaissance Europe, Hayden Corridor Gallery, January 3-24. The role of Renaissance art in the development of scientific imagination is the subject of a forthcoming book by art historian Samuel Edgerton. The relationship between art and science in great medical and mechanical textbook illustrations of the Renaissance was explored through photo-enlargements of the original works. A lecture was given by Dr. Edgerton.

Ger Dekkers: New Dutch Landscape, Hayden Gallery, February 2-March 7. This exhibition explored the artist's color photographs and slides, including his major work to date, "Planned Landscapes: 25 Horizons." Dekker's art involves images of human intrusions and manipulations of nature and landscapes.

Anthony Dubovsky, Hayden Corridor Gallery, February 2-March 7. This exhibition consisted of photographic prints of photomontages involving a juxtaposition of images taken from magazines, art reproductions, and advertising materials.

Two Views: Two Installations, Hayden Gallery, March 24-April 29. Two large-scale sculptures designed to respond to the specific spatial qualities of Hayden Gallery were built on-site by artists Peter Berg and Ed Rothfarb. These two installation pieces existed as both architecture and discrete art objects. The gallery was opened twice during the construction process, giving the public an opportunity to speak with the artists and to chart the works' development.

Paintings and Pastels, Hayden Corridor Gallery, March 24-April 29. "Paintings and Pastels" included recent works by two young artists, Paul Brown of Boston and Stuart Diamond of New York. Both allude to still-life objects or interiors while exploring complex pictorial events, painterly surfaces, and coloristic nuances.

Processes in Architecture: A Documentation of Six Examples, Hayden Gallery, May 19-June 24. The focus of this exhibition was to illuminate the creative processes through which architects trace and evaluate various formal and organizational options while arriving at a final conception and built reality. The selected architects -- all of whom were or are associated with M.I.T. -- and their regional projects included Marvin E. Goody (master plan, renovations and additions, Simmons College); Louis I. Kahn (The Yale Center for British Art); Gerhard Kallmann (Boston Five Cents Savings Bank); Donlyn Lyndon (Pembroke Dormitories, Brown University); John R. Myer and Robert Slattery (Chandler Village, Worcester State College and Prescott House, Hampshire College); and Richard Tremaglio (The Arena Residence, Marblehead). Original preliminary diagrams, sketches, finished and working drawings, models, slides, and photographs were included in each of the architect-designed installations. The exhibition sought to illuminate each architect's personal methods as well as the client's participation.

Alan Saret: Stair, Water and Canopy Arrangements, Hayden Corridor Gallery, May 19-July 15. This exhibition included drawings, photographs, and text illustrating this visionary artist's creative methods and his interest in sculpture's relationship to landscape and architecture.

Richard Smith Traveling Exhibition

The exhibition "Richard Smith: Recent Work 1972-1977" held in Hayden Gallery from March 18 to April 19, 1978 was organized as a major North American traveling exhibition sponsored by the Committee on the Visual Arts. The exhibition has increased substantially public and professional awareness of the Hayden Gallery, the Committee on the Visual Arts program, and the arts at M.I.T.

COMPTON GALLERY

The Margaret Hutchinson Compton Gallery, located in the midst of the Alumni Association Offices, continued a program of exhibitions reflecting the wide range of Institute concerns and activities. The gallery, now in its second year of operation, is intended to link the interests of faculty, students, and alumni, and to provide a special opportunity for visitors and prospective students to learn more about M.I.T.

Exhibitions Program

The 1978-79 year began with an expansion of *Gyorgy Kepes: The M.I.T. Years 1945-1977*, originally presented in conjunction with the 1977-78 Hayden Gallery exhibition. Several Kepes paintings and his sculpture *Photoelastic Walkway* were added to the photographs, publications, and other art works by Kepes, his students, and fellows at the Center for Advanced Visual Studies.

During the summer months, extensive preparations were under way for the fall opening of "Aspects of Art and Science," based on the research and concepts of Institute Professor Emeritus Cyril Stanley Smith, who stated that "... this exhibition shows that the qualities and nature of the materials to which the artists responded sensually are inherently the same as the properties and structures that are measured and explained by the scientist." Originally curated by Dr. Jon B. Eklund for the Smithsonian Institution's Museum of History and Technology, the exhibition was expanded and a major catalogue developed through the cooperative efforts of Virginia Gunter, Director of the Gallery, Joel Orlen, Executive Officer in the Provost's Office, Dr. Eklund, Professor Smith, and many others throughout the Institute.

The total of 72 diverse objects included a 1500 BC Egyptian glass amphora, an 18th-century Japanese sword, many early scientific publications and a Peruvian double cloth weaving, from such institutions as the Boston Museum of Fine Arts, the Science Museum in London, the Metropolitan Museum of Art, and private collections.

On January 26, the Compton Gallery opened "Books 2000: Publishing at the MIT Press." In the manner of book production, the editorial and design departments of the Press collaborated closely to present a striking display. A substantial number of Press books, historical materials, authors' manuscripts, illustrative examples of publishing procedures, and a video disc computer terminal provided an in-depth view of the procedures and products of the Press.

"The Computer -- from Counting to Cognition" opened on May 4. This exhibition illustrated early counting and calculating methods as well as the influential explorations undertaken at M.I.T. Early objects such as Napier's Bones and wheels from a Babbage Analytical Engine provided an introduction and contrast to the later development of the core memory and the activities at the Laboratory for Computer Science (formerly Project MAC). A section on the connections between computers and chess proved of interest; a small computer chess game had constant challengers.

Audience and Hours

In addition to casual visits by M.I.T. staff, students and faculty, a large number of local and international visitors came to the gallery as did numerous alumni and school groups. Institute functions such as the Alumni Officers Conference and Technology Day were coordinated with the gallery calendar. Members of the Corporation were invited to see "Aspects of Art and Science" and meet with the Director after their fall meeting. During this exhibition, several groups of materials scientists had special viewings after gallery hours; when possible, these visits included a gallery talk by Professor Smith. Through the efforts of the News Office, invitations were sent to local high school principals; several inner-city student groups were given introductory comments by the Director, and teachers in other area schools and colleges brought their classes to the gallery. The MIT Press hosted several lunches and receptions which featured visits to "Books 2000" by the faculty, authors, librarians, and directors of other university presses.

The regular Monday through Friday, 9 to 5 schedule was expanded for Employees' Open House, Alumni Officers Conference, and Technology Day activities. The director arranged and encouraged

Provost

use of the gallery in connection with Alumni Association Bush Room activities. Beginning in May, the gallery also was open Saturday and Sunday afternoons; the record of attendance will indicate the value of this procedure.

Policy and Future Planning

Many of the meetings of the Compton Gallery Committee and the director examined the exhibition program, policy, and budget. Major issues discussed were the gallery's relationship to the Alumni Association; the policy for exhibition selection; the organization of a group of research and resource advisors; and budgetary restraints.

Although the gallery is adjacent to the Alumni Association Offices, a structure for communication and collaboration had not been effected. Within the past few months, joint meetings of the Committee and Association staff have begun to provide positive interactions.

In order to ameliorate certain management problems related largely to limited financial and staff resources, the Committee decided to limit the 1979-80 schedule to two five-month long exhibitions and to organize a group of advisors from various departments. The first of the two exhibitions will be Gjon Mili's retrospective including his extraordinary collection of photographs entitled "M.I.T. Revisted." Mili, a Time-Life photographer, graduated from M.I.T. and was one of the first to explore the potential of Professor Harold Edgerton's strobe techniques. It is anticipated that this exhibition will provide the framework for an I.A.P. activity such as a workshop with Mili or a lecture series.

The spring exhibition, focusing on past and present activities housed in Building 20, will among other things document the beginnings of the Institute's commitment to interdisciplinary and inter-departmental research -- an orientation which has become a hallmark of M.I.T.

BORIS MAGASANIK

Division for Study and Research in Education

The D.S.R.E.'s sixth year was one of encouraging progress in the formation of an intellectual community through which M.I.T. can address issues of educational theory and practice. Including long-term visitors and members of the research staff, the Division's professional community now numbers nearly 30. This group of psychologists, mathematicians, physicists, and social theorists is conducting a variety of inquiries into the ways in which children, high school and college students, and even adults, intuitively view various domains of learning. The effort is to understand the stance from which the learner approaches new material. This begins with determining the learner's set of lenses, so to speak, as shaped by his own intellectual and social history, and by the contexts in which he has found himself. He views the intellectual terrain before him through these lenses as he engages the material which his school, teacher, the social context or his own initiative, set before him. Beyond this focus on individuals, studies are also under way to better understand the educational policies and organizational practices which give rise to particular educational contexts.

The Division's effort to develop a coherent intellectual community to address these issues has been immeasurably aided by a generous gift from Cecil H. and Ida M. Green. Given in 1974, the Green fund was intended as a program development fund, and has been of critical support in bringing new people, and therefore new ideas, into the Division. We are now at the beginning of a several-year process to move the Division's annual funding onto a more regular combination of endowment income, M.I.T.-held funds, and sponsored research support. The Green fund has enabled the Division to develop an array of research enterprises which are now fully articulated and are being supported by the several Federal agencies and private foundations which are the primary supporters of education research.

The growth of the Division's intellectual community also provides the basis for scholarly collaboration with several parts of the M.I.T. community -- in particular with the Center for Cognitive Science, the Program in Science, Technology, and Society (S.T.S.); the Whitaker College of Health Sciences, Technology, and Management; the Departments of Urban Studies and Planning, Electrical Engineering and Computer Science, Psychology, Mathematics, Physics, Mechanical Engineering, and the Sloan School of Management. Collaboration with the Center for Cognitive Science is broad ranging, but focuses on the work of Professors Susan Carey and Daniel Osherson on conceptual development in children. The Division collaborated with S.T.S. in the establishment of a Norbert Wiener Study Group in which the unfolding of a creative life was the main issue. Professors William Martin and Howard Gruber of the Division were co-founders of the Study Group, together with Professor Kenneth Manning of S.T.S. Work with Whitaker College centers on the studies of learning disabilities and has involved Drs. Osherson, Benson Snyder, and Sylvia Weir from the Division.

The Division looks forward to increased connection to M.I.T.'s undergraduate program through the project being undertaken jointly by D.S.R.E., the Departments of Physics and Mathematics, and with the encouragement of the Laboratory for Computer Science and the Artificial Intelligence Laboratory. Under the direction of Professors Harold Abelson and Andrea di Sessa the project will develop an alternative freshman option in mathematics and physics which will take advantage of the kind of educational use of computation which has been developed in the LOGO Lab over the past several years. In addition, the Division expects to have closer articulation with M.I.T.'s development of educational video, which is now the responsibility of Dr. Edwin Taylor, Senior Research Scientist in the Department of Physics and the Education Division. Needless to say, all of these undertakings owe much to the confidence which Cecil and Ida Green placed in the Division five years ago. We are deeply grateful for their generosity.

The strong and diverse academic base which is now established in the Division also attracted two senior scholars to spend their sabbatical leaves at the Division. Dr. Howard F. Gruber, Professor of Psychology at Rutgers University, and Dr. Sheldon H. White, Professor of Psychology at Harvard University, both joined D.S.R.E. as very active visiting professors, participating fully in the intellectual life of the Division. We wish to acknowledge most gratefully the contributions of Professors White and Gruber to the intellectual climate of the Division. We will be fortunate in having them both with us again, at reduced amounts of time, during the next academic year.

Support of Professors Gruber and White was possible through the generosity of the Ford Foundation, which, as we reported last year, made a \$160,000 program development grant to the Division. As in the case of the Green fund, this grant has provided support for a number of crucial Division activities, largely those focused on developing links with other educational researchers. In particular, the Division this year began a working paper series, with the support of the Ford grant. Three papers have been printed: "The Figural-Formal Transaction" by Professors Donald Schon and Jeanne Bamberger, "Music and Cognitive Research: Where Do Our Questions Come From; Where Do Our Answers Go?" by Professor Bamberger; and "The Structure of Mathematical Knowledge" by Dr. Edwina Rissland Michener. The advent of this working paper series increases the avenues by which members of the Division can enter the realm of discourse in education research. We view it as a most important element in the development of the Division.

In addition to providing support for the working paper series and the presence of Professors Gruber and White, the Ford grant this year provided support for Professors Abelson and di Sessa in developing their proposal for the use of computers in freshman mathematics and physics at M.I.T.; Professor Bamberger's work on development and change in teachers' thought; Dr. Weir's investigations of learning problems associated with certain specific disabilities, and Dr. Snyder's pilot longitudinal study of members of the M.I.T. Class of 1965. The Ford grant also provides continuing support for Silvia Sutton in the development of an historical record of the Division's development. We note here that the development of the Division is of considerable interest to those, like the Ford Foundation, who are concerned with promoting greater understanding about human learning processes, the nature of educational institutions, and the ways in which universities come to dedicate themselves to new areas of inquiry. The "history" which Ms. Sutton is preparing is thus of substantial interest to all of us.

In addition to the working paper series and the particular set of collaborative inquiries in which the Division is engaged, the Division's weekly seminars, which are open to the M.I.T. community, are an important element in the development of the Division's intellectual community. This year

the seminars focused on a series of issues in the sociology and politics of education, the learning of particular subjects, and topics in psychology and linguistics. A.H. Halsey, Professor of Sociology at the University of Oxford, spoke on "Change in British Society: Relations between the Generations;" Geoffrey Caston, Registrar of Oxford University, spoke on "Conflict in the University Community." The study of the learning experiences of university students in England was discussed by Joan Bliss and Jon Ogburn of Chelsea College, London. Dr. Diana Laurillard of the University of Surrey reported on her research into how students learn physics. Various contributions of artificial intelligence to education were described by Ira Goldstein of Xerox Corporation (formerly of D.S.R.E.), Margaret Boden of Sussex University, and Gerhard Fischer of the Institut fur Informatic of Stuttgart University. Dr. Peter Wolff of Harvard Medical School spoke about maturation and learning, and Dr. Francesco Varela of the New York University Medical Center spoke on "Circular Processes and Cognition." Of special interest was the lecture by Professor Jerome Lettvin on "Whatever Happened to Final Cause," based on the work of Leibnitz.

Jointly with the Department of Linguistics and Philosophy, the Division sponsored three seminars by Professor Ray Jackendoff of Brandeis University entitled "Semantics and Cognition" as well as one by Roger Wales of the University of Melbourne on didactic expression: "Here and There on This and That." Benny Shanon of Hebrew University spoke on "'Where' Questions: How people answer them." Division faculty members presented aspects of their research: Jeanne Bamberger on the development of the figural-formal transaction; Judah Schwartz on semantic aspects of quality; Sheldon White on the history of psychology and education; Howard Gruber on creativity; Hermina Sinclair de Zwart on recent research in Piaget's group; and Eleanor Duckworth on teachers' learning.

ACADEMIC PROGRAM

The Division's academic offerings consisted of 19 graduate and undergraduate subjects this year including six new subjects offered by new and visiting members of the faculty. In addition to the Division's regular offerings in the areas of developmental psychology (offered jointly with the Department of Psychology), music cognition, metaphor as conceptual change, organizational learning and professional education, the following new subjects were offered: 1) Learning in Context, the study of different intellectual styles in relation to the nested contexts of class, course, department and institution (Dr. Malcolm Parlett); 2) The Social Psychology of Schools, with emphasis on the effects of self-fulfilling prophecies on students' learning (Dr. John Terry); 3) Seminar in Creative Thinking, an examination of creative processes in the sciences and the arts (Professor Gruber); 4) Cognitive Aspects of Musical Development and Learning, examining cognitive processes related to musical understanding (Professor Bamberger); and 5) Natural Concepts, an exploration of what concepts humans find natural, i.e. readily understandable and easily encoded in natural language (Professor Osherson).

Some 63 students enrolled in subjects offered by the Division this year, down somewhat from the average annual enrollment. The reduction may be related to the fact that several subjects were not offered this year as faculty members devoted increased time to the planning of a formal Ph.D. program.

In addition to offering subjects of instruction, the Division's faculty is supervising 15 doctoral students in joint programs with a number of M.I.T. departments: four with the Department of Electrical Engineering and Computer Science, four with the Department of Urban Studies and Planning, two each with the Sloan School of Management and the Department of Mathematics, and one each with the Departments of Mechanical Engineering, Physics, and Psychology. Of the 15, two were newly admitted, one joint with Urban Studies and Planning and one with Mechanical Engineering.

Two students were awarded the Ph.D. in 1978: Stephen Ehrmann, jointly with the Sloan School of Management, whose thesis was entitled "Academic Adaptation: Historical Study of a Civil Engineering Department in a Research-Oriented University;" and Robert Lawler, jointly with the Department of Electrical Engineering and Computer Science, whose thesis was entitled "One Child's Learning: A Cybernetic Theory of Learning Based on the Micro-Genetic Analysis of an Ecological Study."

Under the auspices of the interdisciplinary Ph.D. program, seven students have received doctorates since 1974 and 15 are currently enrolled. During the past year the Division's faculty undertook a careful review of its resources, activities, and present academic program with a view to designing a formal program of graduate study leading to the Ph.D. in Education. This year-long process of deliberation was considerably aided by the participation of Professors Gruber and White. Their investment of long hours in committee meetings was an unexpected benefit without which the work of the faculty would have been substantially slowed.

Discussions of a formal Ph.D. program involved members of the Division in serious consideration of career trajectories for education research, of basic intellectual skills which would be taken as necessary for proficiency, and of the adequacy of the current array of intellectual resources available to the Division. The faculty will be giving final consideration to a specific plan early in the fall of 1979, and we hope to begin discussions with the requisite M.I.T. committees during the 1979-80 academic year.

RESEARCH PROGRAM

The Division's budget has grown from less than \$300,000 in fiscal year 1974, all of which was M.I.T. funds, to nearly \$1 million in fiscal year 1979, of which sponsored research from government agencies is the largest single source (one-third). We take this changing configuration in our funding to be a healthy sign that the Division is earning a place for itself in the world of education research. Project support currently comes from the Bureau for Education of the Handicapped, US Office of Education; The National Institute of Education; and the Fund for the Improvement of Postsecondary Education. In addition, several projects are supported by the Ford Foundation, Texas Instruments, Inc., and several other private donors.

Professor Judah L. Schwartz's study of the social purposes and intellectual foundations of educational assessment received a grant from the National Institute of Education, supplementing last year's Ford Foundation support. In March a panel of educational psychologists and teachers gathered to discuss assessment in the service of instruction. Essays for publication as a collection are in preparation. A second panel will meet in the fall to discuss the ways in which testing and assessment are used by our society to serve its needs for accountability.

Professor Bamberger's research into the process by which an individual restructures or takes a new view of a problem, situation, or idea focuses this year on an experiment in teacher development, funded by the National Institute of Education. Seven elementary school teachers from Cambridge have participated in weekly seminars probing the connection between students' intuitive knowledge and school curriculum; a primary goal of the project is to help teachers communicate that understanding to other teachers. At the request of the NIE, this project is planning to continue at full strength for a second year.

Professors Abelson and di Sessa have received the support of the Departments of Mathematics and Physics for their proposal to develop curriculum modules based on reformulations of the standard mathematics and physics curriculum. The program, which will provide an alternative math and physics course for M.I.T. freshmen, is based on seven years of experience in innovative courses with M.I.T. undergraduates and on three years of experience with National Science Foundation sponsored summer workshops for high school sophomores and juniors. This experience has shown that the appropriate use of computer technology can lead to better integration of formal and intuitive knowledge, improved ability to deal with open-ended problems, and enhanced self-image on the part of students. Their proposal is an ambitious educational experiment involving the use of computer technology in M.I.T.'s undergraduate program. They propose to create a freshman option which would incorporate a unified approach to calculus, physics, and computer science. Funding for the proposal is now being sought.

Professor Roy Kaplow, under a grant from the Fund for the Improvement of Postsecondary Education, has undertaken a project to design and implement a computer-based public facility with direct user-accessibility for the purpose of providing services in response to user-initiated requests such as a referral service and an information bank. The project involves the Cambridge Public Library and the Cambridge Office for Community Development. An operational prototype

will be installed, tested, and evaluated probably in the main branch of the Cambridge Public Library. The overall concept and design are aimed at ease of use, economic operation, and low cost of replication to facilitate the potential of national impact through duplication in many communities.

D.S.R.E. has begun a collaborative project with the Lamplighter School of Dallas, Texas to integrate personal microcomputers into the Lamplighter's elementary school program. The project, led by Professor Seymour Papert, builds on established links between M.I.T., Austin College of Sherman, Texas, and Texas Instruments, Inc. Two computers capable of running LOGO were installed at Lamplighter this year and a program of teacher training was begun. Peripheral devices and teaching materials are under development. It is planned to introduce the personal microcomputers in the fall for the use of third grade students. This project provides a rich environment for inquiry into children's learning and into the ways in which the computer becomes integrated into the educational life of the Lamplighter.

Under a grant from the HEW Bureau for the Education of the Handicapped, Professor Papert and Dr. Weir have been investigating the use of a computer-based learning environment as an informational prosthetic device to study the learning of spatial and linguistic concepts in severely handicapped children. This project has involved the introduction of LOGO activities into two local schools for physically handicapped persons. Several tasks have been developed and tested for assessing the spatial thinking of physically handicapped persons and the investigation of linguistic structures of those with impaired speech. Intensive work with one student has led to encouraging results. The student is now himself teaching five others; the school administration has decided to continue the LOGO program on its own after the project ends.

Professor Gruber joined Dr. Benson Snyder in organizing a monthly seminar on the case study method of research. The seminar served as a context in which scholars from M.I.T., Harvard, Tufts, and several other institutions presented work in progress. Discussion centered on the patterns of inference involved in "making sense" of the unfolding of historical events and of the life of an individual. Dr. Snyder also has worked on developing pilot interviews and a research design for the follow-up study of M.I.T.'s Class of 1965. Initial analysis of the pilot interviews strongly suggests that the "fit" between the subjects' cognitive competences and skills and their network of career-related tasks and concerns is a crucial issue.

Related Projects

Two projects associated with the Division which form important parts of M.I.T.'s outreach to the local educational community are the Program on Work in Technology and Science (WITS) and the Secondary Technical Education Project (STEP). Both had achievements of note this year.

WITS offered programs to local secondary school teachers and counselors designed to increase their knowledge of issues and careers in technology and science. Seventeen teacher/counselors from 14 schools participated in a summer internship program providing them with "hands-on" experiences in local technological and scientific industries. Lectures on recombinant DNA and on computers provided a forum for teachers, counselors, and students to discuss current public policy issues as well as careers in technology and science. Site visits to scientific and technological organizations, including the Massachusetts Electric Company and the Department of Transportation, served to familiarize teachers and counselors with the applications of their academic disciplines.

Under the aegis of STEP, M.I.T. has worked with the Boston Public Schools to develop the Mario Umana Harbor School of Science and Technology, and STEP continues to provide a steady stream of M.I.T. advisors to the project. The school is one of the two most popular magnet schools in Boston and graduated its first class in June 1979.

PERSONNEL

On sabbatical leave in Israel was Donald A. Schon, Ford Professor of Urban Studies and Planning. New members of the Division include: Dr. Barbara Scott Nelson, assistant professor and associate director of D.S.R.E., who had previously been Assistant to the President and Chancellor; and Dr. Daniel N. Osherson, associate professor jointly with the Department of Psychology.

Educational Video Resources

Dr. Howard F. Gruber, professor of psychology, Rutgers University, and Dr. Sheldon H. White, professor of psychology, Harvard University both spent their sabbatical leaves as visiting professors in the Division. Dr. Malcolm Parlett, director of the Higher Education Project, Education Development Center, Inc. joined the Division as a part-time visiting lecturer. In addition, Magdalene Cawley, Dr. Eleanor Duckworth, and Dr. Michael Garet were appointed as research associates.

Shorter-term appointments to the Division included: Joan F. Bliss, lecturer, Center for Science Education, London University, England; Harvey A. Cohen, senior lecturer in computer science and applied mathematics, La Trobe University, Australia; Dr. Harry Judge, director of the Department of Educational Studies, University of Oxford, England; Jon M. Ogborn, reader, Center for Science Education, London University, England; Dr. Bertrand Schwartz, professor of engineering education, University of Paris, France; and Dr. Hermina Sinclair de Zwart, professor of psychology, University of Geneva, Switzerland.

BENSON R. SNYDER

Educational Video Resources

During the spring of 1979 the educational video operation moved administratively from the Center for Advanced Engineering Study (C.A.E.S.) to the Provost's Office. This move took place after considerable study and discussion of existing and potential educational uses of video at the Institute and after a search for a new director. The new director accepted his position at the beginning of April. The organization, renamed Educational Video Resources (E.V.R.), will remain for the present in Building 9.

The central recommendation to emerge from the discussions and the reason for the administrative transfer to the Provost's Office, was to better emphasize the role of video in the on-going educational program of the Institute. Some of this year's initial activities toward this end are outlined below.

Professional Quality Production Facility

The Professional Quality Production Facility includes a fully equipped large color studio, and master and production control rooms. Central among the activities carried out in this facility is the production of tapes for the M.I.T. Self-Study Program of C.A.E.S. This activity continues, with E.V.R. providing services to C.A.E.S. Since this is the only professional quality video facility at the Institute, it is used also by creative artists at the Center for Advanced Visual Studies and members of the Film/Video Section of the Department of Architecture who wish to produce broadcast quality tapes. We are making this facility available to the Film/Video Section for a subject in video processing. We are also adding a full-time assistant who will relieve the Manager of Video Operations of the routine tasks of setting up this facility for use.

Small-Format Production Facility

The Small-Format Production Facility is used by faculty and students to produce and edit a variety of tapes for instruction and for broadcast on the Cable System. We provide directions and advice to users who wish to operate the studio or the editing equipment themselves. Until now the editing has been in the older 1/2" format; we are going to a 3/4" cassette system.

Equipment Library

The Equipment Library provides portable cameras and recorders for a variety of student and faculty educational, club, and hobby activities, as well as recording and playback facilities for classroom and laboratory use by faculty. This equipment has been in heavy use and much of it is worn out. The portable equipment is in the old 1/2" format. We have studied library use and

Provost

have committed funds to replace the portable equipment with 3/4" cassette machines. New equipment will be placed on a preventive maintenance schedule to increase its reliability.

The Cable System

The M.I.T. Cable System provides several hours of programming a day to a limited set of public monitors, TV sets in student lounges, and sets in student rooms. We have studied ways to expand both the programming on the Cable and the number of locations and viewers. One of the present channels will be converted to an announcement channel carrying information about "Today at the Institute" along with Cable schedule information; one channel will remain as a program channel; the third channel will begin broadcasting programs on demand. We have ordered equipment to add commercial channels to the cable as an added inducement to the students and staff to connect to the Cable. The special converter used at each set to receive these channels will make available for educational as well as entertainment use the full 21 downstream channels of the Cable.

Any large-scale Cable operation will exceed our ability to support the necessary staff. We have begun a study of student-run organizations at M.I.T. and elsewhere in planning for increased student responsibility in operating an augmented Cable System. Student participation in the many aspects of cable operation should be educational in its own right and should add a stimulus for the production of tapes by individual students, student groups, and as part of course work in several departments.

We have arranged for the installation of new TV sets attached to the Cable System in two classrooms, and have come to an agreement with the Registrar's Office about the sharing of responsibilities for similar future installations.

Other Activities

We have interviewed many of the students active in video, soliciting their advice on the plans outlined above. We met with the Dormitory Council on the expansion of the Cable System, and are collaborating with the M.I.T. Libraries in planning a new tape viewing facility. We have begun consulting with an educational evaluator, Malcolm Parlett, who we hope will help us with the strategy of educational innovation implicit in our program. Now that the initial decisions on staff and equipment have been made, we have begun talking with key faculty members on increased use of video in the regular educational subjects of the Institute.

EDWIN F. TAYLOR

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

The Harvard-M.I.T. Division of Health Sciences and Technology seeks to engage the full range of the sciences basic to human biology and medicine in the education of physicians and health scientists. This effort requires the productive contributions not only of the biological and chemical sciences but also of mathematical and physical sciences and engineering. In addition, the social and behavioral sciences have important roles in the development of humane and effective systems of health care and in the education of physicians and health scientists for careers of service that reflect compassionate concern and social responsibility. Exploration of the broad range of these sciences as they apply to medicine requires the human and physical resources of the university. We are fortunate to be able to offer our students and faculty members the strengths of two universities.

There are, however, significant constraints on the full utilization of these sciences in education for the health professions. The requirement of professional competence is an imperative of highest priority with the ever-increasing volumes of information to be assimilated in a limited period of time. The challenge for us is to develop educational programs which not only assure professional competence but which also reflect the explosive growth of knowledge in the life sciences, the increasing

importance of the chemical and physical sciences and engineering for deeper understanding of biological phenomena and for the technology of health care, and informed appreciation of the social, economic, political, and ethical issues that are inherent in the provision of health care.

Professional competence can be achieved and maintained by developing an understanding of the scientific basis of medicine, and by continuing to build on this foundation through a lifetime of learning marked by avid scientific interests, openness to new ideas tempered by sound critical sense, and by a determination to maintain high standards of performance.

We believe that a fruitful approach to the development of these qualities and attitudes is to be found in engaging students of medicine in creative scholarship or research. All H.S.T. candidates for the M.D. are required to submit a thesis based on original, scholarly work and approximately 30 percent of the H.S.T. students are candidates for the Ph.D. as well as the M.D. Rigorous scientific education coupled with clinical experience and training of high quality should serve to assure professional competence.

The question of how best to introduce the other natural sciences and engineering and the social and behavioral sciences into medical education provides us with challenges and opportunities. By integrating medical education into general university education we can more effectively treat education for the health professions as a continuum, beginning in college and extending through professional and graduate education into the postdoctoral period of fellowship or internship and residency. In this continuum, considerably longer than the conventional four years of medical school, it should be possible to provide a rich variety of educational offerings at the interfaces of health and medicine with natural sciences and engineering and with the social and behavioral sciences. We look forward to working in close concert with the faculties of both universities in the development of curricular offerings and innovative teaching methods that are effective, economical of time, and appropriate to the various stages in the educational continuum.

The Governing Board

The members of the Governing Board are Harvard University President Derek C. Bok, M.I.T. President Jerome B. Wiesner, Francis H. Burr (Harvard), Thomas D. Cabot (M.I.T.), Maurice Lazarus (Harvard), and Gregory Smith (M.I.T.). The Governing Board approves the appointments of faculty and research members of the Division. The role of the Governing Board in consideration of the budget of the Division, the appointment of a Visiting Committee, and review of the activities of graduates of the Division was discussed this year. Also this year, Mr. Lazarus and Mr. Smith met with a group of H.S.T. students, heard presentations of various research programs under the auspices of the Division, and visited the Biomedical Engineering Center for Clinical Instrumentation.

The Administrative Council

The members of the Division's Administrative Council are: Dr. S. James Adelstein, Dean Robert A. Alberty, Professor Ernest G. Cravalho, Dean Howard H. Hiatt, Dr. Irving M. London, Dean Paul C. Martin, Dean Henry C. Meadow, Provost Walter A. Rosenblith, Dean Henry Rosovsky, Dean Robert C. Seamans, Jr., Dean Eleanor G. Shore, and Dean Daniel C. Tosteson.

During the past academic year, the Administrative Council continued to review activities related to the health sciences at Harvard University and M.I.T. Dean Martin assisted by Professors Ralph Mitchell and Thomas McMahon described the activities of the Division of Applied Sciences to the Harvard Faculty of Arts and Sciences, particularly in the areas of environmental sciences and applied physics and physiology.

The development of the M.I.T.-Harvard Program in Toxicology Research was discussed with a description of the different organizational patterns being considered in each university. Criteria for the joint use of special facilities and equipment, especially of very expensive instruments such as newly developed nuclear magnetic resonance equipment, were discussed.

The plans for the physical facilities of the Whitaker College of Health Sciences, Technology, and Management at M.I.T. were presented. There was discussion of the planning effort designed to

develop the scope and content of the educational and research programs of Whitaker College. Current plans include activities in human genetics, environmental biology and toxicology, human physiology, pathophysiology and experimental medicine, and health policy and management. Since Whitaker College comprehends the M.I.T. components of the Harvard-M.I.T. Division, the staffing of Whitaker College will engage the Division of Health Sciences and Technology.

A report on the development of plans for the Department of Toxicology at the Harvard School of Public Health was presented by Dr. Armen Tashjian who described a new doctoral program in toxicology scheduled to begin in academic year 1980-81. Dr. Gerald Wogan, who directs the toxicology program at M.I.T., described the current character of this program and indicated the plans that are under way for the development of a more comprehensive program in Whitaker College. Dean Robert Alberty described Course 25 at M.I.T., which offers students a variety of interdisciplinary curricular opportunities at the bachelor's and master's level including a Master of Science in Environmental Sciences.

The development of the Harvard University Division of Health Policy Research and Education to be directed by Dr. David Hamburg was discussed by Dean Tosteson.

Joint Faculty Committee

Members of the Division's Joint Faculty Committee are: Dr. Walter H. Abelmann, Professor George Benedek, Dr. William Berenberg, Professor Cravalho, Dr. Herman N. Eisen, Professor Robert Hulsizer, Professor Farish A. Jenkins, Jr., Professor Richard Kronauer, Dr. Alexander Leaf, Dr. London, Professor Boris Magasanik, Professor Robert W. Mann, Professor Roger G. Mark, Dr. William V. McDermott, Jr., Professor Thomas A. McMahon, Dr. James L. Whittenberger, and Professor Laurence R. Young.

During this academic year, the Joint Faculty Committee reviewed the reports and activities of the admission and curriculum committees of the Biomedical Sciences and the Medical Engineering-Medical Physics Programs. A report on the activities of the Biomedical Engineering Center for the Application of Microprocessors to Clinical Instrumentation was presented by Professor Cravalho who discussed the efforts involved in the successful transfer of technology to commercial development.

The Radiological Physics Training Program, previously operated jointly by the Harvard School of Public Health and M.I.T., has been incorporated as a unit of the Medical Engineering and Medical Physics Program with Dr. Bernard Hoop, Jr. as head of the program.

The Joint Faculty Committee approved the nominations of new faculty and research members; these appointments are listed in Appendix A and Appendix B of the archival version of this report.

Professor George B. Benedek has been named the Alfred Caspary Professor as a joint appointment in the Department of Physics of M.I.T. and in the Harvard-M.I.T. Division.

EDUCATIONAL PROGRAMS

The Biomedical Sciences Curriculum

The Curriculum Committee of which Drs. Abelmann and Eisen are co-chairmen conducted seven subject evaluations during the past academic year. The subjects reviewed included: HST 020 Bone and Connective Tissue; HST 090 Cardiovascular Pathophysiology; HST 080 Hematology; HST 070 Human Reproductive Biology; HST 130 The Human Nervous System; HST 100 Respiratory Pathophysiology; and HST 110 Renal Pathophysiology.

The Committee recommended the development of three new subjects: biostatistics to be offered in January or June 1980 by Dr. Marvin Zelen; a seminar on Social Issues in Medicine to be led by Dr. Stanley Reiser; and the pathophysiology of the central nervous system to be offered by Dr. Norman Geschwind and Dr. Michael Moskowitz in 1980.

The concentration and thesis requirements were reviewed and the decision to emphasize these aspects of the curriculum was confirmed. Students were encouraged to submit their theses for consideration for honors. Of the 13 students graduating from the Harvard Medical School with honors in June 1979, seven were H.S.T. students.

The members of the Biomedical Sciences Curriculum Committee are listed in Appendix C of the archival version of this report.

Medical Engineering-Medical Physics Program

During the past year, this program has continued to evolve successfully under the supervision of Professor Cravalho, Associate Director for Medical Engineering and Medical Physics. The doctoral program has been developed further. Professor Walter H. Olson, who joined the Division faculty in January 1978, and Dr. James C. Weaver offered two new subjects in medical instrumentation: HST 580J Medical Engineering Measurements and HST 581J The Medical Engineering Measurements Laboratory. HST 580J focuses on the engineering principles for the transduction and display of biomedical signals; as a special feature, experts from industry present case studies of recently developed clinical instruments. HST 581J provides opportunities for students to engage in static and dynamic testing of biomedical transducers and instrumentation on animal models.

Experience with the first class of students in the Medical Engineering-Medical Physics Ph.D. Program indicated that biochemistry should be established as an entrance requirement. To accommodate those students who have not studied biochemistry, subject 7.05 at M.I.T. is offered in the tutored video instruction mode during the summer session prior to the first year of the program.

The development of clinical experiences for students in the doctoral program has continued with particular attention to the Introduction to Clinical Medicine and Engineering. This course is being developed by Professors Mark and Abelmann and will be offered for the first time in the fall of 1979 at the Beth Israel and Mt. Auburn hospitals. A clinical experience in orthopedics is being developed under the direction of Dr. Augustus A. White III, Professor of Orthopedic Surgery at Harvard Medical School and the Beth Israel Hospital, and his associates Drs. George E. Lewinnek and Wilson C. Hayes.

It is highly desirable that those Ph.D. candidates who also wish to obtain the M.D. have the opportunity to do so. Exploration of the various mechanisms by which this option can be provided is in progress.

The second class of students admitted to the doctoral program was selected by an admissions committee consisting of faculty members from M.I.T., Harvard College, Harvard Medical School, and two students from the first class of medical engineering and medical physics. Members of the Admission Committee are listed in Appendix D of the archival version of this report. Ten students were selected for admission in September 1979. Three of the students hold master's degrees and one holds the M.D. Five are educated in the engineering sciences and five hold degrees in the physical sciences. The students in this class are listed in Appendix E of the archival version.

The fifth class of Harvard-M.I.T. students to receive the Doctor of Medicine graduated in June 1979. The list of graduates, their honors, and their internship appointments is presented in Appendix F, and the students admitted to the Class of 1983 are listed in Appendix G, both also in the archival version of this report.

RESEARCH ACTIVITIES

Current research programs and their principal investigators are: Biomedical Engineering Center for Clinical Instrumentation, Roger G. Mark, M.D., Ph.D.; Control of Protein Synthesis by Double-Stranded RNA, Daniel H. Levin, Ph.D.; Cryopreservation of the Isolated Rat Heart, Ernest G. Cravalho, Ph.D.; Center for Health Effects of Fossil Fuels Utilization and Associated Research

Programs, Gerald N. Wogan, Ph.D.; Increased Corneal Curvature by Electrical Heating, Walter H. Olson, Ph.D.; Investigation of Antigen-Antibody Agglutination Using Single Particle Counting Technique, Richard J. Cohen, M.D., Ph.D.; Measurement of Perfusion from Thermal Properties, H. Frederick Bowman, Ph.D.; Medical Radiological Physics Training Program, Bengt E. Bjärngard, Ph.D. and Bernard Hoop, Ph.D.; Optimization of Dose Distribution in Cancer Radiation Therapy, Dr. Bjärngard; Physiological Measures of Mental Workload, John Tole, Ph.D.; Regulation of Hemoglobin Synthesis and Hematopoiesis, Irving M. London, M.D.; Rehabilitation Engineering Center, William Berenberg, M.D.; Short-Lived Radiopharmaceuticals for the Diagnosis and Treatment of Disease, S. James Adelstein, M.D.; Thromboresistant Materials, Edwin W. Salzman, M.D.; and An Ultrasonic Phased Array for Localized Hyperthermia of Subcutaneous Solid Tissue, Leslie R. Fox, Ph.D.

Technology Transfer from the University to Industry

During the past year the Division has devoted considerable attention to the methods of technology transfer. Extensive efforts are being directed to the transfer to industry of projects successfully completed in the Biomedical Engineering Center for Clinical Instrumentation. In this effort the Center is developing collaborative arrangements with various industrial firms for the fabrication of prototype units for clinical testing and ultimately for manufacture and marketing. Under the terms of these arrangements, the industrial firms provide research support and prototype instruments built to the specifications of the Center's scientists and engineers for the clinical trials of the various instruments. The manufacture of the instruments is greatly facilitated by virtue of the industrial firms' participation in these trials. Subsequent payments in lieu of royalties are made by the firms directly to the Center as unrestricted research grants. These funds are then used to support research in new areas and thereby help provide for the continuing activities of the Center.

The Division is developing two new research programs in the field of orthopedics. Under the leadership of Dr. White and Professor Alan J. Grodzinsky (Department of Electrical Engineering and Computer Science, M.I.T.), a program is being developed to investigate electromagnetic stimulation of fracture healing and connective tissue remodeling. A second project under the leadership of Dr. Bertram Zarins, Clinical Instructor in Orthopedic Surgery at the Massachusetts General Hospital, Professor E. Jane Betts of the M.I.T. Athletic Department, and Dr. Stephen Burns, Senior Research Scientist in the Harvard-M.I.T. Division, involves the development of a simple, reliable means for evaluating the training level in athletes or in individuals engaged in exercise programs. The diagnostic system to be developed should also provide a quantitative means of assessing the extent of injury to the musculoskeletal system and thus facilitate accurate diagnosis. This diagnostic system also should be applicable to physical therapy protocols in the treatment of the physically disabled.

Dr. Barbara McNeil, of the Department of Radiology at the Peter Bent Brigham Hospital is serving as Kieckhefer Lecturer in the Division, and is organizing a national symposium on Technology Assessment to be held in Boston in the spring of 1980. The focus of this symposium will be on the methods used to assess various kinds of medical technology and will be concerned with the processes of innovation, diffusion, effectiveness, and cost of new technological innovations. Case studies that are being developed for this purpose should serve as the basis of a new educational offering on technology assessment.

The Division is exploring the development of a collaborative research program with the Biomedical Engineering and Instrumentation Branch of the National Institutes of Health in the field of nuclear magnetic resonance techniques for non-invasive cross-sectional imaging of the human body.

Dr. Irving A. Bernstein, Assistant Director for Research Program Development, plays a major role in the initiation, planning, and implementation of many of these research activities.

FINANCIAL RESOURCES

As of June 30, 1979, endowment funds received or pledged totaled approximately \$8.34 million. New operating funds raised in 1978-79 totaled \$203,560. Since 1970, approximately \$29.8 million has been raised for educational and research programs: \$8.3 million for endowment, \$2.83 million for operations and facilities, and \$18.6 million for research and development.

Dr. Walter L. Koltun, Assistant Director for Resources, is responsible for the fund-raising activities of the Division.

IRVING M. LONDON

Whitaker College of Health Sciences, Technology, and Management

The Whitaker College of Health Sciences, Technology, and Management was established to provide organizational support for the Institute's many activities in health-related fields. The College houses the M.I.T. component of the Harvard-M.I.T. Division of Health Sciences and Technology; provides a focus for education and research in the field of health policy and management; and includes educational and research programs involving selected aspects of contemporary biology as they relate to human health.

Detailed planning and design of the Whitaker College building continued during the past year, especially with the help of Professor Ernest G. Cravalho, Associate Director of the Division of Health Sciences and Technology, Professor Christopher Walsh of the Departments of Biology and Chemistry, and Dr. H. Frederick Bowman, Senior Academic Administrator of the College. The planning is proceeding on schedule and occupancy is scheduled for the fall of 1981. A decision was reached by the M.I.T. administration to add a sixth floor to the Whitaker College building to be devoted to studies in the brain sciences.

Groundbreaking ceremonies for the complex of Whitaker College and the Medical Department facilities were held on June 4, 1979. Dr. Howard Johnson, Chairman of the M.I.T. Corporation, presided at these ceremonies. Brief addresses were made by Mrs. Helen Whitaker, a member of the M.I.T. Corporation and with her late husband Uncas A. Whitaker, a major donor to Whitaker College; Mr. Robert Smith, President of the Glenmede Trust Company, another major donor to Whitaker College; President Jerome B. Wiesner; Provost Walter A. Rosenblith; Dr. Irving M. London, Director of Whitaker College; and Dr. Melvin Rodman, Head of the Medical Department.

The further planning of the scope and content of educational and research programs to be conducted in Whitaker College has been carried out by members of the Faculty Advisory Council. This Council is composed of 22 senior faculty members (listed in Appendix H of the archival version of the Health Sciences and Technology Division's report). Reports of various planning groups were presented and discussed during the past year. Proposals were made for a program in human genetics by a committee chaired by Professor Maurice Fox. Professors Gerald Wogan and Christopher Walsh presented plans for a new doctoral program in environmental biology and toxicology. In the area of experimental medicine, Professor David Baltimore proposed a program in infectious diseases with emphasis on viral, bacterial, and parasitic human disorders. In the field of medical engineering and medical physics, Professor Cravalho identified ultrasound in diagnosis and treatment, new approaches to imaging, such as nuclear magnetic resonance, and biological signal processing, as fields deserving particular emphasis.

In the field of health policy and management, Professors Edward Roberts, Peter Temin, and Jeffrey Harris have proposed the establishment of a new doctoral program. The question of the numbers and kinds of faculty members who should be recruited to help meet the current educational programs of the Division of Health Sciences and Technology is also under study.

IRVING M. LONDON

Independent Activities Period

In its ninth year, Independent Activities Period in January 1979 continued to flourish as an integral part of the academic calendar. Students and faculty in large numbers took full advantage of the opportunity for concentrated and/or independent study and research, and they again attended well over 500 specially organized group activities that were announced in the I.A.P. *Guides*. When I.A.P. 79 was over, both students and faculty continued to give the program a very high rating in response to our annual questionnaire.

The 527 activities in the *Guide* came in every imaginable format -- mini-courses, lecture series, laboratory sessions, seminars, round-table discussions, hands-on shop projects, field trips, workshops, films, research projects, and contests -- and they covered an extremely wide range of topics. Many of the offerings covered serious and technical subjects, such as "Structural Theories of Hydrodynamics," "The Ax-Kochen Transfer Principle," "Bonding and Antibonding in Physical Metallurgy," "Gravitational Radiation," "Computed Tomography," and "Myeloma Tumors in Immunology." Sometimes sessions were designed to augment the curriculum of the regular term, as did the three lectures on "Elementary Ideas of Noise in Electrical Circuits." Other I.A.P. offerings served as introductions to regular subjects; faculty sponsors of the "Logic Lecture Series" and the "Climate and Energy" lectures both reported that participants in these activities later registered for related term subjects. A limited number of students elected to earn credit during I.A.P., either for independent projects or for regular subjects such as "Calculus," "Intensive German I," Mechanical Engineering's "Project Laboratory," or Civil Engineering's "Introduction to Accounting for Project Managers." Among the students gaining practical laboratory experience during I.A.P. were six students who took "Projects in Modern Optics" and four who began construction of a miniature magnetohydrodynamic (MHD) electric power generator, a project they continued into the spring term.

Some faculty members tried novel approaches to academic topics. Approximately 50 people became involved in a series of debates, sponsored by the Water Resources Division of the Department of Civil Engineering, on "Approaches to Aquatic Ecology -- Flask vs. Big Bags vs. Models," which evaluated the three experimental methods most commonly used in that field. In a series of lectures entitled "Gamble If You Will," a lecturer in Mathematics explained the principles of probability with illustrations from games of chance and then let the 90 students test the theories at a casino night. From 10 to 40 students gathered in lunchtime sessions to try to solve "Paradoxes and Puzzles in Physics" presented by an associate professor in that department. Some faculty offered courses outside their regular academic interests. An astrophysicist lectured on "The Physics of the Piano," and offered 25 participants a chance to try to tune a piano. Two faculty members, one in Materials Science and Engineering and one in Mathematics, offered short courses on antiques, and a nutritionist gave advice on "Basic Sports Nutrition." So that students could become eligible for summer jobs in the insurance industry, an associate professor in Mathematics led a mini-course, "Preparation for Actuarial Exams."

Faculty from different departments joined forces for such interdepartmental offerings as "Animal Physiology: An Interdisciplinary Field," "Chemical Analysis: How and Why?" and "Surface Analysis." Through the use of a free classified ad in the first I.A.P. *Guide*, a professor in Meteorology found a history professor interested in co-sponsoring a seminar on "Climate and History;" after the success of their I.A.P. offering, they are considering developing a regular subject on that topic. The Department of Political Science and its Public Policy Program joined with the Center for International Studies to sponsor a series of "Policy, Politics, and ..." activities; the most popular were "Policy, Politics, and Cartoons," a question-and-answer session with *Boston Globe* cartoonist Paul Szep, and "Politics, Policy, Humor and Satire," a lively panel discussion with former Governor Francis W. Sargent, Edwin Diamond from the Department of Political Science, and three newsmen, Jack Cole, Dick Flavin, and Danny Schechter.

As always, the performing arts flourished during I.A.P. Approximately 50 students participated in production preparations for Strindberg's *A Dream Play*, while another 71 rehearsed regularly for the Concert Band's winter tour, which took place between I.A.P. and the spring term. About

Independent Activities Period

35 people met twice weekly to make bamboo pipes; 100 participated in the Chamber Music Reading Party, and 16 members of the Department of Mathematics performed together in a music recital. The Ramon de los Reyes Spanish Dance Theatre performed and held dance and guitar classes and lecture-demonstrations during a week-long residency. Other dance classes were offered in square, folk, disco, modern, and jazz dance.

"How-To-Do-It" courses abounded this I.A.P. as in previous years. Among the skills one could learn were long-distance running, cardiopulmonary resuscitation, bicycle maintenance and repair, woodworking, surveying, juggling, winter mountaineering, baseball scoring, building ships in bottles, wine appreciation, and income tax preparation. An average of 40 people took each of the five courses on English as a foreign language, and 70 people attended lunchtime offerings on legal self-defense.

While many departments put together an impressive collection of offerings, the Department of Mathematics must be singled out for recognition, both for the size of its program (29 activities) and its variety (from a lecture series on "What is Mathematics and Why Won't It Go Away" to a mini-course entitled "Much Ado About Knotting").

Another group which was very active during I.A.P. was the M.I.T. Libraries. Besides sponsoring the M.I.T. College Bowl (which this year had 240 contestants and 600 attending the finals, making it I.A.P.'s biggest single event), the M.I.T. Libraries organized a number of activities aimed at making the resources of its various units better known to the M.I.T. community. For example, the Institute Archives offered a workshop entitled "Quick and Easy Advice on Old Prints, Photographs, Books, and Letters." In addition, the Library Staff Association organized a four-part series on censorship that included panel discussions and films, and the Humanities Library held lectures on current issues in human studies. For entertainment, Barker Engineering Library offered "Action and Animation under the Dome," a series of Canadian animated films.

I.A.P. policy is supervised by a faculty-student committee appointed by the President. As part of its yearly information gathering, the Policy Committee surveys faculty and students about allocation of their time during January and their attitudes toward I.A.P. Based on last year's responses, the questionnaires were revised this year before being distributed to the total faculty and student body. This year, response rates from both groups dropped considerably compared to the previous year's. In view of this, the Committee will have to examine the need for conducting a survey each year; it may be that I.A.P. is now so well established that the annual questionnaire has become superfluous.

With a 29 percent response rate, faculty members again reported spending an average of one-fourth of their working time in January on new and different endeavors. This included an average of 14 percent on new aspects of scholarly work *within* their usual areas of interest, four percent on scholarly work *outside* their usual areas of interest, and eight percent on activities listed in the I.A.P. *Guides*. Asked about their involvement in activities announced in the *Guide*, 58 percent of the faculty respondents said they participated in at least one activity, with 38 percent helping to organize or lead one or more activities. In answer to a question added to the survey this year, 70 percent of the faculty respondents indicated that some portion of their time was spent in activities made possible only by I.A.P.

With 17 percent of the undergraduates and 13 percent of the graduate students responding, both groups continued to report that they spent most of I.A.P. at M.I.T. -- an average of 76 percent of the time for graduate students and 67 percent for undergraduates. Graduate students said they spent an average of 59 percent of their working time continuing academic activities within their usual areas of interest, eight percent on new activities within their usual areas of interest, three percent on scholarly work outside their usual areas of interest, and 15 percent on activities announced in the *Guide*. Undergraduates allocate their working time differently from graduate students: 16 percent for continuing usual work; 10 percent for new activities in their usual areas of interest; 6 percent for work outside their usual areas of interest; and 24 percent for *Guide* activities.

When asked to rate I.A.P. on a scale from one (poor) to five (good), most faculty and student respondents gave it favorable ratings. Seventy percent of the faculty, 77 percent of the graduate students, and 81 percent of the undergraduates rated I.A.P. a four or a five.

Members of the I.A.P. Policy Committee this year were: Professors Woodie C. Flowers (Chairman), Timothy Aarset, Kenneth Brecher, Mr. Richard J. Caloggero, Professors Robert Chen, Catherine V. Chvany, Ernest Cravalho, Kenneth Hale, Paul Hoffman, Mr. Joel Orlen, Professors Robert O. Ritchie, Robert M. Rose, Robert J. Silbey, J. Edward Vivian, Eric A. Von Hippel, George Wolf, and Mark S. Wrighton.

Responsibility for I.A.P. administration rests with the Office of the Provost and is accomplished in large part through rotation of staff volunteers from departments and other offices of the Institute. This year the I.A.P. Administrative Committee included: Richard J. Caloggero (Chairman), Mary Z. Enterline, Edward Gaudiano, Stanley Hudson, Daryl Hymoff, Barbara McCarthy, Dr. Louis Menand III, Joel Orlen, Margaret S. Richardson, Jane Sauer, and William Westcott.

JOEL ORLEN

Laboratory for Computer Science

The Laboratory for Computer Science (L,C,S,) is an M.I.T. interdepartmental laboratory whose principal goal is research in computer science and engineering.

Founded in 1963 as Project MAC (for Multiple Access Computer and Machine Aided Cognition), the Laboratory developed the Compatible Time-Sharing System (CTSS), one of the first time-shared systems in the world, and Multics -- an improved time-shared system that introduced several new concepts. These two major developments stimulated research activities in the application of on-line computing to such diverse fields as engineering, architecture, mathematics, biology, medicine, library science, and management. Since that time, the Laboratory's objectives have expanded, leading to research across a broad front of activities that now span four principal areas.

The first such area, entitled *Knowledge Based Programs*, involves making programs more intelligent by capturing, representing, and using knowledge which is specific to the problem domain. Examples are the use of expert medical knowledge for assistance in diagnosis and for drug administration carried out by the Clinical Decision-Making Research group; the use of mathematical knowledge by the Matlab Research Group for an automated "mathematical assistant;" the use of knowledge in programs that comprehend typed natural-language (English) queries; and the use of knowledge about programming by an automated "programming apprentice."

Research in the second area, entitled *Machines, Languages and Systems*, strives to effect sizable improvements in the ease of utilization and cost effectiveness of computing systems. For example, the Programming Methodology Research group strives to achieve this broad goal through research in the semantics of geographically distributed systems. Toward the same goal, the Real Time Systems group is exploring the programming of real-time systems that control physical processes from higher-level, domain-specific languages. Other research examples in this area include the study of data bases, the architecture of very fast multiprocessor machines by the Computation Structures Research group, the architecture of individual "personal" machines, the networking and organization of geographically distributed systems of computers, and the structure and function of computer systems for office automation. The latter research program is carried out by the Computer Systems and Programming Methodology Research groups from the point of view of exploiting the decreasing costs of processors and memories, improving overall performance and reliability, protecting information, and ensuring the privacy and authentication of data.

The Laboratory's third principal area of research, *Theory*, involves exploration and development of theoretical foundations in computer science. For example, the Theory of Computation Research group strives to understand ultimate limits in space and time associated with various classes of algorithms. Other research in this area includes the Semantics of Programming Languages from both analytical and synthetic viewpoints and the links between mathematics and the privacy/authentication issues associated with distributed systems.

The fourth area of Laboratory research is entitled *Computers and People* and entails societal as well as technical aspects of the interrelationships between people and machines. Examples of

research in this area include the sociological impact of computers on individuals; the ethical problems of distributed responsibility posed by multiprogrammer systems; and various dynamic and sophisticated graphic interfaces between computers and their users.

During the past year, the Laboratory consisted of 279 members -- 36 faculty, 4 visiting faculty, 17 visitors, 90 professional and support staff, 85 graduate and 47 undergraduate students -- organized into 14 research groups. During the reporting period, Professor Albert Meyer was appointed Associate Director of the Laboratory, replacing Professor Joel Moses, who became Associate Head for Computer Science and Engineering in the Department of Electrical Engineering and Computer Science. The academic affiliation of most of the faculty and students is with the Department of Electrical Engineering and Computer Science. Other academic departments represented in the Laboratory membership are Mathematics, Architecture, Division for Study and Research in Education, Humanities, and the Sloan School of Management. Laboratory research during 1977-78 was funded by 10 governmental and industrial organizations, of which the Advanced Research Projects Agency of the Department of Defense provided about half of the total research funds.

The 1978-79 year was very active. Technical results were disseminated through the publications of the Laboratory members and will not be discussed here. Highlights of the year included the following.

The major recent breakthroughs achieved by Professors Ronald Rivest, Leonard Adleman, and Adi Shamir in linking privacy and authentication of machine data to unsolved mathematical problems, were further enhanced. During the reporting period, an efficient hardware implementation of the RSA public-key cryptographic method was pursued; a new integer factorization algorithm was designed and analyzed; and a model of the VLSI layout and routing problem was constructed.

The Technical Services group formed in 1978 now functions in both a research and support role within L.C.S. The group is responsible for the development and implementation of hardware for the L.C.S. local network, which is part of our distributed systems effort. Its support functions include development and maintenance of an electronics laboratory facility as well as management and maintenance of the L.C.S. network. During the year, the group achieved operation of the local L.C.S. network.

Since 1977, geographically distributed systems have evolved into a major Laboratory focus, involving about half of our Laboratory personnel and resources. Research in this area strives to make possible geographically distributed systems consisting of a large number of processors. The central theme of our research involves local autonomy of each processor, as well as application cohesiveness of the overall system. This theme is pursued at the various levels of representation that characterize this research. In particular, at the hardware level, the Real Time Systems group is developing a single-user computer that will be manufactured for us by the Heath Company, while the Technical Services group is pursuing the network that will link at least 100 of these machines within our Laboratory.

At the operating system level, the Real Time Systems group is pursuing research in and development of a distributed operating system that will reside on these machines. The Computer Systems Research and Programming Methodology groups are pursuing a general-purpose language especially suited to the semantics of distributed systems. At the applications level, our newly formed Office Automation group is researching the semantics of a language suitable for describing office procedures. At the same level, our Programming Technology group is researching the structure of a system that makes possible planning in the presence of large amounts of data -- in the context of energy policy planning. Finally, our Theory of Computation group is involved in this research through the research and development of methods for ensuring the privacy and authentication of data.

The Office Automation research group was created this year under Professor Michael Hammer. It focuses its research on the overall function of offices rather than on new technology to perform established low-level tasks.

Another newly formed research group, Digital Mechanics, under Professor Edward Fredkin, focuses its research on a new approach for implementing fast digital circuits. In this approach, energy representing bits of information is spatially steered, rather than consumed, as is the case with today's circuits.

Provost

The Laboratory's Distinguished Lecturer Series, initiated in 1976, has proved very successful in attracting members of the M.I.T. community. The 1978-79 lecturers under this series were Ruth M. Davis (Deputy Under Secretary of Defense for Research and Engineering, Department of Defense), Lewis M. Branscomb (Vice President and Chief Scientist, IBM), Juris Hartmanis (Professor and Chairman, Department of Computer Science, Cornell University), Butler W. Lampson (Senior Research Fellow, Xerox Corp.), Alan J. Perlis (Eugene Higgins Professor of Computer Science, Yale University), Herbert A. Simon (Professor of Computer Science and Psychology, Carnegie-Mellon University). Professor Simon's presentation on "Learning by Examples and Learning by Doing," was given to an overflow audience at M.I.T. on November 2, 1978, one week after his being awarded the Nobel Prize in economics.

During 1978-79, research in previously established areas yielded several new results which were published through Laboratory technical reports (TR202-TR218) and technical memoranda (TM106-TM137), as well as through articles in the technical literature.

MICHAEL L. DERTOUZOS

Laboratory for Information and Decision Systems

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

The Laboratory was founded in 1939 and was originally called the Servomechanisms Laboratory. Its name was changed to the Electronic Systems Laboratory (E.S.L.) in 1959. Until March 1, 1978 E.S.L. was a departmental laboratory in the Department of Electrical Engineering and Computer Science. E.S.L. was then designated an interdepartmental laboratory and now reports to the Provost's Office. On September 20, 1978 the name was changed to Laboratory for Information and Decision Systems (L.I.D.S.) to more accurately reflect the research interests of its faculty, staff, and students.

The Director of L.I.D.S. is Professor Michael Athans, the Associate Director is Professor Robert G. Gallager, and the Assistant Director is Professor Alan S. Willsky. In the past year, 18 faculty members, 4 visiting faculty, 16 full-time research staff, 4 visiting scientists, 16 support staff, and approximately 70 graduate and undergraduate students have been affiliated with the Laboratory. Research support has been provided by the American Newspapers Publishers Association, the National Aeronautics and Space Administration, the Defense Advanced Research Project Agency, the the Department of Transportation, the Gannett Foundation, the Office of Naval Research, the Army Research Office, the Department of Energy, the National Science Foundation, the Air Force Office of Scientific Research, the Library of Congress, the National Library of Medicine, and the General Motors Corporation.

RESEARCH

Systems and Control Theory

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

Professors Willsky and Sanjoy Mitter and Dr. Alan Laub continued their research in the area of algebraic system theory and numerical aspects of different algorithms that are important in understanding the structural properties of linear systems. Professors Willsky, Timothy Johnson, and Paul Houpt are studying appropriate methodologies for utilizing microprocessors and finite state machines for estimation and control of dynamic systems.

Professor Willsky and Dr. Stanley Gershwin are continuing their studies on the development of theory of failure detection and isolation algorithms. Research topics include the effects of dynamic system modeling errors upon the performance of sensor failure detection and isolation algorithms, and trade-offs between algorithm complexity and performance.

Professors Athans and Willsky and Dr. David Castanon are developing a methodology for the design of robust control systems, with special emphasis on actuator failures, and trade-offs involving possible reconfigurations of the control system following the identification and isolation of a failed component.

Professors Johnson and Mitter continued their study of problems of representation and control of distributed parameter systems, including representation and control studies for systems that involve time delays and wave phenomena, as well as the optimal control of systems described by partial differential equations.

Professors Athans, Gunter Stein, and Nils Sandell are examining the robustness of multivariable control systems using the Linear-Quadratic-Gaussian design methodology. Important areas of investigation relate to the development of inherent and guaranteed robustness properties. A workshop on the above topics was held at M.I.T. in April 1979.

Professors Willsky and George Verghese and Drs. Castanon and Bernard Levy have initiated an investigation of the design of efficient estimation algorithms given spatially distributed data. The motivations for this study are the design of high-performance decentralized estimation systems and the development of procedures for mapping spatial random fields.

Professors Mitter, Sandell, Willsky, and Athans continued research on several aspects of modern estimation theory. Specific problems investigated include the development of algorithms and performance bounds for nonlinear filtering problems.

Communication Networks and Systems

A second major area of basic research deals with problems in the analysis and design of complex communication networks. This research is motivated by the increasing use of both civilian and military data communication networks.

Professors Gallager, Dimitri Bertsekas, Cyril Leung, and Pierre Humblet have continued their studies in data communication networks. Specific research projects include the development of decentralized routing algorithms methodologies to assess the minimum amount of protocol information needed for routing, effects of link and node failures, security and reliability aspects of data communication networks, and the dynamics of data communication networks in general.

Professors Gallager, Bertsekas, Humblet, and Mr. John E. Ward initiated a research project that deals with fundamental understanding of all aspects of mobile packet radio communication networks. The basic problem involves a set of moving nodes that wish to be able to communicate to both geographically fixed and other moving nodes.

Professors Athans, Sandell, Tenney, and Wilbur Davenport, and Drs. Castanon and Levy have continued studies dealing with distributed information, communication, and decision problems as motivated by problems in Naval and Air Force Command, Control, and Communications systems. Research topics involve surveillance and search theory, multisensor correlation studies, tracking algorithms, the dynamics and control of distributed data bases in a complex failing communications network environment and general problems of command theory, game theory, and decentralized decision making under uncertainty. A two-week workshop on this topic was held at the Naval Postgraduate School in Monterey, California in July 1979.

Information Transfer Systems

Professor J. Francis Reintjes and Mr. Richard Marcus continued their research in the networking of interactive information-retrieval systems. Further investigation was conducted on the concept of a translating computer interface to provide simplified access, even by inexperienced end users, to heterogeneous retrieval systems by means of a common command language and extensive on-line instruction. An advanced version of an experimental interface was tested with several users.

Aerospace Systems

Professors Stein, Athans, and William S. Widnall initiated a study of the landing control of VTOL (vertical takeoff and landing) aircraft on board small ships in high sea states. Objectives include assessing basic performance characteristics of the VTOL vehicles and exploring the applicability of modern control methodologies for design.

Transportation Problems

Professors Athans, Houpt, and Dr. Gershwin continued their applied research on the control of freeway corridor systems, that is, the control of entrance ramps to a freeway and the coordination of signals in parallel arterials.

Mark Connelly is studying several aviation industry problems, a simulation evaluation of the combined use of 4DRNAV and the Airborne Traffic Situation Display in de-randomizing the flow of traffic into a busy terminal, an evaluation of methods of detecting and compensating for vertical and horizontal wind shear effects in landing, and a study of techniques for quantitative measurement of pilot and air traffic controller workloads.

Professors Stein, Athans, and Houpt have continued the research program which deals with the application of modern control and estimation techniques to problems related to the multivariable control of internal combustion engines. The study involves the coordination of several engine controls so as to minimize, to the degree possible, pollutant emissions, while maximizing fuel economy without sacrificing driveability.

Professors Houpt and Willsky have initiated a study of the design of reliable control systems for automated guideway transit (AGT). Methods for detecting sensor and actuator failures in individual vehicles or in a string of vehicles are presently being developed.

Energy Systems

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

Professor Athans and Drs. Gershwin and Levy are studying the concept of effectiveness of power systems with respect to the reliability of service. This study attempts to quantify the worth of the energy delivery system from the customer viewpoint, the cost to the utility, and the role of the regulatory agency.

Professors Willsky, Mitter, and Johnson and Drs. Castanon and Levy have begun a study of the stability of complex interconnected power systems. The goal of this study is the development of analytical tools appropriate to understanding the cascade of events phenomena characteristic of large-scale blackouts.

Text-Transmission Systems

Professor Reintjes and Donald Knudson have demonstrated their full-text transmission system in the Laboratory. The system, being developed under the auspices of the Library of Congress, transmits text at a rate of one page per five seconds to both soft-copy and hard-copy stations located within a mile of the transmitter.

Manufacturing Systems

Professors Athans, Cook, Levy, Drs. Gershwin and Laub, and Mr. Ward continued their investigations of the system aspects of flexible automated batch manufacturing systems. The research being carried out includes investigation of scheduling methods for classical flowshops with buffers, the impact of intermediate buffers on the production efficiency of an automated transfer line, and optimization strategies at both the static and dynamic levels for interconnected manufacturing networks.

Economic Systems

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

Biomedical Problems

Professor Johnson continued research on defining and measuring the nonequilibrium electrochemical properties of electrodes and their effects on the accuracy of measurement of bioelectrical phenomena; he also conducted research on modeling and system theoretic properties of the human motor control systems.

General Purpose Software

Professor Athans, Dr. Laub, and Ms. Virginia Klema began experimental computing research, and design of developing stable numerical algorithms that culminate in robust software for certain problems in control and estimation.

Models for Behavior of Mathematical Software

Dr. David Hoaglin, Ms. Klema, and Mr. Stephen Peters continued research and design of robust software for statistics. Their research is an interdisciplinary mix of work in numerical and statistical analysis and software science and engineering.

Display Terminals

Professor Roy Kaplow and Mr. Ward have initiated a study aimed at exploitation of a previously designed alphanumeric/graphics display terminal featuring a keyboard with variable, computer-controlled key labeling.

MICHAEL ATHANS

Libraries

It is increasingly evident from the major activities and concerns of the M.I.T. Libraries during the past year that along with other academic research libraries, the M.I.T. Libraries are strongly influenced in decisions and actions by external forces, over only some of which do the Libraries have any significant control. At the global level, inflation and continuing rise in the production of information have combined to inhibit substantially the ability of the Libraries to maintain strong, current collections. Nationally, the Libraries are deeply involved in the analysis of current

operations and planning for the future in the light of several possible changes in the field: a proposed National Periodicals Center; the impending adoption of the Anglo-American Cataloguing Rules (AACR II) and its effect on traditional catalogues; the possibility of the establishment of a National Level Bibliographic Record for decentralized input to a national data base; as well as a number of cooperative resource-sharing projects like the OCLC Interlibrary Loan System and a developing research libraries network.

On the local level, cooperative work continues with the Boston Library Consortium, with the New England Library Information Network (NELINET), with various units of the Harvard University Libraries, and with Brown University. The substantial number of variables that all these existing and potential options offer is compounded by the need to consider a series of complex internal problems, including the future of the card catalogue; the design and development of various automated library systems; the coordination of the acquisition, cataloguing, bibliographic control, and service functions inherent in the Resource Sharing Center; serials control; preservation; photocopying; and, of equal importance to any of the above, collection development.

The orchestration linking all the planning and analysis involved in each of these projects, in terms of staff participation and fiscal implications, occupies a considerable amount of staff time and must be accomplished while maintaining a high level of service for a constituency with an ever-growing appetite for information. Establishing and maintaining a suitable balance of our efforts between current activities and future planning requires the assistance and cooperation of the entire staff. The Libraries are most fortunate in having had their complete support to enable the accomplishment of so much in the past year.

In terms of long-range planning, three concurrent efforts are under way that will continue into the next academic year. One involves the future of bibliographic control in the M.I.T. Libraries, particularly as it is affected by the impending adoption of new cataloguing rules (AACR II). These rules require major decisions on the future of existing card catalogues and possible replacements of them through either microform or computerized storage. As a first step, the M.I.T. committee responsible for this project is nearing completion of a report that will recommend the production of a microform copy of the Dewey Decimal Catalogue (DDC), representing the major portion of the Libraries' acquisitions from the earliest days of the Institute until the end of 1963. It is anticipated that once records have been withdrawn for items discovered as missing through a complete inventory of DDC holdings, the Catalogue will be filmed and a microform copy will be available for duplication. This will mean that for the first time a complete record of all DDC classified books in the library system will be available in all libraries. Following this phase of the project, the committee will begin work on planning for conversion of Library of Congress (LC) classified catalogue records either to a computer-output-microform (COM) format or to some type of on-line catalogue. The date for adoption of AACR II is January 1, 1981.

A second study is devoted to a comparative analysis of costs, services, and future potentialities of two library networks: OCLC, Inc., and the Research Libraries Group (RLG). M.I.T. has been a participant in the OCLC system for approximately five years and uses this system principally for cataloguing. Beginning in April 1979, the OCLC member libraries also were able to use the network for interlibrary loan message switching. The RLG with its processing arm, RLIN (Research Libraries Information Network) is a relatively recent entry into the computerized network field. The founding members include Columbia University, Yale University, New York Public Library, and Stanford University, with the recent addition of the libraries of Dartmouth College, University of Iowa, University of Michigan, University of Pennsylvania, Princeton University, Rutgers University, and Brigham Young University. The task for M.I.T. is to assess the benefits, both intellectual and financial, of belonging to a large, diverse library network including various types and sizes of libraries with strong assets but slowly developing services as compared with a new, relatively unproven, research library oriented consortium whose goal is to develop resource sharing capabilities as well as computerized services.

The third area of investigation is the design of specifications for automated library systems. The conversion of a manual circulation system to one that is computer based has obvious advantages; it appears clear that technology has developed to the point where several commercially available systems meet most of the requirements of the M.I.T. Libraries. It is likely that this is the first area where automation will be applied. The interdependence of an automated circulation system and the cataloguing system alluded to above makes decisions on both timing and vendor rather complicated. In addition, serious study is under way with regard to acquisitions and fund accounting systems and to serials control. All these operations have a substantial number of common elements in terms of system components and data bases, so that a decision in any one area will necessarily affect all the others.

Collection Development

The Libraries continued to build on recommendations emanating from the Collections Analysis Project, which was completed in March 1978. The Collections Advisory Group, composed of the collection coordinators from each of the five divisional libraries and chaired by the Collections Development Librarian, completed an impressive number of projects during the year. Among the most significant were: the development of a framework of 66 subjects as the basis for written collection policies and budget allocations; restructuring of the budget request process for monographs; preparation of three documents, *Guidelines for Writing Collections Development Policies*, *Guidelines for Evaluation of Collections*, *Collection Evaluation Manual*; preparation of a description of the functions of collection coordinators; and drafting of collection policies on nutrition and food, food science and technology, linguistics, and the history of science and technology.

The need for a more sophisticated and mission-related collection development program is evident when one looks at the effects of inflation on the Libraries' acquisition program during the past 12 months. Despite the addition of almost \$54,000 to the budget for serials (journals, annuals, newspapers, etc.), the rate of inflation combined with the declining value of the dollar abroad produced a shortfall of almost \$22,000. These additional funds will, unfortunately, have to come from money earmarked for the acquisition of monographs, thus further reducing the Libraries' ability to keep up with current publishing output. Some examples of price increases in foreign periodicals appear in the table below. While admittedly these represent some of the more extreme cases of inflation, they are by no means isolated. For a library system like M.I.T.'s that is so heavily dependent upon current periodical literature, the prospect of a continued spiral is frightening to contemplate. The Spartan approach the Libraries have taken with regard to duplication and subscriptions to less-used titles will probably prove inadequate to meet the effects of these increases. Solutions will have to be found through other means such as cooperative acquisitions, requests from large repositories of periodicals, and more use of microforms in lieu of hard copy.

Price Increases in Foreign Periodicals

<u>Title</u>	<u>Country of Publication</u>	<u>1978 Prices</u>	<u>1979 Prices</u>	<u>Percent Increase</u>
<i>Acta Anatomica</i>	Switzerland	\$360.00	\$429.00	19.1
<i>Behaviour</i>	Netherlands	130.45	174.45	33.7
<i>Bulletin des Sciences Mathematiques</i>	France	85.65	108.20	26.3
<i>Chemistry and Physics of Lipids</i>	Netherlands	115.05	216.45	88.1
<i>Environmental Policy and Law</i>	Switzerland	51.00	77.00	50.9
<i>Enzyme</i>	Switzerland	134.00	217.00	61.9
<i>Journal of Econometrics</i>	Germany	163.57	338.82	107.1
<i>Nippon Kagaku Kaishi</i>	Japan	66.60	90.00	35.1
<i>Nuovo Cimento</i>	Italy	288.00	430.00	49.3
<i>Russian Engineering Journal</i>	England	96.32	150.00	55.7
<i>Theory and Decision</i>	Netherlands	56.50	148.30	162.4
<i>Water Pollution Control</i>	England	29.76	40.00	34.4

Inflation in the prices of hard-bound books acquired by the Libraries more or less kept pace with the general increase in the cost of living, with the total for the year at about nine percent. The cost of binding, however, far outpaced that figure. Prices for binding will increase from between 21 percent for periodicals to 35 percent for monographs; the net effect will be an additional cost of \$10,000 for fiscal year 1979-80.

Resource Sharing Center

With the receipt of a three-year grant of \$100,000 from the Booth Ferris Foundation in November 1978, the Libraries moved into high gear in implementing plans for a Resource Sharing Center (R.S.C.). A staff was assembled and work was begun on the transfer of less-used materials to storage facilities temporarily located in Buildings N51 and N52. The permanent location of the Center in the present Metropolitan Storage Warehouse is now scheduled for some time in 1982. Among the collections that have been or are being moved are the archival copies of theses and the Tech Collection from the Institute Archives, the technology portion of the Dewey Decimal Collection (600s) in the Hayden Library, and periodicals from the Dewey and Lindgren libraries. A substantial amount of staff time has been devoted to establishing bibliographic control and circulation procedures as well as to expanding the Library Institute Delivery System (L.I.D.S.) to provide service from R.S.C. collections. With the prospect of the move to Metropolitan Storage Warehouse some years off, it is clear that additional space will have to be found in the immediate future in order to provide growth space for current acquisitions.

Cooperative Acquisitions Program

A major investment of time was put into the preparation of a joint proposal with Brown University under Title II-C of the Higher Education Act for research libraries. The proposal, totaling almost \$350,000, provided for cooperative acquisition programs in areas in which both institutions were engaged in research and in teaching at the doctoral level, and included provision for bibliographic control, joint access, and preservation. Unfortunately, it was announced late in June that the proposal was not being funded. The Office of Education, which oversees the program, received 85 requests for support and was able to fund only 20 of these. The effort expended was, however, not without future benefit. The potential for cooperation with Brown has been established in several areas and, in addition, discussions will take place in the fall of 1979 on the possibilities for a joint proposal to be submitted in the next fiscal year. The preparation of documents needed for the proposal also produced a significant amount of useful information about M.I.T.'s collections in the fields of applied mathematics, applied mechanics, computer science, economics, energy, health sciences, history of science and technology, and linguistics.

Independent Activities Period

The Independent Activities Period is one of the most exciting features of life at the Institute, and the Libraries' participation serves both as an opportunity for staff involvement and a challenge to develop interesting, attractive programs. The January 1979 session included: the third annual M.I.T. College Bowl; a Library Staff Association film and lecture series on problems on censorship; a film series in the Barker Engineering Library featuring the work of the National Film Board of Canada; two seminars in the Dewey Library, one on corporate information and the other on the *Social Science Citation Index*; three lectures on "The Museum as Educator" in Historical Collections; two talks on "Current Topics in Human Studies" sponsored by the Humanities Library and a seminar there on the *Arts and Humanities Citation Index*; a session entitled "Quick and Easy Advice on Old Photographs, Prints, Books and Letters," held in the Institute Archives and Special Collections; the third annual Chamber Music Reading Party sponsored jointly by the Music Library and the M.I.T. Chamber Music Society; a series of exhibits documenting the major cities of the world, prepared by the Rotch Library; and, finally, a course in T'ai Chi conducted by a member of the staff of the Collections Development Department.

Catalogue Department

Significant changes in two areas in the Catalogue Department affected and will continue to affect a wide spectrum of activities in the Libraries. The acquisition of a high-speed printer connected to the OCLC cataloguing terminals has resulted in more effective use of the data base in a number of ways. The terminal provides interactive use of the OCLC Interlibrary Loan System, and with hard copy printout now available, interlibrary loan transactions consume considerably less staff time and paper. The printer permits off-line editing of catalogue records that heretofore had to be changed on-line as part of the cataloguing process, thus releasing more time for cataloguing record input. The printer is also used to record bibliographic information for recommended acquisitions where the nature of the item requires consultation between the Collections Development Department and subject specialists.

A second project was to develop a coordinated set of specifications and a timetable for the computerized production of *Serials and Journals in the M.I.T. Libraries (S&J)*. In cooperation with Inforonics, Inc., a system was developed for on-line editing by M.I.T. staff of changes to the data base; this compares most favorably with the previous system of handwritten or typewritten changes that were then batch processed at a fairly high cost by Inforonics. In addition, new title information will henceforth be produced using an OCR (optical character recognition) typing element; the listings thus generated can be optically scanned at Inforonics and fed directly into the data base. It is expected that with the issuing of a complete update of the list on microfiche in the fall of 1979, the Libraries shall be able to adhere to a schedule of a semiannual edition. With this prospect in view, a decision was made to identify *Serials and Journals* as the master record for serials holdings in the M.I.T. Libraries and, consequently, to move toward elimination of updating serials information in the Institute Library Catalogue and the catalogues of divisional and branch libraries.

Institute Archives and Special Collections

In the Institute Archives and Special Collections, considerable progress was made in the processing of collections supported under a three-year grant from the National Endowment for the Humanities (NEH). Among the manuscript collections fully or partially processed under the grant this year were the papers of Dugald Jackson, Samuel Stratton, Norbert Wiener, and the architectural firm of Howe, Manning and Almy. A number of major policy documents were written and put into effect including those concerning access to the Minutes of faculty meetings, a uniform gift agreement, access to personal papers, and a collection development policy for archives and manuscripts.

The Institute Archivist and the Director of Libraries worked closely with the Dean of the Graduate School in preparing a revision to faculty regulation 2.71 dealing with theses; the revised version, passed by the faculty in May 1979, responds to the requirements of the new copyright law and will be of great assistance to the Libraries in the processing of graduate and undergraduate theses. With this approval by the faculty, the Libraries can now proceed with a revision of the pamphlet on thesis specifications and will have the document ready by the fall of 1979.

Other Activities

One of the most persistent problems faced by the Libraries over the past decade has been that of low-cost, self-service, coin-operated photocopiers. Efforts to identify a plain paper copier to replace the wet-process, coated-paper copiers currently in use were unavailing until this past spring. At that time the Libraries found a machine that would be economical and that would produce reasonably good copies including those from originals containing graphic material. With the strong support of the Institute administration, the Libraries will be acquiring Xerox 3100 copiers for all public service locations; the machines should be in place by the beginning of the fall 1979 term.

The Corporation Visiting Committee for the M.I.T. Libraries met on December 7 and 8, 1978. The principal topics discussed, in addition to a review of current programs, were the Institute Archives and Special Collections, Historical Collections, Records Management, the Collection Analysis Project, the Resource Sharing Center, and national programs and their impact on M.I.T.

The Public Services Group (P.S.G.), made up of the heads of the divisional and branch libraries, has responsibility under the Assistant Director for Public Services for a wide range of services and functions. These individuals are responsible for directing the book selection, reference, circulation, and related activities that are the Libraries' principal services to users. The Group has done a great deal of effective work in coordinating policies and procedures and in identifying problem areas. Among P.S.G.'s activities this year were: the coordination of policies with the head of the Resource Sharing Center; identification of levels of service provided to non-M.I.T. users; and preparation of a policy on the confidentiality of circulation records (later adopted by the Libraries).

The Libraries' computerized literature searching service, NASIC, continued to flourish. Twenty-two data bases were added to the offerings, bringing the total of data bases now available to 124. In an effort to keep up with the increased use of the service, an experiment will be conducted

beginning in the fall of 1979 whereby limited searching services will be offered on social science data bases in the Dewey Library. It is anticipated that searches there will be limited to members of the M.I.T. community and limited to a single data base. Non-M.I.T. users and multi-data base searches will be referred to the central NASIC office.

The establishment of a library liaison program for the Mining and Mineral Resources Research Institute (M.M.R.R.I.) in the Barker Engineering Library has proved most successful and hopefully will serve as a model for future programs in other centers and laboratories. A part-time librarian and an assistant, supported by funds from M.M.R.R.I., are responsible for identifying faculty research areas and matching these with recommendations for library acquisitions, publication of a newsletter including lists of acquisitions in all M.I.T. libraries, and production of specialized bibliographies and on-demand literature searches.

One of the most significant developments during the past year was the establishment of a Records Management Program for M.I.T., administered under the Institute Archivist. With strong support from the President, Chancellor, and Provost, a position of Records Management Officer was created. Beginning in January 1979 the individual filling this position has been working with a wide range of academic and administrative departments to identify records and to develop schedules and policies for retention, transfer, and destruction on a systematic basis that ensures the preservation of all essential records and yet avoids the use of sorely needed academic, administrative, and research space for the storage of little used or unneeded files. The designation of an area in the proposed Resource Sharing Center as a Records Center offers an alternative to the assignment of space to files and to the annual acquisition of expensive filing equipment. Until such time as the R.S.C. is located permanently in the Metropolitan Storage Warehouse, the Records Center will be housed temporarily at 224 Albany Street.

In addition to the grant from the Booth Ferris Foundation for support of the Resource Sharing Center, the continuing support from NEH for manuscript processing, and support from NHPRC for the architectural drawings collection, the M.I.T. Libraries were included in a major grant to the Institute and Harvard University that established the Aga Khan Center for Islamic Architecture. Although still in the planning stage, the program will involve close cooperation between the Rotch Library of Architecture and Planning and the Fine Arts Library at Harvard. Among the projects envisioned are cooperative acquisitions, shared access for members of the Center, and the development of a documentation center that would provide both bibliographic information from a computerized data base and source material for individuals interested in Islamic architecture in the United States and abroad.

The Libraries continued to be deeply involved in the various programs of the Boston Library Consortium. Along with expedited interlibrary loan, shared access, and staff development programs, the Consortium allocates funds for the joint acquisition of research materials. This year one of the Consortium acquisitions was *Housing and Urban Affairs*, a set of urban documents on microfiche that has been assigned to the Rotch Library. In addition to acquisition of the basic set covering the period 1965-1976, Consortium funds will be provided for the annual supplements. The joint acquisition program is clearly a demonstration of the great potential for resource sharing on the local level.

STAFF

Two departures from the staff require special comment. William Presson, Associate Dewey Librarian, retired in December 1978 after 22 years of outstanding service to the Institute. Mr. Presson was honored in 1976 as co-recipient of the Murphy Award for distinguished service to the M.I.T. community, the first member of the library staff so honored, and he will truly be missed by all those whom he served so well over the years. Margaret Otto, Associate Director of Libraries and member of the staff for 16 years, resigned on June 30, 1979 to become the 16th Librarian of Dartmouth College. Ms. Otto had a major role in the development of the Libraries in a variety of positions and most recently was responsible for the day-to-day operations of the entire system.

Libraries

Two members of the librarian staff were recipients of grants offered by the Council on Library Resources (CLR). Mary Pensyl, Head of NASIC Services, was chosen for the CLR Fellowship Program. She will spend three months studying the impact of user demands on the reference departments of academic and research libraries that have offered on-line bibliographic services for several years. Susan Nutter, Associate Librarian of the Barker Engineering Library, was awarded one of two CLR Management Internships for the academic year 1979-80. This program recognizes outstanding mid-career librarians who have shown a potential for the assumption of major administrative roles in academic libraries and provides for a year's leave with pay to work closely with the director of a major research library. Ms. Nutter will spend her year working with James Govan, Director of Libraries at the University of North Carolina. The second Management Internship was given to Rebecca Dixon, director of the Library Services Division of the Center for the Study of Youth Development, Boys Town, Nebraska; Ms. Dixon will spend the year at M.I.T.

Staff Activities

The staff of the Libraries were involved in a broad range of professional activities this year.

Gina L. Balestracci was a performing member of M.I.T.'s Early Music Society. Sheelah Britt was a member of the Task Group on Classification of the M.I.T. Working Group on Office/Clerical Issues. Laura B. Carchia was a member of the International Committee of Industrial Relations Librarians. Clara-Mae Chittum was a member of the steering committee for the American Library Association (ALA) Booksellers Discussion Group. She also was a member of the planning committee for the ALA 1980 Preconference on Acquisitions.

Katharine G. Cipolla gave a seminar on electronics reference sources for Professor Paul Gray's Class 6.332. Her paper "M.I.T.'s Point-of-Use Concept: a Five-Year Update" was accepted for publication in the *Journal of Academic Librarianship*. Her paper "Bibliographic Instruction II: Production of an Instructional Program in a Non-Print Medium" was sent to ERIC/IR (Educational Resources Information Center/Clearinghouse for Information Resources).

Clementine I. Coblyn participated in M.I.T.'s Supervisory Development Program II. She was a member of the Boston Library Consortium (BLC) Readers Services Committee. She also was a member of the Black Caucus of ALA. Jacqueline Z. Colby was a member of the BLC Cataloguing Committee. Linda Cuccurullo showed an exhibit of her photographic works at the M.I.T. Faculty Club in July and at the Rotch Library Visual Collections in November.

Margaret E. De Popolo served on the School Council of the M.I.T. School of Architecture and Planning. She participated in the Workshop on the Collection Analysis Project at M.I.T. in November. She was Conference Chairman of the Council of Planning Librarians (CPL) 1979 annual meeting in Miami Beach in March, and served as President of the CPL.

William J. Duggan was a member of the Finance Committee of the New England Library Information Network (NELINET). David S. Ferriero served as coordinator for the Libraries for the M.I.T. United Way/Boston Black United Fund. He was a member of the OCLC, Inc. Advisory Committee on Interlibrary Loan. He was a member of the NELINET Committee on Interlibrary Communication, and chaired the Simmons College Library School Alumni Day Program. Mr. Ferriero chaired the New England Library Association College Libraries Section, and was Deputy Chair of the Association of College and Research Libraries (ACRL) National Conference Local Arrangements Committee.

Richard M. Fletcher was Independent Activities Period (I.A.P.) Coordinator for the Libraries. Steven Gass participated in M.I.T. Administrative Development Program (ADP) XIII. Ann M. Gilkerson gave a lecture, "H.H. Richardson's Woburn Library," at the Student Symposium of the Society of Architectural Historians at the Boston Architectural Center in March and at Rotch Library Visual Collections in April. Kristin W. Janghorbani served as a member of the Board of Trustees for the Burlington, Massachusetts, Public Library and was elected Vice Chairperson in April. She also was a member of the Massachusetts Library Trustees Association. Micheline E. Jedrey participated in ADP XII.

Irma Y. Johnson was a member of the Chapters Committee ACRL and was Deputy Chair of the Program Committee for their national conference. She was a member of the Board of Directors of the New England Chapter of ACRL. She was a voting delegate to the Governor's Conference on

Libraries and Information Science. Ms. Johnson's review of "Current Research on Scientific and Technical Information Transfer" appeared in *College & Research Libraries* in September. Her article "Dissemination of Research Results and a National Information Policy" also appeared in *College & Research Libraries* in January.

Robert L. Kehner was M.I.T. Community Service Fund Coordinator for the Libraries. He was a member of the NELINET Government Documents Task Force. Carolyn Kent participated in the Workshop on the Collection Analysis Project at M.I.T. in November. Anne Marie LaFreniere was a student monitor at the ACRL National Conference in Boston in November. Aleksander Leyfell was a Research Fellow at the Harvard University Russian Research Center. Leonore Linsky was Secretary of the BLC Programming Committee.

Eugene Liu taught a course on T'ai Chi during I.A.P. 1979. The course, which started at I.A.P. 1978, was later included in the curriculum of the M.I.T. Athletic Department, and Mr. Liu was invited to be the instructor there.

Jay K. Lucker was Treasurer of the M.I.T. Chapter of Phi Beta Kappa. He served as an M.I.T. Freshman Advisor and was a member of the M.I.T. Press Editorial Board and the M.I.T. Advisory Committee on the Writing Program. He served as a member of the Board of Directors of the BLC and of the New England Deposit Library. He was a member of the Brown University Library Committee, the Lehigh University Library Visiting Committee, and the Southeastern Massachusetts University Advisory Committee on University Library Communications Center. Mr. Lucker was a member of the Executive Committee and chaired the Personnel Committee of NELINET. He was a member of the Planning Committee on Subject Access of the Committee for the Coordination of National Bibliographic Control. He continued as chairman of the Association of Research Libraries (ARL) Interlibrary Loan Committee. He was a member of the ARL Board of Directors and of the ARL National Advisory Committee for the Academic Library Program. He was a member of the ALA Council, the Interlibrary Loan Committee, and the ACRL Committee on Standards and Accreditation. Mr. Lucker was a member of the Middle States Association of Colleges and Secondary Schools Commission on Higher Education accreditation team for Vassar College. He was a member of the Chemical Abstracts Service Advisory Board. He was a contributor to *American Reference Books Annual*, published by Libraries Unlimited, Inc., and his article "Library Resources and Bibliographic Control" appeared in *College & Research Libraries* in March. He also reviewed grant proposals for the National Endowment for the Humanities.

Karen Lynch gave a talk in May on M.I.T.'s Tech Show to the New England Gilbert and Sullivan Society. Barbara Mann participated in ADP XIII. Marlene Manoff taught a freshman writing seminar at Brandeis University. Sylvia A. McDowell was Coordinator of Black History Month Activities, M.I.T. She made a presentation on staff reserve units at the BLC Reserve Workshop in Wellesley in March.

Marilyn G. McSweeney participated in the Workshop on the Collection Analysis Project at M.I.T. in November. She was a member of the ACRL National Conference Local Arrangements Committee. Suanne W. Muehlner was a member of the M.I.T. Classification Review Committee. She was a member of the ALA Resources and Technical Services Division (RTSD) Reproduction of Library Materials Section Telefacsimile Committee. She was President of the Simmons College Library School Alumni Association and Vice President of the Simmons College Alumnae Association.

Judith I. Nathans was a member of the M.I.T. Working Group on Office/Clerical Issues Task Group on Career Development. Frances R.L. Needleman was a member of the ALA RTSD Computer Filing Committee. Susan K. Nutter participated in the Workshop on the Collection Analysis Project at M.I.T. in November. She served as Treasurer of the New England Section of the American Society for Information Science (ASIS). She presented a paper entitled "The Collection Analysis Project and Its Successful Application in the Libraries of the Massachusetts Institute of Technology" at the annual meeting of the American Society for Engineering Education in Baton Rouge in June. She received a Council on Library Resources Academic Library Management Internship for 1979-80 to be spent at the University of North Carolina.

Margaret A. Otto was a member of the Selection Committee for the M.I.T. Supervisory Development Program. She served on the ALA Library Administration and Management Association Library Organization and Management Section (LOMS) Executive Committee as Member-at-Large and on the committee to study the future role of LOMS. She was a member of the Board of Directors of the Universal Serials and Book Exchange.

Mary E. Pensyl participated with Susan Woodford in Richard Marcus's CONIT study (at the M.I.T. Laboratory for Information and Decision Systems) of how trained on-line searchers differ from beginners in developing search strategies. She gave a guest lecture with Ms. Woodford at Professor Colin McKirdy's class in automation at the Simmons College School of Library Science. She taught a six-week course with Ms. Woodford at Simmons in the fall and spring on on-line continuing education. She was a member of the Public Affairs Committee of the New England On-Line Users Group (NENON) and was a panelist at the spring NENON meeting. Ms. Pensyl continued as a member of the ALA Committee on the Evaluation of On-Line Services (Machine Assisted Reference Section on the Reference and Adult Services Division). She was awarded a Council on Library Resources Fellowship for 1979-80 to study the impact of user demands on the reference departments of academic and research libraries that have offered on-line bibliographic services for several years.

Kathleen A. Powers participated in ADP XII. She chaired the BLC Readers Services Committee. She was a member of the ACRL National Conference Local Arrangements Committee. Jutta R. Reed participated in the Workshop on the Collection Analysis Project at M.I.T. in November. She was Secretary of the BLC Selection/Acquisitions Committee. She was a member of the ALA Collection Development Committee. She served as co-facilitator for the Collection Analysis Project at Case Western Reserve University. She chaired the session on serials and presented a paper at the Fourth Annual Library Microform Conference in Washington, DC in October. She gave a talk entitled "Collection Analysis Project in the M.I.T. Libraries" at the ACRL 1978 National Conference in Boston in November. Ms. Reed spoke on collection analysis at the spring meeting of the New England Chapter of the Music Library Association (MLA) in April. She presented a paper on "Collection Analysis: An Economic Tool" at the annual meeting of the ACRL New England Chapter and New England College Librarians in Orono, Maine, in May. She spoke to the sales and marketing staff of University Microfilms International on subscription serials in microform in Boston in May.

Carole Schildhauer participated in ADP XI. She served as a consultant to Reidel Publishers to review their journal publication *Natural Resource Forum*. She edited the applied science and technology section of *Serials for Libraries*, a forthcoming book from Neil Schuman Publishers, Inc. She designed an assignment dealing with library instruction and prepared 17 reference guides for James Materazzo's Library Science class at Simmons College. Her paper "Bibliographic Instruction I: Development of an Instructional Program" was submitted to ERIC/IR.

Peter R. Scott served on the National Micrographics Association (NMA) Microfiche Standards Committee, on the NMA Conference of Fellows, and on the NMA Awards Committee. He chaired the NMA Microfiche Image Area Committee. Mr. Scott was a member of the American National Standards Institute Committee on Micrographics. He was honored by the New England Micrographics Association for local and national contributions to micrographics.

Patricia M. Sheehan was a member of the M.I.T. Ad Hoc Committee on Faculty and Staff Retirement Income and Related Benefits. She was organizer of a meeting of administration, faculty, and business representatives to explore the role of actuarial science in the M.I.T. curriculum. She served on the Governor's Conference on Libraries and Information Science as a member of the Core Committee, as delegate to the Wind-Up Conference in Worcester in March, and as Editor of the *Proceedings*. Ms. Sheehan was New England Representative at the ASIS Special Interest Group Public/Private Interface Committee on White House Conference. She was an invited speaker at the 1978 ASIS Annual Meeting in New York and at the 1979 Mid-Year Meeting in Banff Springs. She served as NELINET Liaison and was a member of the NELINET Technical Advisory Committee. She was a member of the BLC Serials Committee. She spoke at the Simmons College Program for Continuing Education Institute on Library Automated Circulation Systems in October.

Helen W. Slotkin was a member of the Archives of Science and Technology Committee of the Society of American Archivists (SAA). She presented a paper, "The Impact of the New Copyright Law on Archival Institutions," at the fall meeting of SAA. She was a member of the Joint Committee on Archives of Science and Technology. She chaired the Education Committee of the New England Archivists (NEA). She gave a presentation and chaired a session on archival education in New England at the spring meeting of NEA. In August, she presented a talk, "The Institutional and Legal Constraints of Servicing Manuscript Collections," at the Berkshire Conference on the History of Women. Ms. Slotkin gave lectures in a course on archives at the University of Massachusetts at Boston. She also presented a talk, "Ethics in Archives," at the May meeting of the New York Metropolitan Reference and Research Library Agency (METRO).

Provost

Merrill W. Smith was a member of the Exhibition Committee of the M.I.T. Department of Architecture. She represented the Rotch Libraries on the Massachusetts Committee for the Preservation of Architectural Records. Her weaving was exhibited in group shows in Dallas and Houston and in a one-person show at the Society for Designers/Craftsmen, Hereford, England.

Linda I. Solow was a Member-at-Large of the International Association of Music Libraries (IAML) US Branch Board of Directors and a member of the Nominating Committee. She chaired the MLA Publications Committee and Publications Council, and the MLA New England Chapter By-Laws Revision Committee and Nominating Committee. She received an IAML-US Branch travel grant to attend the meeting in Lisbon in July; her article "IAML Meets in Lisbon" was published in the September-October issue of the *Music Library Association Newsletter*. Her index to David Epstein's *Beyond Orpheus* was published by the M.I.T. Press in 1979.

Sandra Spurlock was co-author with Ellen Yen of "A Study of Life Sciences Book Use in the M.I.T. Science Library: Budgetary Implications" in *Quantitative Measurement and Dynamic Library Service*, published in 1978 by Oryx Press. With Ms. Yen she presented a paper, "Applications of an Operations Research Model to the Study of Book Use in an Academic Research Library," at the ACRL National Conference in Boston in November. David C. Van Hoy was a member of the BLC Ad Hoc Serials Committee and the standing Serials Committee. He also was a member of the ALA Gay Book Award Committee.

Susan Woodford participated with Mary Pensyl in the CONIT study. She was a member of the advisory group to the research project "Networks for Aiding Biomedical Information Transfer" with Richard Marcus. With Mary Pensyl she gave a guest lecture at Professor Colin McKirdy's class in automation at the Simmons School of Library Science. Also with Ms. Pensyl she taught a six-week course at Simmons in the fall and spring on on-line continuing education. She continued as Treasurer of the NENON Steering Committee.

Ellen Yen participated in the Workshop on the Collection Analysis Project at M.I.T. in November. She was a panel member at the ADP XII Information Panel Session. She was co-author with Sandra Spurlock of "A Study of Life Sciences Book Use in the M.I.T. Science Library: Budgetary Implications" in *Quantitative Measurement and Dynamic Library Service*, published in 1978 by Oryx Press. With Ms. Spurlock she presented a paper "Applications of an Operations Research Model to the Study of Book Use in Academic Research Library," at the ACRL National Conference in Boston in November. Clare E. Yerburch was a student monitor at the ACRL National Conference in Boston in November.

The following appointments to the Libraries staff were made this year: Stephen Cooper, Records Management Officer; Jaunette T. Eaglesfield, Lindgren Librarian; Bethany J. Easter, Assistant Barker Librarian; Steven Gass, Resource Sharing Center Librarian; Arlyne A. Jackson, Associate Dewey Librarian; Kristin K. Janghorbani, Assistant Barker Librarian; Deborah L. Kram, Exchange and Gifts Librarian; Karen T. Lynch, Archival/Manuscript Specialist; Roland G. Madany, Archival/Manuscript Specialist; Mary Jane McCavitt, Archival/Manuscript Specialist; Merrill W. Smith, Assistant Rotch Librarian for Visual Collections; and Nancy R. Whitman, Mining and Mineral Resources Librarian.

Promotions this year included: Clementine I. Coblyn, Circulation Librarian; Marlene Manoff, Assistant Humanities Librarian; and Ellen Y. Yen, Assistant Science Librarian.

William Presson, Associate Dewey Librarian, retired from the staff this year. Resignations this year included: Christine L. Baldwin, Assistant Science Librarian; Florence J. Doksansky, Assistant Rotch Librarian; Fae K. Hamilton, Head, OCLC/LC Cataloguing Section; Hedy Mattson, Cataloguer; Margaret A. Otto, Associate Director; Nancy C. Schrock, Assistant Rotch Librarian for Visual Collections; Sandra E. Spurlock, Assistant Science Librarian; and Astrid H. Steele, Exchange and Gifts Librarian.

GIFTS

The Libraries received a substantial number of gifts of materials and money for the support of its activities. A complete list of individual donors is included as Appendix I in the archival copy of this report. Among the major gifts received during the year were a large collection of *Frost and Sullivan Reports* from Stanley Klein; the *Encyclopedia of World Art* from Henry W. Fitzpatrick; Jacob P. Hartog's M.I.T office collection including valuable monographs in applied mechanics; four early 19th-century American imprints including *The Western Tourist and Emmigrants Guide* from James S. Offutt; and a 24-volume set *Galeries Historiques de Versailles, 1838-1845* from the Massachusetts State Library. Among the major donations of manuscripts were papers of Robley D. Evans, Harold E. Edgerton, William R. Ware, Morris Halle, Martin Buerger, William W. Seifert, Arthur Ippen, Carroll L. Wilson, Carl R. Soderberg, and William Shurcliff. Among the additions to the archival collections were the Karl T. Compton and James R. Killian presidential files, the first accession of Jerome B. Wiesner's presidential papers, and a portion of the papers of Walter A. Rosenblith as Provost. A most unusual and extremely useful gift was two Kardveyors -- equipment to be used for the storage of microfiche -- from the Charlestown Savings Bank. Among the major additions to the Historical Collections were parts of the Whirlwind Computer donated by the Digital Equipment Corporation.

HISTORICAL COLLECTIONS

The collections of photographs, drawings, instruments, models and the like that comprise Historical Collections continue to grow. Considerable progress was made in the cataloguing of a number of these, especially the architectural drawings, supported in part by a grant from the National Historical Publications and Records Commission (NHPRC). Also catalogued were the instruments collection, and the Charles Stark Draper Laboratory Historical Collections.

The staff was responsible for a dozen exhibitions including ones on the 75th anniversary of the Laboratory of Physical Chemistry; the Rogers Building; the 50th anniversary of the Department of Meteorology; Blacks at M.I.T.; the Einstein Centennial; 111 Years of M.I.T. Diplomas; the 50th anniversary meeting of the Acoustical Society of America; the M.I.T.-Wellesley Exchange Program; and John E. Burchard, former dean of the School of Humanities and Social Science, in connection with the dedication of a memorial plaque in the passageway between Buildings 2 and 14.

Five seminars were held at Historical Collections on the general subject of conservation with support of funding from the Council for the Arts at M.I.T. The success of this program has led to plans for another series in the next academic year.

One of the principal means by which the Institute maintains close ties with its alumni is through Historical Collections and the Institute Archives. These two departments of the Libraries are the recipients of numerous gifts from alumni and alumnae and, in turn, provide a wide range of services to these groups. Of 52 individuals who donated materials to Historical Collections this past year, 33 were alumni; the Institute Archives received gifts from alumni of personal papers, student notebooks, and the records of the Class of 1897, the M.I.T. Club of New York, and the Alumni Club of Washington, DC. The archives of the Alumni Association covering the period 1870-1971 were formally transferred to the Libraries as well. Historical Collections hosted a number of functions of alumni groups including meetings of the Classes of 1934, 1944, 1959, 1964, and 1969; the Alumni Association President's Planning Board; and the Association of M.I.T. Alumnae.

Finally, the Libraries through Historical Collections and the Institute Archives, provide a range of informational activities, including, for example, material used in a film on the history of the Class of 1923, and responses to inquiries for biographical information, the preparation of obituary notices, copies of theses and reports, and any type of data on the Institute, its staff, its history, its buildings, and its programs.

This report has attempted to cover some of the major activities and concerns of the M.I.T. Libraries during the past year. For those who may wish more detailed information on any of the areas included, copies of the reports of each of the departments are in the office of the Director of Libraries.

JAY K. LUCKER

Lowell Institute School

The Lowell Institute School (L.I.S.) was established at the Massachusetts Institute of Technology in 1903 to provide evening instruction in technical subjects for residents of the Boston area. Today the School continues this tradition by offering subjects in the areas of modern technology which are not readily available at other evening institutions. The general level of instruction is geared to the practicing technician who has an Associate's degree or equivalent experience.

The programs of study range from single subjects designed to broaden an individual's skill level in his or her present job to comprehensive study of new technological areas which will prepare a technician for employment in a new field. There is a strong emphasis on practical aspects of a field and development of careful experimental technique combined with sufficient theory to provide an adequate foundation of understanding. Certificates are awarded to those who satisfactorily complete a course. In addition, special certificates are awarded to students who complete a program of courses in the fields of Drafting Technology and Electronics Technology.

During 1978-79, L.I.S. continued to offer the following courses: Mechanical Drafting, Technical Illustration, Oral Communication, Creative Photography, High Speed Photography, Basic and Advanced Scientific Glassblowing, Principles of Metal Joining, Machine Tool Fundamentals, Television, Principles of Video Tape Recording, Applied Mathematics, Introduction to Electronics, Semiconductor Devices, Op-Amp Applications, Electronic System Design, Introduction to Digital Electronics, Advanced Digital Electronics, Introduction to Microprocessors, and Dimensioning and Tolerancing Techniques. In addition, the following new courses were offered: Printed Circuit Board Design, Electrical/Electronic Drafting, Welding Fabrication and Testing, Introduction to Numerical Control, Mathematics for Drafting and Machine Shop, Advanced Applied Mathematics, Electronics and Instrumentation, and Fundamentals of Quality Control/Assurance.

L.I.S. continued to offer intensive courses for individuals working in industry in cooperation with the Boston section of the Institute of Electrical and Electronics Engineers. In this cooperative program, an intensive one-week daytime course in microprocessors was offered, and a course in power electronics was conducted on 10 consecutive Tuesday evenings.

For the second successive year, in cooperation with the Departments of Mechanical Engineering and Materials Science and Engineering, L.I.S. organized and conducted a 12-week training program in the field of machine tools under the Comprehensive Employment and Training Act (C.E.T.A.). This Federally funded program is designed to teach employment skills to disadvantaged and hard-core unemployed persons. This past year's program was offered solely for residents of Cambridge. The L.I.S. curriculum included not only intensive training on metal cutting machines but also instruction in shop math, blueprint reading, and welding in order to maximize the students' future employability. All students who successfully completed this program during the summer of 1978 gained employment as machinists or as machinist-trainees.

L.I.S. admitted a total of 1,002 students to its courses this year, 880 to the evening classes and 122 to the intensive courses. This represents a 28 percent increase in total enrollment over the 1977-78 figure of 780. Of those who enrolled, 75 percent successfully completed the certificate requirements. Among those who completed courses were 23 M.I.T. employees and three regular M.I.T. students. Two students received the first special certificates in Drafting Technology awarded by L.I.S., and eight students received special certificates in Electronics Technology. In order to qualify for these special certificates, a student must complete a specific number of courses in the respective fields.

Enrollment at L.I.S. has increased for the sixth straight year, and the high percentage of students who successfully complete their courses indicates that both the subjects offered and the level of instruction are well matched to their needs.

BRUCE D. WEDLOCK

Neurosciences Research Program

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

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

To carry out these activities, some 36 scientists, leaders in major neuroscientific disciplines, are elected to serve as N.R.P. Associates to provide advice and guidance to a small professional staff at the N.R.P. Center in Boston. The N.R.P. is housed in a building with the American Academy of Arts and Sciences. N.R.P. also enlists participation in its activities by scientists from the neuroscientific community at large; over 1,500 scientists have served as invited consultants.

The following Work Sessions and/or Conferences (chairpersons shown in parentheses) were held during the academic year 1978-79:

"The Role of Peptides and Behavior" (J.B. Liebeskind and R.K. Dismukes); "Prospects for Research in Neurogenetics" (S. Benzer, R.L. Sidman, and J. Hall); "Non-Adrenergic, Non-Cholinergic Autonomic Neurotransmission Mechanisms" (G. Burnstock and T. Hökfelt); "Dynamics of Brain Cell Microenvironment" (C. Nicholson); "The Role of Fast Transport in the Nervous System" (H. Thoenen and G.W. Kreutzberg).

A five-day meeting entitled "Cerebral Cortex Colloquium" was held at the Woods Hole Marine Biological Laboratory in May 1979. Thirty scientists participated in an intensive examination of the current state of research on the functional organization of the cerebral cortex. There were six major sections:

- 1) The role of cerebral cortex in higher brain function, chaired by H. H. Jasper and B. A. Milner;
- 2) Organization and connections of the neocortex, chaired by A.M. Graybiel;
- 3) Functional micro-organization in the cerebral cortex, chaired by W.M. Cowan;
- 4) Development, plasticity, and evolution of neocortex, chaired by P. Rakic;
- 5) Chemical signaling and circuitry in cerebral cortex and its interconnections, chaired by F.E. Bloom; and
- 6) Impact of theoretical constructs and modeling of cortical function, chaired by G.M. Edelman.

The 36th Stated Meeting of N.R.P. Associates, held October 15-18, 1978, included inaugural addresses given by newly elected Associates, Drs. Ann M. Graybiel (Department of Psychology, M.I.T.), Richard M. Held (Psychology, M.I.T.), J.J. Hopfield (Biophysics, Princeton), and H. Thoenen (Biochemistry, Max Planck Institute).

The 37th Stated Meeting of N.R.P. Associates, held March 19-21, 1979, included two valedictory addresses by N.R.P. Associates who were finishing their term of active membership and transferring to the status of Honorary N.R.P. Associates. The address by Manfred Eigen was entitled "T-RNA: A Primordial Gene?" Dr. Werner E. Reichardt's address concerned the research approach to the sensory processing of information, the development of abstractions by selective destruction of this sensory information, and the generation of an output by the organism.

The scientific program of the Stated Meeting also included lectures by L.N. Cooper on theoretical approaches to the acquisition and storage of memory; R.L. Llinás on distributed properties of the central nervous system; and by A. Pellionisz on the application of tensorial modeling and computer simulation.

Provost

In the executive session, the following were elected N.R.P. Associates: T. Poggio (Max Planck Institute, Tubingen), C.F. Stevens (Physiology, Yale University), and E.M. Shooter (Neurobiology, Stanford University).

The F.O. Schmitt Medal and Lectureship

A feature of the spring Stated Meeting of N.R.P. Associates was the Sixth F.O. Schmitt Lecture in Neuroscience given on March 21, 1979, in the Little Theater, Kresge Auditorium at M.I.T. The 1979 medalist, Dr. Stephen W. Kuffler, Department of Neurobiology, Harvard Medical School, gave an address entitled "Synaptic Transmission: In Search of Models."

During the academic year the following *NRP Bulletins* were published: Schmitt Lecture in Neuroscience, 1977, *The Brain as an Endocrine Organ*, R. Guillemin (Supplement); *Gap Junctions, Electrotonic Coupling and Intercellular Communications*, M.V.L. Bennett and D.A. Goodenough; *Peptides and Behavior: A Critical Analysis of Research Strategies*, J.C. Liebeskind et al.; *Neuron-Glia Interactions*, S.S. Varon and G.G. Somjen; *Specificity and Plasticity of Retinotectal Connections*, M.V. Edds, Jr., R.M. Gaze, G.E. Schneider, and L.N. Irwin; *Non-Adrenergic, Non-Cholinergic Autonomic Neurotransmission Mechanisms*, G. Burnstock et al.

The Neurosciences: Fourth Intensive Study Program, F.O. Schmitt and F.G. Worden, eds. was published in June 1979.

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

FREDERIC G. WORDEN

Northeast Radio Observatory Corporation Haystack Observatory

M.I.T. is a leading member of NEROC, a consortium of 13 institutions* formed in 1967 to promote radio and radar astronomy research and facilities in the northeastern United States. NEROC receives financial support for its principal facility, M.I.T.'s Haystack Observatory, from the National Science Foundation and project support from NSF, the National Aeronautics and Space Administration (NASA), and the other Federal agencies, and it uses the administrative services of M.I.T. in the conduct of its business. Observing proposals submitted by prospective users are considered by a review committee, on the basis of scientific merit and suitability for the available instrumentation.

The main instrument at the Observatory, located at Westford, Massachusetts, is a 120-foot diameter paraboloidal antenna enclosed in a radome. It is heavily used by the astronomy community as a radio telescope with radiometers in the 18-, 3.8-, 3-, 2-, 1.35-, and 0.7-cm regions. The Haystack telescope constitutes an important astronomical resource, particularly in the wavelength region 1.5-0.7 cm, which lies between the shortest wavelengths covered by most of the larger telescopes and the longest wavelengths at which the smaller, true millimeter-wave instruments are most profitably used. At 0.7 cm, the telescope has a beamwidth smaller than the 1-arc-minute resolution of the human eye.

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

In the past year, five candidates were awarded the Ph.D. for research conducted mainly at Haystack. Twenty-five other students are involved in research at the Observatory. The 1978 bibliography lists 35 refereed radio astronomy articles, of which 24 reported work in the 1.5-0.7 cm wavelength region. Ten such articles were published in the first quarter of 1979.

Very long baseline interferometer (VLBI) research and development continued as a leading in-house activity at Haystack. The VLBI technique involves simultaneous observations of the same object with widely separated radio telescopes; records of these observations are subsequently brought together in a correlation processor to yield interferometric fringes. For astrometry and studies of complex source structure, VLBI provides resolution of an order available by few if any other means. With support from NASA, better methods are being developed for applying VLBI techniques to precise geodetic as well as astronomical measurements. Under this program a new data acquisition and processing system called Mark III has been developed to provide a five-fold increase in sensitivity over past systems. Final hardware is now being built for Haystack and several other observatories collaborating in this work.

During a recent Mark III test using Haystack and the 140-foot telescope of the National Radio Astronomy Observatory in Green Bank, West Virginia, only two minutes of data were sufficient to resolve the "apparent binary" quasar 1038+522 into a main component 400 millijanskys in strength and a 100 mJy companion 33.5 ± 0.1 arcsec to the northeast.

Single-antenna programs by visiting scientists tend to emphasize high-resolution spectral-line studies using the shorter wavelength receivers and the 1,000-channel digital correlation spectrometer. Interesting examples of this included observations of the $V=3, J=1 \rightarrow 0$ line in SiO maser sources at 42.5 GHz¹ and the detection of the $J_{K-K_4}=3_{12} \rightarrow 3_{13}$ doublet line of formaldehyde (H_2CO) at 29 GHz², using a new receiver built at M.I.T.

Some of the observing time (see attached table) is scheduled for radar observations of satellites, under the sponsorship of M.I.T. Lincoln Laboratory.

The telescope pointing, already excellent for a large instrument, has been further improved through the installation of state-of-the-art position angle encoders to replace the original units installed in 1963. Additionally, an improved cryogenic maser receiver for 20-26 GHz was completed and installed in July 1978. A new system for the 5-GHz (6-cm) region is under construction, as is an improved receiver for 42-44 GHz (0.7 cm). Such developments must continue if the excellent qualities of the telescope are to be fully exploited.

PAUL B. SEBRING

¹ Reported by L.E. Snyder, University of Illinois

² Reported by P.C. Myers, M.I.T.

TELESCOPE UTILIZATION

1978

<u>INSTITUTION OR ACTIVITY</u>	<u>TIME, HOURS</u>
*Boston University	60
*Center for Astrophysics (Harvard)	1,848
Cornell University	55
Herzberg Institute of Astrophysics	126
*Massachusetts Institute of Technology	1,594
*State University of New York (Stony Brook)	102
Tufts University	134
University of Illinois	300
University of Maryland	48
*University of Massachusetts	1,161
University of New Mexico	7
Wellesley College	42
Williams College	75
 TOTAL SINGLE ANTENNA	 <u>5,552</u>
Very Long Baseline Interferometry (VLBI)	<u>1,325</u>
 TOTAL ASTRONOMY OBSERVING	 <u>6,877</u>
Lincoln Laboratory (Radar Operations)	644
Helium Fills; Experiment Setups	222
Maintenance; Box Changes	512
Pointing Checks; Engineering Time	484
Antenna Idle	21
 TOTAL	 <u>8,760</u>

Hours for individual institutions do not include any VLBI projects in which they may have been involved.

Institutions listed are those of the principal investigators. It would be cumbersome to list those of all co-investigators. Also, so many investigators and institutions are typically involved in VLBI experiments that no listing is attempted here.

Office of Minority Education

The past year has seen substantial changes in personnel in O.M.E. Professor Wesley L. Harris, who served as director since the Office was founded in 1975, resigned from that post in February. He is currently on leave from the Institute, working for the National Aeronautics and Space Administration in Washington, DC. Professor Arthur C. Smith has served as acting director since February 1979. In addition, Nelson Armstrong has served as acting assistant director from February to July 1979. Lisa Egbuonu has been assistant to the director since February and will continue through August 1979.

An increase in the staff of O.M.E. to include a full-time assistant director was authorized in 1978 and a search was carried out during the past year. Over 100 resumes were received and reviewed by the O.M.E. staff and a student search committee, chaired by Gwendolyn Wise and consisting of Ronald Adolph, Sylvia Barrett, Rocklyn Clarke, Dera Gray, Alan Letton, Jay Lynch, John Miller, Gene Norman, and Iranice Reddix. Pearlina Davidson was selected for this position and will assume her duties on July 1, 1979.

* NEROC Institutions

Advisory Structure

A committee to advise the Associate Provost in the selection of a permanent director has been appointed by Professor Hartley Rogers to be chaired by Professor Smith and consisting of Mr. Adolph, Ms. Gray, Dean Mary O. Hope, Professor Arthur P. Mattuck, David Venecia, Jr., Dr. Clarence G. Williams, and Professor James E. Young.

O.M.E. has continued to receive the counsel of the Faculty-Staff-Student Advisory Group as reported last year. The Office provides a center of activity and informal support for students. It is capably staffed by Gloria Payne, administrative assistant, Ligia Domingo, secretary, and several student staff members.

Project Interphase

Project Interphase continues to fill an important role in providing academic preparation and orientation for a select group of entering minority first-year students. The program has seen a substantial increase in the number of students, from 33 in 1977, 41 in 1978, to 51 in 1979. Professor Alan Davison served as academic director of Interphase in 1979, continuing several years of participation in the program.

The basic structure of the program remains unchanged from past years, focusing on rigorous academic preparation in chemistry, humanities, mathematics, and physics together with opportunities to explore other areas, such as computer programming. A formal introduction to the resources of the Institute and general academic skills also is provided. Group athletic and social activities are planned for students and staff. Tutors for the program live in the dormitory with the students and are thus able to provide effective assistance and support.

Black Student Union Tutorial Program

The Black Student Union Tutorial Program has continued to provide tutorial assistance to undergraduates. The tutors are graduate students and upperclass undergraduates whose services are coordinated by student coordinators and program secretaries. In 1978-79, the program provided over 4,500 hours of tutoring in more than 50 subjects. Guy M. Emanuel was the coordinator. The program also operated the Freshman Buddy System in which an upperclass student contacts several assigned first-year students weekly to offer friendly support and give guidance in the use of Institute services.

Freshman Watch

Freshman Watch is an academic counseling program operated by O.M.E. with the cooperation of the faculty and staff teaching science requirement subjects. Information is supplied to O.M.E. at mid-term regarding performance of minority students in these subjects. Students who are having difficulty are asked to come to the Office for counseling and tutorial assistance. This program supplements the activities of the freshman advisor, and communication with each advisor is maintained.

Second Summer Program

The Second Summer Program is a new activity of O.M.E. Intended for students after their first year, the program consists of eight weeks of industrial experience at cooperating companies followed by a four-week academic program on campus. The goal of the program is to strengthen both motivation and preparation for students entering engineering departments in their second year. In the summer of 1979, 10 students will take part in the program as paid employees at E.I. duPont de Nemours & Company (Wilmington, Delaware), Goodyear Tire & Rubber Company (Akron, Ohio) and Monsanto Company (Everett, Massachusetts). They will return to M.I.T. in August for a program including mathematics, engineering science, and academic skills and planning.

Tutored Videotaped Instruction

Tutored Videotaped Instruction continued during 1978-79 covering the subjects 5.41 Introduction to Structure, Bonding and Mechanism in fall 1978 and Physics II 8.02 in spring 1979. We have experienced several terms of this program, and a review of its effectiveness will be carried out in the coming year.

Other Activities

O.M.E. cosponsored events for minority students during Residence/Orientation Week 1978 with the Black Student Union. During I.A.P., O.M.E. presented a set of preview lectures on 8.02, a seminar on preparing for the Medical College Admission Test, and a seminar on problem solving.

O.M.E. sponsored student delegates to the national conventions of the National Society of Black Engineers, and the National Medical Association. O.M.E. is helping to defray costs of a film about minority students at M.I.T.; it is being produced by the student chapter of NSBE and the Black Student Union. The Office also is assisting a group of Hispanic students in forming a student chapter of the Society of Professional Hispanic Engineers.

Awards and Gifts

O.M.E. selected Carolyn Towler to receive the Monsanto Achievement Award as the third-year engineering student with the best academic record. The award consists of a plaque and a \$500 award given by Monsanto Company to promote academic excellence among minority engineering students at M.I.T.

O.M.E. received the 1979 Irwin Sizer Award from the Graduate Student Council for the "most significant improvement to M.I.T. education." O.M.E. received gifts of \$10,000 from E.I. duPont de Nemours & Company and \$5,000 from Bethlehem Steel Company to further the activities of the Office in increasing the number of minority engineering graduates of the Institute.

ARTHUR C. SMITH

Operations Research Center

The Operations Research Center conducts interdepartmental academic and research programs in the field of operations research. The academic staff of the Center is drawn from many departments, including Electrical Engineering and Computer Science, Urban Studies and Planning, Aeronautics and Astronautics, Civil Engineering, Mathematics, Physics, and the Sloan School of Management. At present, approximately 18 students are in the operations research doctoral program and a comparable number are in the master's program. Most of them come to M.I.T. specifically to study operations research and are admitted directly by the Center, although some learn about the graduate operations research program by attending seminars or subjects.

During the past year, the academic staff of the Center was engaged in an expanded range of basic and applied research sponsored directly by the Center and, in part, by other laboratories at M.I.T. Basic research was carried out in the areas of mathematical programming, optimization, and statistics. Applied research projects included those in energy systems, transportation and communication networks, traffic systems, urban systems, operations management, public program evaluation, and criminal justice systems.

Basic research continued into experimental and theoretical methods for mixed integer programming. Lagrangean duality and group theoretic methods were integrated to produce a new theory of shadow prices for integer programming. Related inverse optimization techniques produced new

results and solution methods for a class of capacitated facilities location problems with parameterized demand constraints. In addition, experiments were performed on network synthesis and covering problems using a large-scale, interactive mixed integer programming code developed at the Center. Experiments also were performed on aggregation methods for large-scale facilities location and production planning problems.

Other research in mathematical programming included work on traffic equilibrium problems, multi-objective mathematical programming, the traveling salesman problem, linear fractional programming, nondifferentiable optimization and decomposition methods. Additional basic research was performed in the areas of stochastic optimal control, dynamic programming, reliability theory, and techniques for nonlinear least-squares estimation and robust regression.

Center faculty and students were engaged in a number of projects where operations research models and methods were used to study energy policy questions. Mathematical programming decomposition methods were used to integrate coal supply and distribution models with electric utility capacity expansion and operating models. The integration can be effected by either price or resource directive methods that have meaningful economic interpretations. The integration of a coal supply model with a US energy sector model was effected by similar approaches that address issues of resource depletion and fuel competition. The last integration was used to study US coal supply for the period 1980-2000. An interesting by-product of the analysis is a derived demand curve for coal by the energy sector. Further research using stochastic programming was done to measure the effect of uncertainty in electricity end-use demands on the derived demand for coal and related utility expansion decisions. As a result of this work in energy planning, the Center has organized a new one-week summer course, entitled "Energy Planning Models."

Several research projects were directed at the analysis of transportation and communication networks. Work was completed on a new algorithm for the traffic equilibrium problem. The algorithm has been fully implemented and tested on a number of established test problems. New heuristics for analyzing network design problems were developed and their worst case performance determined. A separate project addressed related issues of locating new passenger facilities on a transportation network with stochastic travel times. Work continued on the network analysis of rail freight management problems. Center faculty also were involved in a project to develop algorithms for routing data in communication networks at the Laboratory for Information and Decision Systems.

A related new traffic systems project used mathematical programming and network techniques to extend a theory of optimal signal timing for arterial signal systems. One result was a class of new models for signal control. A matrix generator for these models was implemented to construct mixed integer programming problems for real-time operation. The implemented system is being tested using data from site locations in Cambridge and Washington, DC.

Modeling and analysis of urban vehicular services continued during the past year in the areas of location and network theory, the optimal dispatch of emergency vehicles, and real-time allocation of emergency vehicles. The median problem was generalized and analyzed to include queueing-like congestion of facilities, each of which is assumed to have a finite number of servers. Related research was directed at the case in which facilities can be moved, at a cost, on the network in response to changes in the network. Research was completed on methods to find rectilinear distance paths in networks with barriers.

Several members of the Center staff were involved in the application of operations research to the management of industrial operations. An interactive logistics planning system was designed and implemented that permits the easy generation and automatic optimization of mixed integer programming models. A novel feature of the system is a modeling language that allows the decision maker to describe his or her decision problem in natural terms and relate the problem to the appropriate data bases. Related continuing research was directed at the design of hierarchical planning systems for multilevel logistics decisions and the implementation of a computer-based operations management system. Research also was performed on operational problems arising in a production context including the scheduling of production for a family of products produced on a single facility using traveling salesman type models, safety stock determination for these products, and the development of a methodology for complex systems to analyze trade-offs among component reliability, inventory, and repair capacity.

Two projects are continuing in the area of criminal justice research. Much of the empirical work required for the study of public program evaluations was completed. Specifically, a sample of 200 criminal justice program evaluations is being statistically analyzed. Bayesian and other decision-theoretic approaches are being taken to model the evaluation process. The goal of the project is to develop procedures for achieving more adaptive and comprehensive program evaluations. Criminal justice research also continued into the development of improved statistical methods for analyzing the implications of crime statistics, both with respect to the magnitude of the problem and to the effects of public policy decisions related to crime. For example, a statistical study using data from 33 states was made to see if executions can deter murders. The results lean slightly but not unambiguously toward the view that capital sanctions can cause reductions in homicide rates.

Support for the Center's research during the past year has come from the National Science Foundation, the Law Enforcement Assistance Administration (US Department of Justice), the US Department of Transportation, the US Office of Naval Research, the US Army Research Office, and the Center for Energy Policy Research at M.I.T.

RICHARD C. LARSON
JEREMY F. SHAPIRO

R.O.T.C. Programs

Enrollments in the Reserve Officer Training Corps (R.O.T.C.) programs continue to grow at M.I.T. In 1978-79, 385 M.I.T. students were enrolled in the three R.O.T.C. detachments. Of these students, 319 receive R.O.T.C. scholarships. An additional 86 students from Harvard University, Northeastern University, Tufts University, and Wellesley College who receive instruction from M.I.T. Army and Air Force instructional staffs were included administratively in the two units.

The R.O.T.C. Faculty Advisory Committee has found that each of the three units gained numerical strength over the recent past. The enrollments in R.O.T.C. remain strong and the reputation of the units on campus is positive.

The curriculum for each of the three units is determined by each military service. Although no academic credit toward the M.I.T. diploma is granted for any of the service undergraduate subjects, those subjects do appear on the students' academic transcripts. Many subjects in the regular M.I.T. curriculum are either required or strongly recommended by each of the detachments.

During this year the Committee reviewed candidates for various positions within the units and was pleased to recommend the appointment of Colonel Adrian V. Polk to be the incoming commander of the Air Force R.O.T.C. unit. Colonel Polk replaced Colonel William R. Trott at the conclusion of the academic year in June 1979; Colonel Trott will be retiring from the Air Force in July 1979. Careful review of all officer assignments to M.I.T. furthers the role the Committee plays in guaranteeing that officer assignments are appropriate for this institution. Recent discussions between the former chairman of the Committee, Professor Harvey Sapolsky, and the Navy have been helpful in each institution understanding the needs of the other where personnel assignments are concerned. These discussions are similar to those in earlier years held with the Air Force.

In recent years the Army and the Air Force have, with Institute approval, allowed cross enrollments from Harvard, Tufts, and Wellesley. By special arrangement Air Force R.O.T.C. officers provide training to students at Northeastern University. By Navy policy and by Institute policy, there have been no cross enrollments in the Navy unit. The Committee reviewed the current cross enrollment picture, and recommended that cross enrollment in the Navy unit from Harvard and Wellesley be allowed starting in September 1980. That proposal will be reviewed by officials of the Institute.

Sea Grant Program

In April 1979, Provost Walter A. Rosenblith appointed Professor Frank E. Perkins to be the new chairman of the Advisory Committee. Professor Perkins is Head of the Department of Civil Engineering and has long had an interest in R.O.T.C. matters. Professor Sapolsky resigned as the chairman of the Committee because of the press of research commitments. He served as chairman from 1975 to 1979.

The members of the R.O.T.C. Advisory Committee are: Professors James M. Austin, Robert M. Hollister, Ralph Katz, Judith T. Kildow, Frank E. Perkins (chairman), David K. Roylance, Ralph H. Staley, John H. Sweeney III, and Mr. Daniel T. Langdale (Admissions Office), and Dr. Louis Menand III. Routinely, the heads of the three services meet with the Committee.

LOUIS MENAND III

Sea Grant Program

The academic year 1978-79 marked the Sea Grant Program's ninth year at the Institute. From its initiation as a small coherent project, the Program has expanded and evolved as an Institute focal point for marine research and study. Each new grant from the Office of Sea Grant of the National Oceanic and Atmospheric Administration (NOAA) in the US Department of Commerce has allowed Sea Grant to draw upon a wider range of Institute departments and a greater number of faculty and students. With the designation of M.I.T. as a Sea Grant College in 1976, NOAA recognized the Institute's important contributions and achievements in the marine field, and the Program emerged more fully committed to utilizing the extraordinary human resources of the Institute in meeting the challenge of developing the rich potential of the nation's marine resources.

During this past year, to support the Sea Grant's research, advisory, and education projects, NOAA awarded M.I.T. \$1.3 million. Matching funds came from the Institute, the Henry L. and Grace Doherty Charitable Foundation, the Commonwealth of Massachusetts, the University of Massachusetts, the Massachusetts Maritime Academy, and marine industries. The diversity of these funding sources points to one of Sea Grant's greatest strengths: the partnership of many groups in finding new technologies and ways to use the seas with concern for both present and future generations.

Dean A. Horn, Director of the M.I.T. Sea Grant College Program, maintains close ties with the Institute faculty as a senior lecturer in the Department of Ocean Engineering. He and the Director of Research, Professor Jerome J. Connor, Jr., of the Department of Civil Engineering, have received the valuable counsel of the M.I.T. Sea Grant Policy Committee and the Sea Grant Faculty Council in establishing coherent, thematic guidelines for matching the interests and strengths of the Institute with the identified needs of the marine community. Both advisory groups, chaired by Professor Emeritus Alfred A.H. Keil, founder of the M.I.T. Sea Grant Program, have continuously sought to synthesize marine research with the education of M.I.T. students, the future scientists, engineers, and teachers upon whom the nation will depend.

Ernst R. Pariser, as Associate Director for Education and Training Coordination, continued to guide the development and direction of an expanded educational effort. Management of Advisory Services was handled by Mr. Horn with the aid of Norman A. Doelling, Arthur B. Clifton, and Elizabeth T. Harding. A group of citizens from government, industry, and private life advised Sea Grant of community concerns through the Sea Grant State Industry Advisory Council, chaired this year by Mrs. Jephtha Wade, a new member of the M.I.T. Corporation. Sea Grant's daily operations were managed by Administrative Officer Lawrence W. McKinnon.

ADVISORY SERVICES

Sea Grant's advisory services make it unique among government-sponsored marine research programs. Close ties with the community help the Program recognize those problems that require

attention and enable Sea Grant to transmit and translate results for direct application to the nation's development of its marine resources.

At M.I.T. -- because the constituent groups are diverse and range from large industries and government agencies to small businesses, local governments, and coastal residents -- the Program has established a multifaceted advisory service staff. To foster the special partnership that the M.I.T. faculty has always had with national and international industry and with the Federal government, the Marine Industry Advisory Service (MIDAS) was created in 1975.

A critical review completed this year by Mr. Doelling, the project manager, will serve as a blueprint for setting objectives and assessing accomplishments in the coming years. Each year, significant economic opportunities based on current marine research are identified and analyzed in four concise, well-documented briefs. Sent in advance to over 90 members of the MIDAS Collegium, the briefs attract business and government representatives to workshops to confer with academic researchers on the potential applications of the results. In addition, the meetings elicit new ideas and feedback on unsolved industrial problems and prospects.

The subject of the first meeting, "Teleoperators Under the Sea," had been cited several years ago as technology of special interest to the offshore industry. In response, Sea Grant expanded its support in this area. Two other workshops addressed aspects of design, construction, and maintenance of offshore structures: "Toward Improved Techniques for Predicting Soil Strength in the Offshore Environment," and "Risks and Costs for Offshore Structures." Harnessing the ocean's tremendous energy to replace diminishing and uncertain supplies of oil and gas is a topic of growing interest to both government and industry. In a Collegium meeting, "Wave Power Systems," M.I.T. researchers assessed the economics and engineering potential of two promising devices, the Salter cam and the Cockerell raft.

In 1976, when M.I.T. became a Sea Grant college, the Institute established close ties with the University of Massachusetts Cooperative Extension Service to monitor the needs of residents and businesses in the cities and towns of coastal Massachusetts. Under the direction of Mr. Clifton, the Marine Liaison Service Manager, specialists provide technical assistance and disseminate Sea Grant research results to the citizens of the Commonwealth. During this past year, Sea Grant's coastal engineer monitored the installation and performance of an erosion control technique, using sand-filled plastic bags to trap sand and raise the level of a beach. His observations are being published, pinpointing the conditions under which the technique can and cannot work. Three other specialists in coastal affairs cooperated with M.I.T. researchers as "friends of the project," acting as liaisons between Sea Grant researchers and the user groups in the community.

With the passage of the 200-mile offshore fishing limit, the potential of the Massachusetts fishing industry was greatly enhanced. M.I.T. Sea Grant researchers and advisory services have helped through the development of fishing gear that is safer and more economical to operate. In the past year, final tests have been run on a new trawl door, the equipment that keeps the net open as it is towed over the fishing grounds on the ocean bottom. A license for manufacturing the gear was granted to a Boston company that had made significant contributions to the design through fabrication of test models.

The advisory services act as a vital link for the transfer of technology from laboratory to the marine community. Working person-to-person, through Sea Grant's sponsored seminars, or in cooperative projects with Federal, state, and local government officials, the advisory service staff disseminates information and research results on subjects ranging from the economic modeling of a deep-sea mining operation to the biological and chemical factors causing the toxic algal blooms in coastal waters.

In 1978, the Communications-Information staff, managed by Ms. Harding, published 22 reports to transmit the fruits of Sea Grant research to user groups. Over 11,000 copies of these publications reached audiences throughout the world. Beginning in September of 1978, Barbara Steen-Elton assumed responsibility as the Program's Information Specialist and streamlined the Marine Resource Information Center's collection of Sea Grant publications, journals, reference books, and marine subject files.

EDUCATION

M.I.T.'s educational philosophy rests on the premise that the most effective method for teaching science and engineering is to involve students in research. Therefore, students work side by side with faculty researchers in all Sea Grant projects. Both graduate and undergraduate students are learning skills and gaining insights that will help them develop better methods for farming the seas, transporting materials, and extracting new raw materials and energy from the ocean.

The ongoing development of a strong ocean-oriented curriculum has been an important focus for Sea Grant support. New courses added each year to the Department of Ocean Engineering transmit the most current information to students. In 1978-79, Marine Hydrodynamics I and Marine Hydrodynamics II were introduced as new subjects.

In the Department of Civil Engineering, Professor Oral Buyukozturk developed an integrated subject in designing and building offshore structures. Parallel coordination of materials into a textbook will make this evolving course available to students in coming years as well. Change in the marine field is constant so that the curriculum must remain flexible to reflect real-world considerations.

For several years, Professor William Seifert of the Department of Civil Engineering has engaged his students from many disciplines -- law, economics, management, engineering, political science -- in a coastal urban planning course. This past year in this interdisciplinary systems design course, the students recommended plans for converting underutilized waterfront resources into a revitalized shopping area and expanded recreational facility in Hyannis, Massachusetts.

Sea Grant supports continuing education for professionals through the M.I.T. Special Summer Session Programs. In 1978, six two-part subjects included: Transportation Systems and Management Analysis; Air Transportation; Port Planning and Development; Urban Transportation; Freight Transportation; and Forecasting Transportation Demand.

Not all educational projects are academic in the traditional sense. Professionals from the fishing industry, many of whom have sharpened their skills at sea, took advantage of Sea Grant sponsored courses at the Massachusetts Maritime Academy (MMA). Two- to five-day workshops included classes on diesel engine maintenance, Loran C, netmending and construction, vessel safety, navigation and seamanship. The courses, team-taught by industry professionals and MMA faculty, elicited a tremendous positive response. It was, in fact, impossible to accommodate all applicants even with a greatly expanded schedule made possible by the support of the Commonwealth of Massachusetts when they designated MMA the state's official fisheries management and training center.

An educational event oriented to both the M.I.T. community and the public is the annual Sea Grant Lecture. In September 1978, Erling D. Naess, chairman of the International Association of Tanker Owners (INTERTANKO) delivered "Oil Pollution of the Oceans: a Tanker Owner's Perspective." In lively exchange with a panel, he discussed private, national, and international responsibilities for preventing economically and environmentally costly oil spills at sea. The panel included Jerome H. Milgram, Professor of Naval Architecture in the Department of Ocean Engineering; William M. Benkert, Rear Admiral (Retired) of the US Coast Guard; James A. Cole, Jr., General Manager, Marine Department, of Texaco Incorporated; and Evelyn F. Murphy, Secretary of Environmental Affairs of the Commonwealth of Massachusetts.

In response to the interest Congress expressed in the new 1976 Sea Grant Act, M.I.T. Sea Grant is extending the reach of its educational component. An innovative marine science program in New Bedford has become a testing ground for interdisciplinary teaching modules centered on "water" -- a substance essential to the world's survival and fascinating as a matrix for building competence in mathematics, chemistry, philosophy, and literature. M.I.T. Sea Grant's staff, aided by an advisory panel of M.I.T. faculty members and other experts, will refine the curriculum elements for distribution to schools throughout the United States.

Another new program, "Into the Ocean World," an interdisciplinary course on the sea's influence -- past, present, and future -- was developed under M.I.T. leadership by a consortium of educators from colleges and universities in the Boston area. The course, which will encompass the sciences, social sciences, humanities, and the arts, will be taught in the spring of 1980 to 50 advanced undergraduates from the 25 consortium schools.

RESEARCH

Awareness that the seas held promise and a challenge was evidenced by M.I.T. when the Institute established the nation's first Department of Naval Engineering over 80 years ago. Since that time, in-depth studies have focused on the earth's biological, chemical, physical, and geological processes. Technologies developed at the Institute have helped make possible the safe recovery of oil from the seas, the efficient transport and trade of products vital to people around the world, and an essential understanding of forms of life that share the planet with humans.

From its beginnings, Sea Grant has closely monitored the marine community not only through its advisory services, but also through M.I.T. faculty members who have always been committed to public service. The evolution of the M.I.T. Program reflects the needs of the community and the interests and talents of the Institute's scientists.

As the Institute Sea Grant Program has matured, its research has both expanded and become more focused. There are a greater number of projects each year, knit more closely together through defined research themes. Even the broadest of all the themes, "Technology for Development for Ocean Uses," connects with a common thread the creation of materials and methods that will allow men and women to exploit wisely the world's marine resources.

In the Department of Ocean Engineering, Professor Francis Noblesse, the 1978 Henry L. Doherty Professor of Ocean Utilization, addressed a problem that has plagued ship architects for decades: reduction of the wave resistance of ships. His success could mean reduced fuel consumption, increased speed for carrying goods through the oceans, and minimized environmental disruption in and near coastal areas.

Both the fishing and the recreational boating industry lack certain critical safeguards in fiberglass boat construction. Professor James H. Williams, Jr., in the Department of Mechanical Engineering, is attempting to establish a non-destructive testing method, using heated liquid crystals, to detect flaws in boat hulls before they are subjected to the harsh, and oftentimes violent rigors of the ocean.

Materials and methods of construction that have proved effective on land cannot always be applied at sea. Professors Richard G. Donnelly and Robert E. Cohen of the Department of Chemical Engineering conducted experiments on three methods for modifying polyethylene, a common, inexpensively manufactured polymer. They hope to create a material which would replace degradable fibers in undersea electric cable insulation for such applications as aids to navigation, communications, and other underwater work and survey equipment.

For a number of years Sea Grant has supported research to study the behavior and transport of oil spilled at sea. In the final stage of a project, Professor Donnelly has examined the chemical characteristics of the marine environment that affect the degradation and dispersal of oil introduced into nearshore areas.

Professor Koichi Masubuchi of the Department of Ocean Engineering continued his research into the design and fabrication of new underwater welding tools and techniques for constructing and repairing marine structures. A pressure tank built by graduate assistants allowed the researcher to observe and analyze the quality of welds in depths up to 700 feet.

During this past year, a wholly new thematic area, "Offshore Facilities," emerged from the work of researchers in M.I.T.'s Department of Civil Engineering. As ocean development moves seaward, the uncertainties of building and siting immense working platforms increase. Professor Gregory B. Baecher of the Department of Civil Engineering is employing probability analysis to organize an assessment of geotechnical uncertainties and to evaluate the aggregate risks of offshore construction.

Professor Baecher's model will be aided by new information resulting from the work of Professors Charles C. Ladd and Mohsen M. Baligh, also in the Department of Civil Engineering. To provide engineers with consistent, reliable information on the subsea soil structure, the researchers have investigated the application of a penetration device, known as the Dutch cone, to *in situ* testing of marine soils. They have observed and documented the performance of the instrument at three land sites for correlation to data they will obtain in field tests from a working platform off the coast of Venezuela in the summer of 1979.

"Unmanned, Underwater Vehicles," was established as a theme area at the recommendation of Marine Industry Advisory Service collegium members, because mechanical devices are sorely needed to replace human divers in hazardous deep-sea conditions. In the Department of Mechanical Engineering, Professor Thomas B. Sheridan has developed new underwater control systems for a telemanipulator with general purpose arms, hands, and video-sonar-tactile sensors to investigate the concept's viability for ocean work. The device responds to direct commands from a remotely located human operator who watches its performance on closed circuit television. Computer-logged supervisory control also can be used for guidance. Laboratory tests are being conducted to reveal what combinations of human and computer control are most effective in making the telemanipulator a fast and accurate worker.

Improving communications between the device and the human operator presents an interesting research challenge. Because of the low frequency, highly reverberative nature of water, undersea transmission of audio and video messages is slow and frequently imprecise. Professor Arthur B. Baggeroer, of the Departments of Ocean Engineering and Electrical Engineering and Computer Science, is experimenting with new communications theory and digital systems to create chords that relay information more clearly in the marine environment.

Underwater search and survey submersibles will also employ new communications systems. Professor A. Douglas Carmichael has redesigned a robot, developed by students in a Sea Grant education project several years ago, to make the vehicle lighter, quieter, and more stable. Improvements in microprocessing have made it possible to equip the robot with more sensitive, sophisticated instrumentation and controls.

Improved policy for devising pollution control systems, disposing of land wastes, and expanding coastline development depends on a better understanding of "Coastal Processes," a theme area which is important for the future.

The movement of sand, transported by wave-induced currents, constantly changes the profile of a coastline. Engineers, to control natural erosion or to assess the impact of harbor development, require simple, affordable instrumentation systems. Professor Ole S. Madsen of the Department of Civil Engineering, and the 1977 Henry L. Doherty Professor in Ocean Utilization, developed an array of meters, gauges, and a digital recorder that measures velocity and surface elevation in the surf zone, making available more accurate and consistent quantitative information of sediment transport. In a related project, the researcher began an investigation of the factors that affect the formation, attenuation, and dispersion of waves in the coastal zone in order to create techniques for predicting and mitigating storm surges.

Francois M.M. Morel, the first Doherty Professor in 1975 and a professor in the Department of Civil Engineering, continued research that will be useful in predicting and ultimately controlling toxic blooms of *Gonyaulax tamarensis*, commonly called "red tides." Laboratory identification of a dormant, overwintering cyst as the seed for perpetuating the annual outbreaks led to field investigations of algal behavior and the factors affecting its continuing spread southward in New England.

Contamination of fresh water supplies on islands and peninsulas concerns planners seeking to balance economically beneficial growth with management of existing resources. Professor John L. Wilson in the Department of Civil Engineering created a predictive numerical seawater intrusion model using data collected by the US Geological Survey on Martha's Vineyard. The model, which will have applications in the island and coastal communities around the world, helps planners to predict the effects of growth on overall water supplies, pond levels, underground water flow, and potential seawater intrusion.

In Texas, the Department of Energy is emptying salt caverns using brine to make room for oil in a massive storage program. Disposal of the brine in the Gulf of Mexico, an important shrimping area, could decrease fishery productivity if the water becomes overly saline and dense. Professor Keith D. Stolzenbach cooperated in a national effort to mitigate this problem. A model he created to study the dispersal of the brine has been used to design diffuser systems and has guided the conduct of pre-operational environmental surveys.

In the "Coastal Ecology" thematic division, the biological aspects of the interface of the coast and sea are of particular interest. In some instances, old problems are being addressed; and in others, new marketing opportunities have led to the initiation of the research projects. In Nahant Bay, algal fouling was reported almost 100 years ago, but neither the cause nor solution has been found to date. A research team, led by Professor Alician V. Quinlan of the Department of Mechanical Engineering and a 1978 Doherty Professor of Ocean Utilization, is collecting data about the ecology of the algal mass, the present quality of the water, and the circulation patterns in Nahant Bay to create a hydro-ecodynamic model. The researchers hope to discover why the algae accumulate and will suggest ways to repress its growth or to economically exploit the organisms as a marketable resource.

In some instances, the overgrowth of algae is triggered by the disposal of sewage effluents. Turned to good advantage, this fertilizing effect is being studied when used in controlled algae growing experiments by Dr. Morteza Janghorbani of M.I.T.'s Nuclear Reactor Laboratory and Dr. Guy C. McLeod, Director of Research, New England Aquarium. Of particular importance to the researchers is an assessment of trace element uptake within the aquacultural food chain after the effluents have been treated by high electron bombardment or secondary treatment.

Technology development for finding new raw materials and food sources under the theme "Living Resource Development," has been the subject of Sea Grant attention from the Program's inception. With the extraordinary engineering talent accessible at M.I.T., mechanization of food processing techniques and development of more efficient ship gear have represented a prime effort. In 1978-79, under the guidance of Professor David Gordon Wilson in the Department of Mechanical Engineering, a design prototype for skinning a potentially valuable, underutilized shark neared completion. With encouragement from fishermen, processors, and machine manufacturers, the M.I.T. scientists overcame the serious problem of removing the very tough skin of the spiny dogfish, leaving an unmarred, commercially saleable protein source. Existing demand in Europe and the development of new American markets may relieve some pressure from overburdened fisheries and open up profitable opportunities for US fishermen.

Professor Benjamin L. Averbach of the Department of Materials Science and Engineering is doing research that could turn a shellfish waste into a promising raw material. Following extensive studies of methods for processing chitin and its derivative chitosan, the Sea Grant project turned to exploiting the attractive film-forming capability of these substances. Hopefully, discarded crab shells will be transformed into saran-wrap like materials, possibly replacing petrochemicals in some manufacturing processes. Additionally, Professor Averbach is investigating the effectiveness of chitosan films in removing contaminants such as DDT, PCBs, and radioactive elements from industrial effluents and polluted waterways.

The promise of the ocean's resources is enormous. Through the collaboration of university researchers, industry managers, and government people at all levels, M.I.T. Sea Grant seeks to promote resource development that is tempered with respect not only for the potential, but also the limits of our planet, which is truly a "world of water."

DEAN A. HORN

Summer Session

Special Programs

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

Of the 60 programs planned for the 1978 session, only two were cancelled because of projected low enrollments. The total registration of 1,782 in 1978 represented an average of 31 registrants per program as compared with 30 for the 64 programs in 1977.

The Special Summer Programs have widespread appeal. In 1978, 68 percent of the registrants came from industrial and nonprofit companies, 20 percent from governmental agencies, and 12 percent from educational institutions. The median academic background of a typical registrant was a master's degree. Sixty percent of the registrants had addresses east of the Mississippi. There was a significant foreign contingent with nine percent from Canada and 16 percent from non-North American countries. A noticeable trend in the composition of the student body has been the slow but steady increase in the number of women registrants. They comprised nine percent of the 1978 class as compared with only three percent in the late 60s. The one characteristic of the registrant body which has remained remarkably constant is that the average age of registrants is 37.

Regular Subjects

Graduate students comprise over 80 percent of the student body in the summer. The 1978 registration of 2,344 students was essentially the same as the 2,321 in 1977.

JAMES M. AUSTIN

Technology Adaptation Program

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

A wide range of academic and research activities are available through association with T.A.P.:

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

The research activities of the program have focused principally on those developing countries which already have created the basic prerequisites for effective technological transfer and are in the process of developing more sophisticated technical capabilities. The cooperation of T.A.P. with certain universities and institutions in these countries has often been the catalyst for the introduction of new technology.

The program publishes and distributes a series of reports and papers based on its activities, and maintains a document collection related to science, technology, and development.

TECHNOLOGICAL PLANNING PROGRAM IN EGYPT

In December 1976 AID entered into a one-year contract with M.I.T. to establish a collaborative research effort with Cairo University and various ministries of the Government of Egypt to improve their capabilities in analyzing, planning, and managing important Egyptian developmental problems. At the same time, feasibility studies on institutionalizing this process were conducted. The success achieved during the course of the contract warranted extending funding until October 1980 and program approval for an additional three years. General objectives are pursued through cooperation with Cairo University in developing its capabilities to contribute to the formulation and implementation of science- and technology-related policies for assisting Egyptian development goals. Three specific objectives have been established:

1) mobilization of academic interest in research on specific development plans; 2) organization of technical research in collaboration with Egyptian government ministries; and 3) establishment of an institutional framework through which permanent research and training capabilities can be organized.

The specific research projects organized so far employ three analytic approaches:

1) engineering analysis and technical project evaluation, addressing specifically technical issues, including field and laboratory studies, design, and training requirements; 2) economic analysis, focusing on project, sector, and national planning issues, and micro and macroeconomic studies related to specific Egyptian development programs; and 3) social science analysis of population and labor force issues, socioeconomic change including urbanization, extension of social services, and technology transfer.

Over the past 30 months, 14 collaborative projects have been developed between M.I.T. faculty members and their counterparts at Cairo University and in appropriate ministries or government agencies. These projects focus on a broad range of engineering, economic, and social science topics, as described below. The key element in each of these efforts is the interdisciplinary team drawn from faculty and staff of M.I.T. and Cairo University and government ministry personnel responsible for planning development projects in the topic area. Effective mobilization of the Egyptian academic and government resources has been one of the principal reasons for the success of the program to date. In addition to the research activities, emphasis has been placed on the training of in-country personnel in the techniques of project identification, evaluation, and management, and the development and maintenance of the data necessary to design and monitor their projects.

RESEARCH PROJECTS

The research projects have focused principally on four broad areas:

1) Energy, including electricity generation and distribution; 2) Manufacturing, including small-scale industries, plastics and building materials; 3) Public Works, including housing, transportation, and water resources; and 4) Socioeconomic Development, including population migration, health care delivery, economic planning, and rural communications.

Energy

Long-Term Investment Planning for the Egyptian Electric Power System. The objective of this project is to help develop professional skills in applying tools of mathematical economics and operations research to analyze project alternatives for Egyptians concerned with planning electric power projects. The project is directed by Professor Martin Weitzman of the Department of Economics and Professor James Kirtley of the Department of Electrical Engineering and Computer Science.

Manufacturing

Engineering Applications for the Plastics Industry. The objective of this work is to develop a capability at Cairo University and in several private and public companies that will support the ministries' plans to extend the applications for plastics materials. The project is directed by Professor Frederick J. McGarry of the Department of Materials Science and Engineering.

Public Works

Housing and Construction Industry. The objective of the program is to develop the technical and economic knowledge and tools needed in the determination of national housing policies. Specific recommendations will be developed which focus on investment policies, controls and regulations, provision of services, and other government intervention in housing. The project's goal is to assist the Egyptian government in developing a housing policy which will better enable the various supply institutions to meet the country's housing needs. This project is directed by Professor N. John Habraken, Head, Department of Architecture. Professor Albert G.H. Dietz of the Department of Architecture and Professor William C. Wheaton of the Departments of Economics and Urban Studies and Planning are also participating.

Intercity Transportation Planning. The objective of the project is to develop a methodology for the systematic analysis of future transportation investment policy proposals in Egypt. This program is directed by Professors Fred Moavenzadeh and Terry Friesz of the Department of Civil Engineering. Research Associate Michael J. Markow and Research Engineer Brian Bradmeyer in the Department of Civil Engineering also are contributing to the project.

Urban Transportation. The objective of the Urban Transportation program is to assist the Transport Planning Authority and other agencies in strengthening their project implementation and policy-making processes in the area of urban transportation. This project is directed by Professor Ralph A. Gakenheimer of the Department of Urban Studies and Planning. Professor Steven Lerman of the Department of Civil Engineering and the Center for Transportation Studies is also participating.

Regional Groundwater Studies. The objective of this project is to develop computer models for the Nile Delta Aquifer and the Nubian Sandstone Aquifer to assist in evaluating the aquifers' safe yield, their capability to act as storage reservoirs, and their interaction with irrigation and drainage activities. This project is directed by Professor John L. Wilson of the Department of Civil Engineering.

Stochastic Model of the Nile Inflows to Lake Nasser. The objectives of this project are: 1) to develop computer-based stochastic simulation models which represent Nile River stream flows for use in planning of water resource systems; 2) to model the hydrologic behavior of the Nile swamp to allow prediction of the water yield taking account of uncertainty; and 3) to develop forecasting models for use in reservoir and irrigation systems operations. This project is directed by Professors Rafael Bras, and Peter S. Eagleson, both of the Department of Civil Engineering.

Performance of Paraffinic Asphalt-Cements in Egyptian Road Construction. The objective of this project is to evaluate the properties of the Egyptian waxy asphalt cements and to improve the performance of Egyptian pavements constructed by means of these asphalts. The project is directed by Professor Mohsen Baligh of the Department of Civil Engineering.

Socioeconomic Development

Communications Needs for Rural Development. The objective here is to assess the needs of Egyptian villages for communications facilities, and to suggest means of using communications technologies to improve the economy and society of the villages. This program is directed by Professor Ithiel de Sola Pool of the Department of Political Science.

Egyptian Labor Migration. The objective of the project is to contribute to an understanding of the costs and benefits to Egypt of the migration of labor to other Arab countries. The intent is to provide a set of consistent data on labor migration and on the socioeconomic variables that are related to the migration process. Such an assessment will be useful to the relevant ministries for a comprehensive view of the structure and impacts of migration on the Egyptian economy. Indication of the implications for sector-specific concerns also will be visible. This project is directed by Professor Nazli Choucri of the Department of Political Science.

Health Care Delivery Systems. The objective of the project is to make recommendations to appropriate ministries on ways to improve the delivery of public health services. Focus is on the organizational management responsibilities of the ministry rather than on specific hardware needed to upgrade the system. This project is directed by Professor Richard Eckaus of the Department of Economics. Dr. John O. Field, Research Associate in the Center for International Studies, is taking major responsibilities in this project.

Improved Methods for Macroeconomic and Sectoral Planning. The objective of this project is to develop and apply improved planning methods for overall sectoral policy making. The methods are used to analyze relatively quickly, yet comprehensively, the consequences of alternative proposals such that policy makers are provided with more effective means than heretofore have existed of formulating economic policy with a better appreciation of its consequences. This project is directed by Professor Richard Eckaus of the Department of Economics. Professor Lance Taylor of the Departments of Economics and Nutrition and Food Science is also participating.

DEVELOPMENT RESEARCH AND TECHNOLOGICAL PLANNING CENTER AT CAIRO UNIVERSITY

The Center was established under a decree by Anwar Sadat, President of the Arab Republic of Egypt, as an autonomous unit of Cairo University. Dr. Ali El Salmi has been appointed director of the Center. Prior to his appointment Dr. El Salmi served as a minister in the Cabinet; he holds an appointment as professor of management at Cairo University. The Center's governing body consists of the director and a board of directors chaired by the Rector of Cairo University. The board of directors includes four representatives from the faculty and administrative staff of Cairo University plus three senior members from government ministries.

The Center's purpose is to solve developmental problems of Egypt and to support technological development in the country through applied research and technological planning. This objective will be achieved through the following activities:

- 1) provision of a technical research base to help train Egyptian government cadres involved in planning and implementation of development projects;
- 2) improvement of academic resources in Egypt in order to apply research for the analysis and solution of development problems;
- 3) training Egyptians at both Egyptian and foreign universities; and
- 4) organizing conferences, symposia, and meetings.

The establishment of the Center represents a significant milestone in the accomplishments of the Technological Planning Program. The Center is an institution through which the Program can continue its research activities and other projects on assisting in the solution of Egyptian development problems.

EDUCATIONAL OPPORTUNITIES

T.A.P. has expanded educational opportunities at both M.I.T. and in Egypt. Opportunities for learning have been made available to both faculty and students interested in general or specific topics related to transfer and adaptation of technology, and valuable experience on specific, real problems has been gained. The projects have provided an opportunity for future decision makers to serve as apprentices under experts in particular areas of technical and economic development.

Some of the educational opportunities offered during the past year include those outlined below.

Research Assistantships

During the academic year 1977-78, 24 graduate research assistantships were offered; in the academic year 1978-79 there were 37. Several other students at the graduate and undergraduate level participated in project research, and some have indicated that they will be using their experience as the basis for their master's and Ph.D. theses.

Curriculum and Subject Development

Although no funds are available at this time specifically for the development of new subjects, several faculty members have incorporated material from their project work into regular subjects taught during the academic year. For example, Professor David Marks presented a short course during the Independent Activities Period entitled "Operations of the High Aswan Dam in Egypt," which was based on his program research. A series of lectures on Economic Problems of Egyptian Development was presented in the Department of Economics during I.A.P. in January 1979.

Visits by Foreign Scholars

To date, 78 Egyptian staff members from Cairo University and various government agencies have visited M.I.T. Some have attended short courses on specific topics, while others have followed more informal programs designed to increase their awareness of current developments in their fields. During their visits to the Institute, most of them also have performed work on specific research projects in collaboration with their M.I.T. counterparts. In addition, several have had the opportunity to meet with other M.I.T. staff members interested in similar problems of technology adaptation and development.

Travel by M.I.T. Staff

M.I.T. faculty, staff, and students spent a total of four person-years in Egypt during the past year. Several staff members also were able to visit other locations overseas to meet with experts working on similar development problems, or to attend conferences relevant to project research. In addition to the T.A.P. research and administrative staff, Robert J. Long of the Comptroller's Accounting Office traveled to Cairo to assist in the operation of the Liaison Office.

Conferences, Workshops, and Seminars

Long-Term Investment Planning for the Egyptian Electric Power System. A short course was held in Cairo in December 1978 and January 1979 on Reliability of Power Systems. The course was designed to familiarize personnel with the principles of reliability evaluation, the methods commonly used, and the particular problems which the Egyptian national system may present. The course was given by the Cairo University faculty involved in the project.

Engineering Applications for the Egyptian Plastics Industry. A conference was held in Zurich in January 1979 with representatives from the Swiss Federal Laboratories for Testing Materials and Research to discuss testing methods and analysis. This conference was chaired by Professor McGarry (Department of Materials Science and Engineering).

Housing and Construction Industry. A seminar was held in Cairo in January 1979 on Core Housing and Site and Services Projects. The study, planning, and design of core housing and site and services projects is now reaching the implementation phase in Egypt. Several projects are considering this approach on a large-scale basis and two of the projects are presently constructing prototypes. This seminar was arranged to encourage the exchange of information and make public the basic information of each of the projects, to discuss issues arising from the presentations, and to present basic recommendations on the core housing and site and services issue. Participants invited to the seminar were deliberately limited only to experts with direct involvement in or knowledge of the issues. Professors Habraken and Wheaton contributed to this seminar.

Transportation Projects. Two week-long workshops were held in Cairo, one in November 1978 and one in January 1979. These workshops were well attended by Ministry Administrators, engineers, and transportation modeling experts. In April 1979 a seminar on transportation projects in Egypt was held at M.I.T., chaired by engineer Abdel-Aal Salamawy, chairman of the Transportation Planning Authority. Professors Moavenzadeh and Gakenheimer organized and participated in the workshops.

Water Resources Planning in Egypt. A major conference on Water Resources Planning in Egypt was held in Cairo in June 1979. This conference, the first on water resource planning in Egypt, was jointly sponsored by the Cairo University-M.I.T. Technological Planning Program and the Ministry of Irrigation. Presentations were made by M.I.T. faculty, Cairo University faculty, and ministry officials. Additional papers were presented by researchers from other organizations who are presently involved in studies on Egypt. The conference discussed the Egyptian Water Master Plan, Surface Hydrological Studies, Groundwater Hydrological Studies, Irrigation and Drainage Studies, and Water Quality and River Degradation Studies. Professor Marks (Department of Civil Engineering) chaired the conference jointly with Professor El Assiouti from Cairo University.

ORGANIZATION

The Technology Adaptation Program is directed by Professor Moavenzadeh (Civil Engineering). An Executive Committee composed of Dr. Choucri, Professor of Political Science, Dr. Eckaus, Ford International Professor of Economics, and Professor Moavenzadeh, has the responsibility for the management of the Program. An Advisory Committee which oversees the activities of the program consists of Professors Choucri, Eckaus, Jack P. Ruina (Department of Electrical Engineering and Computer Science), George W. Rathjens (Department of Political Science), Eugene B. Skolnikoff (Department of Political Science and Director of the Center for International Studies), and Deans William F. Pounds (Sloan School of Management) and William L. Porter (School of Architecture and Planning); the Committee is chaired by Professor Moavenzadeh. Jeanne de Pass is the Program's Administrative Officer, and Kevin J. O'Toole serves as Technical Officer. George Petievich is the Administrative Officer of the M.I.T.-Cairo University Liaison Office in Cairo.

PUBLICATIONS

The Program regularly publishes the results of research in the T.A.P. program publications series. In the past year seven reports were published.

In addition to the publication series, working papers have been written and a number of papers have been published in professional journals so that the results of research are available to a wider public.

FRED MOAVENZADEH

Upward Bound Program

The M.I.T.-Wellesley Upward Bound program is a coeducational, multiracial, multiethnic educational program for Cambridge high-school aged youth. Now in its twelfth year, the program services 70 academically promising young men and women who have low achievement aspiration and who come from low income families. The goal of the program is to motivate these youths to attend college and to provide them with the necessary academic and social skills needed to succeed in college. To a large extent the program is influenced by the research done in the area of goal setting or level of aspiration in the 1930s and 40s by the social psychologist Kurt Lewin and his associates. The program has met with good success, operating on the assumption that ego growth and academic performance are closely related. A developing ego needs to experience success in a warm and personal but structured environment to develop strongly, in both a personal and social sense. This development can be brought about through intervention outside of the family and the school.

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

SUMMER PROGRAM

The Summer Program, conducted in residence on the Wellesley College campus for six weeks, is designed to provide the student with an intense academic and social experience. Classes are team-taught by experienced high school teachers, students from Wellesley College and M.I.T., and Upward Bound alumni now attending college. Upward Bound students carry three classes, each of which meets for 50 minutes, five days per week during the six-week summer program. Classes are small and conducted in a seminar fashion. Each student is required to take one mathematics and one humanities or social science course and one elective. Humanities and social science offerings include reading and writing, teens and law, studies in inner city living, government and contemporary issues, and sociology. Science courses include biology, physics, human physiology, computers and chemistry, and are supported in part by a grant from the M.I.T. chapter of Sigma Xi. The mathematics program includes an enrichment section for students who are going to take Algebra I or II, Geometry, or Math IV; a review section for students who have done poorly in Algebra I or II, Geometry, or Math IV; and a pre-calculus course for students who will be attending college in the fall.

THE ACADEMIC YEAR

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

Provost

Study Skills

The M.I.T. Upward Bound offices are open for study five afternoons a week from 3 to 5 pm and four evenings per week from 7 to 9:30 pm. Students are asked to spend at least one afternoon or evening per week at one of these study sessions. Each session has a team of two part-time staff as leaders and, in addition, about four undergraduate volunteers. They work individually or in small groups with students on school-related problems.

Tutoring

Whenever requested or needed, tutors are assigned to individual students. Tutors are typically M.I.T. or Wellesley College undergraduates who meet regularly on a mutually convenient basis with the Upward Bound student and then report back to project staff. For 1979-80, for the third time, space for meetings and tutoring will be available in the Cambridge Public High School during the day.

Saturday Program

The goal of the Saturday program is to furnish a miniature replication of the Wellesley summer experience. Students attend during the fall, winter, and spring on a regular basis for six hours. The Saturday program includes arts and crafts, drama, the use of the pool and gym, as well as a mathematics class.

College Report, Class of 1979

All 16 of the graduating seniors have been placed in colleges as follows: Fitchburg State College, Livingston College of Rutgers University, American International College, Boston University, Husson College, Howard University, University of Massachusetts at Amherst, Boston College, Wentworth Institute of Technology, Northeastern University, Fisk University, Occidental College, St. Olaf College, Antioch College, Pennsylvania State University, and Brigham Young University.

MARSHALL MILNER

Wellesley-M.I.T. Exchange Program

The 1977-78 academic year marked the tenth year of the Wellesley College-M.I.T. Exchange Program. Wellesley College had marked the occasion by a reception and other events in and around Jewett Arts Center on the afternoon of May 5, 1978. During the fall term of the 1978-79 academic year, a number of events were sponsored by M.I.T. to celebrate this tenth anniversary of our Exchange. The events at M.I.T. were launched at the October 21, 1978 concert of the M.I.T. Symphony Orchestra, which was dedicated to the Exchange. Formal remarks were made by Chairman Howard Johnson of the M.I.T. Corporation, President Jerome Wiesner, President Barbara Newell of Wellesley, and two undergraduates, Jeffrey Hangst of M.I.T. and Sylvia Parker of Wellesley. The Orchestra's conductor, Professor David Epstein reminded us the concert was a most appropriate occasion, not only because it was a community event, but also because Wellesley students continue to contribute so much to M.I.T.'s widely acclaimed Symphony.

The celebration continued in the form of an Exchange Seminar Series, designed to introduce some faculty members, and hence some of the educational richness, of each school to the students and faculty of the other. Three seminars were held at Wellesley: "A Linguistic Approach to Literary Analysis" -- Samuel J. Keyser, Head of the Department of Linguistics and Philosophy, M.I.T., with Michel Grimaud, Assistant Professor of French, Wellesley College, as Respondent; "Engineering and Medicine in Three Dimensions" -- Woodie C. Flowers, Associate Professor of Mechanical Engineering, M.I.T., Roger G. Mark, Associate Professor of Electrical Engineering, M.I.T. and

Kenneth N. Stevens, Professor of Electrical Engineering, M.I.T., with Ernest G. Cravalho, Professor of Mechanical Engineering, M.I.T., and Associate Director, Harvard-M.I.T. Division of Health Sciences and Technology, as Moderator; "Two Universes: The Whirlpool and the Hearth" -- Philip Morrison, Institute Professor and Professor of Physics, M.I.T. Three of the seminars were held at M.I.T.: "Can the USSR Become an Autarky by 1984?" -- Marshall I. Goldman, Professor of Economics, M.I.T., as Respondent; "Media Pathology: TV and the Democratic Process" -- Marion R. Just, Associate Professor of Political Science, Wellesley College, with Walter D. Burnham, Professor of Political Science, M.I.T., as Respondent; "Hellenism and Romanticism" -- Jonathan B. Knudsen, Assistant Professor of History, Wellesley College, with Robert E. Jones, Professor of French and Humanities, M.I.T., as Respondent.

As often happens with Exchange events, the Tenth Anniversary Seminar Series sparked a new educational offering. In the spring semester of 1980, Professor Samuel J. Keyser of M.I.T. will teach a new course at Wellesley, "Language and Literature."

Cross-registration, which is the backbone of the Exchange, continued in 1978-79 at approximately the same level it has maintained for 10 years. Wellesley students enrolled in 184 M.I.T. courses in the fall 1978 term and 268 in the spring term, and M.I.T. students took 198 Wellesley courses in the fall term and 196 in the spring term. It was especially rewarding to see eight Wellesley students enrolled in M.I.T.'s Field Geology course, which among other things included a one-month field trip in January, and is sufficiently intense to receive the credit equivalent of a full-term science subject at M.I.T. Both M.I.T. and Wellesley provided special funds to make this possible. Professor Robert Burchfiel of M.I.T.'s Department of Earth and Planetary Sciences took special note of the performance of the Wellesley students in a letter to the College.

In previous annual reports, we have cited numerous examples of faculty cooperation in working on the educational programs of the two institutions. One which we have not mentioned previously is the cooperation of Wellesley's Department of Anthropology and the Anthropology/Archaeology Section of M.I.T.'s Department of Humanities. Four years ago, two meetings were held between the two faculties and a year later it was decided that they should meet regularly. Course offerings for the coming year are discussed and/or modified to ensure the best total offering for students at the two institutions. In addition, a joint seminar had evolved from the discussions. This year's seminar, which is entitled "Colonialism, Development, and Nationalism: The Impact of the State on Traditional Societies" was organized by Professor Jean Jackson of M.I.T. and Professor Sally Merry of Wellesley. Twenty-three students participated in the course. In addition to the seminar meetings there were a number of public lectures by guest speakers; the response to these was very good. Next year, Professor Martin Diskin of M.I.T. and Professor Philip Kohl of Wellesley will oversee the seminar, which will focus on "Marxist Perspectives in Anthropology."

KENNETH M. HOFFMAN

School of Architecture and Planning

This past year has seen a heightened recognition in our educational programs of the professional practices to which they are related; it has seen advances in professionally related research and education; and it has seen increased linkages with other departments at M.I.T.

Relation to Practice

Programs in both departments have increased their emphasis on preparation for professional practice. Short "modules" have been introduced into the Master in City Planning curriculum to help the students acquire methods useful for professional practice. Some of these are now centered on specific clients and their problems. The orientation is increasingly toward the management of public systems which can ameliorate the quality of urban life. The Master of Architecture program has seen a substantial increase of interest in high quality graphic presentation. Methods of the design studio have been extended to the teaching of other subjects in an effort to integrate them into the design process. And professional roles and opportunities as well as architectural philosophies are under discussion in a diversity unknown several years ago.

Undergraduate programs in both departments have become increasingly focused on preparation for the profession. Internships have placed graduate and undergraduate students in both private and public sector offices. Lecture and seminar programs have brought practicing professionals to the School to share and discuss their experiences in architecture, new towns, urban development, architectural education, photography, graphics, race, ethnicity and poverty, urban economic development, planning practice, public/private partnership in city development, and many other areas. Increased interest and activity in placement, both by the Institute's Placement Office, by the newly established placement officer in Urban Studies and Planning, and by the newly established placement activity in Architecture, reflect heightened interest on the part of students in entering the professions directly. The School enjoys a continuing stream of high quality participants in its two mid-career programs: the Special Program for Urban and Studies of Developing Countries (SPURS), and the Community Fellows Program (C.F.P.); it has introduced a new program of practitioner affiliates in the Laboratory of Architecture and Planning (L.A.P.); and it has had many distinguished visitors for extended stays all to enlarge the perspectives within which we conduct our education. Finally, the Laboratory of Architecture and Planning (L.A.P.) has been offering, in collaboration with the Harvard Graduate School of Design, both winter and summer continuing education programs. These programs have involved practitioners, faculty, and students as instructors in approximately 15 courses and have included 140 participants from both the local and national professional communities in architecture and planning.

Professional Development

The School has been active in continuing to rethink the role of the professionals in our fields and to redefine the areas of appropriate professional action. In Urban Studies the M.C.P. Committee has made special efforts to determine how best to incorporate thinking about race, ethnicity, and poverty into the curriculum, especially given a waning national interest in these pressing social problems. Participation by faculty and students in working on problems in Boston and other nearby communities remains an important source of inspiration and information.

In Architecture a new degree program at the master's level, a Master of Science in Architectural Studies, promises to permit both the study of technical problems and the education of students

who should be able to assume new professional roles. The three areas of concentration are environmental design, housing and community design in developing areas, and building technology. In the Ph.D. programs in both departments students are working on problems which clarify the framework for professional action and which prepare them for careers as educators, researchers, and administrators.

The faculty's publications continue to arouse considerable interest within the profession. Examples are within the fields of urban design, institutional analysis, and organizational learning. Sponsored research, at least a partial indication of the School's engaging professional issues of national interest, continues to grow. It has grown in total amount, in the number of faculty carrying research projects, and in the variety of research available to the student. Along with the growth of research there has been a parallel growth in the number of research assistantships open to students.

Encouragement toward research comes from a variety of sources now, but one relatively recent influence bears mention. The Laboratory of Architecture and Planning, started in 1974 with the seeding of promising research projects and using a general set of criteria for what constituted good research, has now developed, with the encouragement of the School Council, an agenda of research areas where it is attempting to build research activity. This strategy should result in significant increases of scale and quality of research in selected areas. Each of these areas (for example, energy and buildings and neighborhood organization and improvement) was selected as an area ready for significant substantive development, related to present and future careers of our students and alumni, and highly likely to have an impact on education and practice in our fields.

In keeping with its commitment to professional education, the School has acknowledged and is vigorously developing a new professional focus in Art and Media Technology. Several groups from within the Department of Architecture in film, photography, graphics, visual design, and computer graphics -- will be combined with the electronic music group of the School of Humanities and Social Science, elements of the Center for Advanced Visual Studies, Educational Video Resources, a research and service group, and, importantly, the Institute's exhibition programs committees. If current fund-raising efforts are successful, these activities will be housed in a new facility on the East Campus. During this past year the directors of these programs have met and planned for this eventuality. During this year as well, the M.I.T. faculty has approved a new master's degree program, the Master of Science in Visual Studies, to make possible graduate professional study in these fields. Polarized around this program, research and teaching activities are developing which should fully justify their position at M.I.T. in terms of providing professionals who will fill important roles in our society, in terms of carrying out research of significance, and in terms of educating undergraduates further to enrich their appreciation of contemporary life and culture.

Linkages

In relation to its larger educational environment, M.I.T.'s School of Architecture and Planning continues to build strong relationships with Harvard and other institutions as well as to strengthen internal connections at M.I.T. In the Department of Urban Studies and Planning, roughly a quarter of the senior faculty are jointly appointed with other departments and divisions at the Institute, and a quarter of the Department's courses are jointly listed. Research of the Urban Studies faculty is carried out through a variety of centers at M.I.T. and through the Joint Center for Urban Studies of Harvard and M.I.T. One of its faculty members, Professor Arthur Solomon, is the Director of the Joint Center; and Senior Lecturer Michael Joroff is the Director of the Laboratory of Architecture and Planning. Professor Lawrence Bacow has served as the leader of an Institute-wide colloquium on environmental issues carried out cooperatively with the new program in Science, Technology, and Society.

Through the L.A.P., the Architecture Department has been carrying out a study of energy and buildings collaboratively with the Energy Laboratory, and this has resulted in an agenda for research and has laid the groundwork for collaboration among faculty members from several disciplines. Also in this Department, the new master's degree in Architecture Studies makes possible the development of a pool of faculty and students in a pattern of activity similar to that of faculty and students associated with master's programs elsewhere at M.I.T. (This new program has a focus on research and inquiry in contrast with the focus of its regular professional degree program,

the M.Arch., on the acquisition of design competence.) This should in the future provide a better basis than has ever existed before for collaboration in research between the Department of Architecture and others at M.I.T.

Students and Space

Despite these signs of health and progress in the School, some problems remain, and among these, the lack of support for students and an inadequate spatial environment for our programs are paramount.

For fields represented in the School, but especially for urban planning, the changing configuration of clienteles and power in society has great significance. As the resolution of problems falls increasingly into the political realm, the professional's role becomes, if not more political, at least cast in a political light. And as power becomes more widely and plurally distributed, newly enfranchised clienteles seek professional assistance from those who understand and even share their particular backgrounds and experience. It is directly through the composition of the membership of the School that we can recognize and deal with these conditions. Affirmative action for this School, then, is an integral part of its strategy to produce professionals who will be effective in society in the years to come. Women are an integral part of our student body in all 10 programs. However, they are underrepresented among foreign students. Blacks are well represented in the M.C.P. program although underrepresented in others. And there are emerging minority groups other than blacks whom we hope increasingly to attract, and who wish to become professionals in fields for which we offer preparation.

Among the faculty and academic staff we search affirmatively for women and minorities, yet the network of information about candidates seems not as well established as for white males. Also there is very stiff competition for minority professionals across a wide variety of organizations and at salaries with which we cannot compete. We have, however, been able to attract two minority graduates to our Urban Studies faculty and have brought other outstanding individuals as visiting faculty to both departments.

It is the C.F.P. program which is now in the greatest jeopardy and which requires a heightened commitment on our part to fund it, either from within or without the Institute. Mid-career professionals drawn from minority groups in our society are needed in our midst in order to understand the problems of America. They act as guides and critics for the directions in which our professions should move in the next several years.

In Architecture there is a much enhanced thrust into working on problems of housing and settlement design of developing countries, which calls out a different but analogous problem. If we are to educate people from other countries who will have the interest and energy to work on these problems, we must be able to offer financial assistance and loan guarantees. And this is doubly important if we are to attract groups not currently in the mainstream of their societies.

With regard to space there is good will and support for us to improve the spatial environment for our program from within the Institute, from our Visiting Committee, and from our alumni who are familiar with the School. Yet the rate of improvement is simply not fast enough to deal with existing problems let alone keep pace with changing requirements and patterns of teaching and research. There is nevertheless progress to report. In response to the plans of Professor Lawrence Susskind, a substantial area on the third floor of Building 7 was renovated this year to create a new common room and social focus for the Department. This has been very intensively used during this year and must be judged a success in concept and implementation. The growth and development of the Architecture Machine, for which Professor Nicholas Negro Ponte is prime mover, called for spatial improvements in its present location, the fifth floor of Building 9. These have proven to enhance the comfort and convenience of researchers and students, and to increase the visibility and clarity of the activities for the other members of the School and Institute as well as for visitors.

However even this amount of remodeling, enormously welcome and important for the success of our programs, is insufficient to deal with a deteriorating spatial environment, much of which has seen no major improvement since it was built in the late 1930s. And it should further be observed that the funds for remodeling for this School, even though falling far short of our

needs, represent a disproportionately large share of remodeling funds with respect to other departments and centers at the Institute. Thus in order to deal with our need and to be fair to other departments and centers, substantial outside funding is required to bring the School's space up to a standard worthy of our own and others' respect. It is our strong hope that such funds can be found to put the School on a schedule of improvement which will result in continued, substantial, and visible progress in the very near term.

In anticipation of the securing of such funds, two important studies have been carried out this year: one to determine the feasibility of using Building 11 for the Rotch Library, and the other to do the schematics for renovating part of the Architectural Design Studio region. Also, preliminary discussions have been carried out with members of the Visiting Committee and selected alumni to determine how best to seek the necessary funds. With the exception of lack of student support, no other resource limitation, in my view, impedes us to the same degree.

DEGREE PROGRAMS AND ADMISSIONS

In the academic year 1978-79, there were 954 applications for September 1979 admission to the graduate programs in the School. This is an increase of 114 over the 840 applications received the previous year. To date, 254 students have been offered admission in September, and 110 have accepted (last year 128 finally enrolled for the fall term).

In the Department of Architecture, the M.Arch. program received 277 applications, of which 41 were offered admission and 24 have accepted. There were also 21 applications for continuing graduate study from students enrolled in the Department's undergraduate programs, with 12 being offered admission and 9 accepting. In the other graduate programs, admissions have gone as follows: The Master of Architecture in Advanced Studies program received 102 applications, offered admission to 37, and has 30 acceptances; 55 applied to the S.M. in Visual Studies program, of which 19 were offered admission and 15 have accepted; the Ph.D. program had 31 applicants and offered admission to 5, of which 4 have accepted.

Applications for the M.C.P. program in the Department of Urban Studies and Planning (D.U.S.P.) increased from 242 last year to 334 this year, of which 47 have been offered admission. Eighty-five students applied to the Ph.D. program (down from 91 last year), with 27 being offered admission. In the Department's special non-degree programs, SPURS (Special Program for Urban and Regional Studies of Developing Countries) and the Community Fellows Program (C.F.P.), 57 people have been invited to participate this coming year: 48 for SPURS, and 9 for the C.F.P. (from 49 applications). So far, SPURS has 20 acceptances and the C.F.P., 8.

Degrees awarded to the School's students in September 1978, February 1979, and June 1979 totaled 173, of which 101 were in Architecture and 72 in D.U.S.P. In the Department of Architecture, the 101 degrees were distributed as follows: 37 students received a B.S.A.D. and S.B.; 32 received an M.Arch.; 23 an M.Arch.A.S. Also, there were 8 S.M.Vis. Studies degrees and one Ph.D. awarded. The D.U.S.P. awarded 72 degrees: 18 S.B.s, 42 M.C.P.s, and 12 Ph.D.s.

SCHOOL NEWS

The National Architectural Accrediting Board (NAAB), based on the Educational Development Plan prepared by the Department of Architecture and on last year's visit by an NAAB team, reaccredited the M.Arch. professional degree program for the full five-year term.

The Visiting Committee of the School met this year in a pattern somewhat different from previous years. During the first afternoon, the Committee divided up into 10 subgroups each to look at one of the School's degree and special programs. On the following morning, the committee members divided again, this time into three groups formed around the new arts facility, the Environmental Design Program, and around research, case studies, and links to practice. This agenda

was possible because during the previous academic year two subcommittees of the Visiting Committee had met, one with the Department of Architecture, and the other with the Department of Urban Studies and Planning. These two subcommittee meetings provided a depth of understanding and background for the 1979 spring meeting.

Based on their own programs of development and responding to Visiting Committee concerns, the departments have been addressing many issues.

In the Department of Architecture:

- the structuring as well as some issues of content in design studio teaching, especially at the advanced levels;
- forging closer links with practice;
- shaping the new Master of Science in Architectural Studies program to retain a major concern for architectural design while moving aggressively ahead to a leadership position in architectural research;
- clarifying plans for the utilization of space.

In the area of Arts and Media:

- working out an organizational plan for the arts and media groups;
- working out teaching and research programs which incorporate both artists and researchers.

In the Department of Urban Studies and Planning:

- finding ways to deepen its intellectual contacts with neighboring fields;
- strengthening both contacts with and teaching about the private sector, its relations to planning, and its potential role in addressing the problems of the cities at the Federal, state, and local levels;
- clarifying plans for the utilization of space;
- securing support for the Community Fellows and SPURS programs to enable them to accept a mix of agency and self-supported individuals, and integrating them more completely into the educational programs of the Department.

This year the School has been the beneficiary of two generous gifts, one for fellowship and student-related support in the Department of Urban Studies and Planning, and the other for a new program in Islamic Architecture funded by His Highness the Aga Khan, the head of the Ismailian Muslims. The Urban Studies program will result in enhanced support for graduate students and will make possible, along with much improved policies for graduate students' tuition and support by the Institute, a new program of postdoctoral fellows. The new program in Islamic architecture will strengthen the faculty in the Department of Architecture through the addition of a senior professor in the areas of architectural history and a visiting professor, each probably drawn from practice and teaching in the Islamic world. It also will make possible much enhanced collections in the area of contemporary Islamic architecture and urbanism, and much improved methods of access and dissemination of such information. This project will be managed by the M.I.T. Libraries. The Program in Islamic Architecture is to be coordinated with a parallel program in Harvard's Department of Fine Arts, also funded by the Aga Khan, to be focused on the more historical aspects of Islamic art and architecture.

This year the Institute's Committee on the Visual Arts sponsored and produced an exhibition entitled *Processes in Architecture: A Documentation of Six Examples*. Professors Lawrence

Anderson and Imre Halasz were guest curators of the exhibition under the overall direction of Kathy Halbreich, C.V.A.'s Director of Exhibitions. The School's magazine, *Plan*, was devoted this year entirely to the production of a catalogue issue to accompany this exhibition. Alumni reaction to this catalogue and to the exhibition has been, overall, extremely positive.

Faculty

Lawrence B. Anderson, Dean Emeritus, continues to serve the School and the Institute. He currently serves the Institute by advising on architect selection and aiding in the review of architectural design.

Dr. Albert Dietz, Professor Emeritus, continues to lead our efforts to locate funding sources for the Building Technology Chair in collaboration with the Institute's Resource Development Office.

Dr. Lawrence Susskind was appointed Head of the Department of Urban Studies and Planning beginning in 1978-79 after Professor Langley Keyes stepped aside. The newly created position of Executive Officer in the Department was filled by Professor Bernard Frieden.

In January, Michael Joroff became Director of the Laboratory of Architecture and Planning and was promoted simultaneously to Senior Lecturer in the Department of Urban Studies and Planning.

Dr. Florence Ladd's promotion to Associate Dean became effective in March, but, unfortunately, she was captured by Wellesley College as their new Dean of Students. However, we hope to remain in contact with her in her new position.

And finally, Dr. William L. Porter announced that he would be stepping out of the position of Dean effective June 30, 1980. His plans are to be on sabbatical for 1980-81 and then to return to the faculty of the School.

WILLIAM L. PORTER

STUDENT ENROLLMENT AND COMPOSITION 1978-79⁺

	<u>Total</u>	<u>Women</u>	<u>%Women</u>	<u>Minority</u>	<u>%Minority</u>	<u>Foreign</u>	<u>%Foreign</u>
<u>Department of Architecture</u>							
Undergraduate	110	23	21	NA	NA	7	6
M.Arch.	96	35	36	18	19	7	7
M.Arch.A.S.	51	9	18	2	4	39	76
S.M.Vis.Stu.	22	12	55	0	0	2	9
Ph.D.	11	5	46	0	0	4	36
Special Students**							
Undergraduate	0	0	0	0	0	0	0
Graduate	11	8	73	0	0	3	27
Joint M.Arch./M.C.P.	11	2	18	3	27	2	18
<u>Architecture Totals</u>	312	94	30	23	7	64	21
<u>Department of Urban Studies and Planning</u>							
Undergraduate	50	13	26	4	8	5	10
M.C.P.	81	39	48	22	27	16	20
Ph.D.	68	33	49	11	16	21	31
Special Students**							
SPURS***	18	3	17	NA	NA	18	100
C.F.P.***	8	3	37	8	100	0	0
Joint M.Arch./M.C.P.	7	1	14	1	14	2	29
Joint Civil/D.U.S.P.	0	0	0	0	0	0	0
<u>D.U.S.P. Totals</u>	232	92	40	46	20	62	27
<u>School</u>							
Undergraduates	160	36	23	(4)	(3)	12	8
Graduates	347	136	39	57	16	93	27
Special Students**	37	14	38	8	22	21	57
TOTAL ENROLLMENT	544	186	34	69	13	126	23

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

** Non-degree candidates.

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

FACULTY, OTHER ACADEMIC STAFF, AND RESEARCH STAFF -- 1976-77, 1977-78, 1978-79

	1976-77			1977-78			1978-79		
	Total	E.F.T.	Minority	Total	E.F.T.	Minority	Total	E.F.T.	Minority
<u>Architecture</u>									
Faculty	37	33	7	38	29	7	45	38	6
Other Academic Staff	19	4.75	4	25	14	7	23	16.5	7
Research Staff	8	6.5	-	6	5	-	7	6.5	-
Without Pay	3	-	-	-	-	-	-	-	-
<u>D.U.S.P.</u>									
Faculty	33	29.27	4	31	27.25	5	29	26.83	3
Other Academic Staff	9	3.40	2	7	2.25	-	7	4.33	-
Research Staff	2	1.50	1	2	2	2	3	3	2
Without Pay	-	-	-	-	-	-	2	-	-
<u>Laboratory of Architecture and Planning</u>									
Faculty	-	-	-	-	-	-	-	-	-
Other Academic Staff	2	3.1	-	2	2	-	2	2	-
Research Staff	2	-	-	3	3	1	4	3.5	1
Without Pay	5	1.2	2	2	-	-	6	3	2
<u>SCHOOL TOTALS</u>									
Faculty	70	62.75	11	69	56.25	12	74	64.83	9
Other Academic Staff	30	11.25	4	34	18.25	7	32	22.83	7
Research Staff	12	8.00	1	11	10	3	14	13	3
Without Pay	8	1.20	2	2	-	-	8	3	2

* 2 foreign

Department of Architecture

Significant Institute funding received this year enabled the Department to begin the S.M. Visual Studies and S.M. Architecture Studies advanced degree programs approved by the Corporation last year. This represents implementation of an adequate graduate program structure after a period of expansion and diversification within the Department. These programs create a setting which affords increased opportunities for research and inquiry in design-related fields, with the intention of developing a wide range of advanced skills. These two graduate programs form, with the existing Master of Architecture professional degree program, an educational agenda without parallel which will ensure the continuation of the Department's leadership in the future.

The Master of Science in Visual Studies has added graduate study in graphics and photography, housed in the Visible Language Workshop and the Creative Photography Laboratory, to the already existing programs in computer graphics, film/video, and environmental art. The expanded program includes a unification of what were three separate programs into a single degree program of increased size, with more areas of concentration, shared intellectual substance, and common academic policies. The program will develop a graduate level of education in visual studies and media technology which will attract high caliber students from varied backgrounds, and increase opportunities for research and study in shared media within the Department and the Institute at large. Professor Nicholas Negroponce chairs this degree program, which has accepted 18 students for fall 1979.

The Master of Science in Architecture Studies has replaced the Master of Architecture in Advanced Studies degree. The new degree is research-based, open both to students with a first professional degree in architecture and to those with degrees in other fields. Three areas of specialization are offered: environmental design, housing and settlement design, and building systems design, with a core of subjects in methods of inquiry and in the economics of the built environment. This program is designed to broaden the scope of research in the Department and to contribute to a deeper, more systematic understanding of the built environment. Professor Julian Beinart chairs this program, which has accepted 25 students for fall 1979.

An event of major importance to the Institute and the Department was the grant by His Highness the Aga Khan for the establishment of a joint program with Harvard University for research on history and contemporary problems in Islamic architecture. The program will support two professional positions in the Department, and will enlarge, develop, and coordinate a documentation center in the Rotch Library for Islamic architecture after 1900. A major search for one permanent and one visiting faculty member will soon be under way.

As it has been for many years, space continues to be a critical problem for the Department. This year, the Institute has authorized studies for the renovation of Department space in Buildings 5 and 7. Professors Maurice Smith and Barry Zevin have developed schematic drawings for the development of studios, meeting and lecture areas, and jury and seminar spaces. These have been reviewed with the Institute's space committee and funding for the renovation is being sought.

The Architecture Machine Group has enjoyed a major renovation of its laboratory, including specific attention to noise control and a new media room. The renovation has been a specific attempt to match the physical environment to the research goals, making both a pleasant place and an electronic "wired" milieu.

Within the Department, further reorganization of the Master of Architecture curriculum was proposed, which includes synthesis subjects in studio format in building technology, history/theory/and criticism, and environmental controls, and special projects in design. The M.Arch. Degree Committee, chaired by Professor John Myer, and the design faculty will continue working on implementation of the new curriculum in coming semesters.

Applicants to the Master of Architecture program this year numbered 277. After painstaking review, Professors Imre Halasz and Jan Wampler made a first cut, from which the entire faculty/student Admissions Committee selected students to be admitted in September 1979.

School of Architecture and Planning

The M.Arch Thesis Workshop, coordinated this year by Professor Halasz and Chester Sprague, was responsible for a notable improvement of this important part of the professional program.

In January 1979, the Undergraduate Program Committee, chaired by Professor Edward Allen, initiated an internship program which provided unpaid full-time positions for students in architectural offices during the January Independent Activities Period. Twenty undergraduate and graduate students were placed in 16 different alumni, faculty, and other offices in the Boston and New York City areas. Reports from students and offices were very positive, and more communication will occur before the program is offered again in January 1980.

The Policy Committee met throughout the year, focusing its discussion principally on curriculum issues, including development of the Department's new graduate programs and reorganization of curriculum in the professional program. The Department is grateful to Professors Allen, Myer, Negroponce, Zevin, David Friedman, Leon Groisser, Sandra Howell, and Starr Ockenga for their participation this year.

The Appointments Committee, chaired by Professor Robert Preusser, with Professors Howell, Sprague, and Waclaw Zalewski, met through the spring, completing a substantial number of reviews for faculty appointments.

In March 1979, the Department had a return visit from the Corporation Visiting Committee, chaired by Norman Leventhal. The two-day session featured meetings with Department degree committees and conferences on the following areas: the proposed arts and media facility for M.I.T., chaired by Dean William Porter; the Environmental Design Program, chaired by Professor Beinart; and research, case studies, and links to practice, co-chaired by Michael Joroff of the Laboratory for Architecture and Planning and Professor John Habraken.

Among other visitors to the Department in 1978-79 was a delegation from the US-USSR Joint Commission on Cooperation in the Field of Housing and Other Construction. They toured the Solar House and Architecture Machine facilities in October 1978. A delegation of architects from the People's Republic of China viewed the Solar House and the Architecture Machine in November 1978, and met with Professors Allen, Eric Dluhosch, Albert G.H. Dietz, and James Becker.

FACULTY

A number of visiting faculty appointments made in 1978-79 were in the History, Theory, and Criticism group. James Foss was appointed a visiting assistant professor in the fall, Henry Okun a lecturer, and Mark Roskill from the University of Massachusetts at Amherst and Martin Steinmann from the ETH in Zurich were visiting professors in the spring. On the design faculty, Michael Pyatok was a visiting associate professor of architecture for the fall term, and Antonio di Mambro, who has been active in the past in the Department's Urbino Program, and Christie Coffin from the University of Oregon served as visiting assistant professors of architecture.

New faculty included Shun Kanda, appointed associate professor of architecture and Barry Zevin, assistant professor of architecture. David Friedman, formerly at the University of Pennsylvania, joined the History, Theory and Criticism faculty as assistant professor of the history of architecture, and Steven Vamosi was appointed associate professor of environmental controls. Others included Michael Gerszo, assistant professor of computer graphics, Rachel Strickland, assistant professor of film, and Marshall Audin, instructor in architecture. Nancy Jones returned as assistant to the Head of the Department.

It was with great regret that the resignations of Professors Vamosi, Whitney Chadwick, and Dolores Hayden were accepted.

Dean Emeritus Lawrence B. Anderson traveled in India for three months in the winter to study schools of architecture under a fellowship from the Indo-US Subcommittee on Education and Culture.

Professor Henry A. Millon was on leave in the fall term at the Institute for Advanced Studies in Princeton, New Jersey. Professor Stanford Anderson and Wayne V. Andersen were on leave in the spring term.

In the 26th Annual *Progressive Architecture* Awards, Professor Howell was honored for her research work entitled: "Private Space: Habitability of Apartments for the Elderly." Professor Anne Vernez-Moudon was consultant on the PA Award winning study, "Change without Laws," on San Francisco zoning legislation.

Professor Negroponete has been appointed chairman of the Conference "Computers in Everyday Life" by the International Federation of Information Processing Societies Foundation in Amsterdam. A major triannual conference will be held in October 1980 in both Tokyo and Melbourne featuring Computers in the Arts, Computers and Leisure, Computers in the Home, Personalized Media, and the Intelligent Telephone.

Professor Millon has been named professor-in-charge of the newly formed Center for Advanced Study in the Visual Arts, located in the National Gallery of Art in Washington, DC. His appointment is effective immediately, but Professor Millon will continue at M.I.T. through the 1979-80 academic year.

EVENTS

The Department's student lecture series offered a full and rich schedule this year. In addition to a list of distinguished speakers, a colloquium was organized, entitled "Six Architecture Schools," with student speakers from Columbia, Cornell, Harvard, Yale, Cambridge (England), and M.I.T. Robert Campbell, architectural critic for the *Boston Globe*, moderated a panel of architects in "Symposium: The Boston Waterfront Hotel."

Wednesday afternoon photography lectures at M.I.T.'s Creative Photography Lab are becoming a tradition in Boston, and weekly audiences frequently number 200. In addition to its regular exhibition schedule in their Gallery, rotating two-week shows of M.I.T. student photographs have displayed much high-quality work.

Bill Eggleston was National Endowment for the Arts artist-in-residence in the Film/Video section this fall. He conducted advanced research and partook in exchanges with faculty and students which afforded an opportunity for unprecedented exploration of quality parameters in color video.

The Film Section has this year created CINE, an experimental network which televised eight hours of programs for 10 cable stations across the country. Among other films distributed, student productions were broadcast in Holland and on WCVB-TV's "Nightshift" in Boston. Professor Richard Leacock's *Isabella Stewart Gardner* film broke WGBH-TV's audience records in November this year.

The New Town Lecture Series, funded in part by the Ernest A. Grunsfeld Memorial Fund, the M.I.T. Corporation, and visiting design professionals, offered a series of lectures and seminars which ran parallel to the Department's Urban Tissue Design Project. Local as well as international architects and planners designing new towns worldwide participated. A series of public lectures and seminars was held in the Department, concluding in a two-day conference at M.I.T. involving the six new town design teams, M.I.T. faculty, and students.

In January, Professor Habraken, Dluhosch, Gerszo, Beinart, and Vernez-Moudon conducted a two-week seminar on SAR (Stichting Architecten Research) methods in Rio de Janeiro sponsored by the Brazilian National Bank of Housing. Professor Dluhosch then conducted a second seminar on housing systems in Rio sponsored by the National Association of Homebuilders.

The Agency for International Development (AID) sponsored a program jointly with Cairo University and M.I.T. on Housing and the Construction Industry in Egypt, and held a two-week meeting at M.I.T. in May. The team's report on Site and Service Projects for the Low Income is soon to be published in both English and Arabic. M.I.T. members of the research team, Professors Dluhosch, Dietz, Zalewski, Reinhard Goethert, and John Habraken (co-director) will continue to meet with the Cairo University team in a series of meetings planned to be held in Egypt and again at M.I.T. in 1980.

Away from M.I.T. this spring in Savannah, Professor Stanford Anderson chaired a session at the Society of Architectural Historians' 1979 annual meeting entitled: "Savannah: The Plan of Savannah

as Resource." Papers were presented by Professor Anderson and Department students Jonathan Mathews, Martha Pollak, Roy Strickland, K. Michael Hays, and Hong-Bin Kang.

RESEARCH

Continuing research in the Department includes a project directed by Professor Ron MacNeil and sponsored by Compupaint Inc. for the development of computer systems for the production of large-scale imagery in color.

Principal Research Associate Timothy Johnson continues projects sponsored by the US Department of Energy and Owens-Corning Co. on passive systems for utilizing solar energy.

Research at the Architecture Machine Group continues to grow. The laboratory supports three major programs: Spatial Data Management, Mapping by Yourself, and Personalized Movies. This year has included a major shift toward film and video, working intimately with the Film Section on a "Movie Map." This shift is in part a recognition of the convergence of computer graphics, image processing, and broadcast technologies and in part the beginning of a new Media Technology Program, embracing the larger interests of Film/Video and the Visible Language Workshop in particular.

The Urban Tissue Design Project, funded for three years by the Ernest A. Grunfeld Memorial Fund, is systematically comparing four methods of analyzing and describing urban tissues and evaluating their potential usefulness to architects and urban designers. This spring the methods were used to study Cambridgeport, Massachusetts; Savannah, Georgia; San Francisco, California; and New York City. The project took the form of a semester-long seminar/workshop for students and faculty.

Professor Vernez-Moudon holds a grant from the National Endowment for the Arts for research on "Urban Patterns and Change," and is joint researcher with Professor Howell on a National Science Foundation funded project on Design Research.

UROP (Undergraduate Research Opportunities Program) continues to be the Department's major forum for undergraduate research. Forty-six students participated this year.

STUDENT AWARDS

Awards made to graduating M.Arch students were as follows: Frank Miller received the American Institute of Architects (AIA) Medal, and Peter Polhemus the AIA Certificate. The Chandler Prize was given to Mary Griffin. The Chamberlain Prize was won by William L. Rawn III.

William Gilchrist received the Institute's Karl Taylor Compton Award for good citizenship within the M.I.T. community. The Ida M. Green Award was made to Dorine Holsey, a graduate M.Arch student entering the Department in September 1979. Steven Imrich was awarded the AIA Foundation Scholarship for 1978-79. The Albert P. Hinckley Traveling Fellowships were given to James Anderson and Linda Gatter.

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N. JOHN HABRAKEN

Department of Urban Studies and Planning

The leadership of the Department of Urban Studies and Planning (D.U.S.P.) changed hands at the beginning of the 1978-79 academic year. Professor Langley Keyes stepped aside and Professor Lawrence Susskind assumed the post of Department Head. In addition, Professor Bernard Frieden is now in the newly created position of Executive Officer. With the assistance of the various degree program directors, activity area coordinators, and students, and with the active support of Dean William Porter, the new departmental leadership has initiated a series of activities aimed at sharpening the focus of each of the degree programs, building strong bridges to other departments and centers at M.I.T., creating a tighter and more supportive scholarly community within the Department, enhancing the volume of sponsored research, and working to reshape public perceptions of the planning profession.

FOCUSING THE DEGREE PROGRAMS

The Undergraduate Program

Professor Aaron Fleisher, director, and Professors Lawrence Bacow and Joseph Ferreira, associate directors, proposed a long overdue re-orientation of the undergraduate (S.B.) program. They have urged a move away from an emphasis on the study of problems in cities toward a more professional emphasis on the management of urban systems and the implementation of public policy.

The undergraduate program continues to attract students interested in pursuing a variety of career paths, especially in the environmental planning field. The Course XI undergraduate program also serves a great many students, majoring in other departments, who are interested in the application of scientific and engineering principles to the resolution of urban and environmental

problems. This past year, the Department of Urban Studies and Planning initiated a new undergraduate option focused on the special problems of developing nations.

The Professional Degree Program

Professor Ralph Gakenheimer, director, and members of the Master's in City Planning (M.C.P.) Committee spent a substantial amount of time this past year searching for ways of strengthening the professional focus of the Master's program. A great deal of emphasis was placed on ways of highlighting the issues of race, ethnicity, and poverty in the core subjects that all professional degree candidates are required to take. The Department of Urban Studies and Planning continues to attract one of the most racially and internationally mixed student bodies in the country.

Most students enter the M.C.P. program with prior work experience on which they are anxious to build. The Department's continued focus on fieldwork and internships responds, in part, to this desire to "learn by doing." New proposals intended to introduce additional workshops, practicums, and a client-centered thesis option into the curriculum were discussed briefly, and will receive further attention next year.

M.C.P. students are also interested in acquiring advanced analytical skills. The introduction of six new Methods Modules provides students a chance to select a package of analytical and public management skills matched to their specializations. As always, the D.U.S.P. continues to search for new ways of blending analytical studies with a focus on action.

Doctoral Program

Professor Robert Fogelson, director, and the members of the Ph.D. Committee reiterated the Department's intention to keep the doctoral program focused broadly on research and teaching in applied social science. The Department of Urban Studies and Planning graduated its largest number of Ph.D.s ever (12). This increase in the number of graduates is the result of the Ph.D. Committee's implementation, over the past several years, of a more intensive monitoring program aimed at tracking student performance and intensifying faculty advising.

SPURS

The Special Program in Urban and Regional Studies (SPURS), headed by Professor Lloyd Rodwin, admitted its largest class ever (18). Mid-career professionals from Japan, Poland, Chile, other Latin American countries, and Africa spent the year in the Department taking classes and pursuing individual research interests.

Since the Fellows are encouraged to pursue an individual course of study, the only components common to all Fellows are two weekly seminars. The Wednesday luncheon seminar provides an opportunity for Fellows to meet a wide range of guest speakers. This year the speakers included, among others, Professor Erwin Galantay of the Ecole Polytechnique Federale de Lausanne in Switzerland; Professor Koichi Mera of the University of Tsukuba in Ibaragi, Japan; Professor Paul Samuelson of the Department of Economics at M.I.T.; and John F.C. Turner of University College in London.

In addition, SPURS, together with the Department, hosted two more extended visits. In October, Professor Ignacy Sachs, director of the International Research Center on Environment and Development and a leading member of the European environmental movement, spent two weeks at M.I.T. as the Charles Abrams Visiting Professor giving lectures and seminars on appropriate technology and environmental issues in developing countries. In April, Professor Antoni Kuklinski of the University of Warsaw in Poland spent a week here. Professor Kuklinski is the editor of the 10-volume UNRISD (United Nations Research Institute for Social Development) series *Regional Planning*. He met with faculty and students to discuss the work of UNRISD and possibilities of extending collaborative relationships between the University of Warsaw and scholars in North and South America.

The M.I.T. SPURS Association was created last year to provide an information network among the growing number of SPURS alumni around the world. In December the Association sent a mailing to all past participants, which has resulted in a slow but steady stream of responses.

The Community Fellows Program

The Community Fellows Program, headed by Adjunct Professor Melvin King, had a somewhat smaller group of Fellows (6) than usual. The Program continues to attract mid-career community activists concerned with a range of problems that people of color face in contemporary America. Applications to the Community Fellows Program reached their highest level ever, but the problem of finding a stable funding base sufficient to maintain the desired scale and mix of fellows persists.

BUILDING BRIDGES TO OTHER DEPARTMENTS

One of the strengths of our Department, compared to other urban and regional planning or urban affairs programs throughout the United States and the world, is that the D.U.S.P. maintains close connections with a great many related departments and centers at M.I.T. and Harvard. These bridges allow students to pursue interdisciplinary courses of study, provide a context for collaborative research and teaching, and permit scholars and activists interested in planning and policy implementation in the public sector to build on the insights and accumulated knowledge of a wide range of disciplines.

A number of D.U.S.P. faculty members hold important leadership positions in various M.I.T. centers or interdepartmental programs. Professor Arthur Solomon continues to serve as Head of the M.I.T.-Harvard Joint Center for Urban Studies. The Joint Center, once again, provided national leadership in defining the housing, economic development, and social welfare problems confronting urban America. Michael Joroff was promoted to the post of director of the Laboratory of Architecture and Planning. The L.A.P. provides a common ground for architects and planners with shared research interests in environmental management, the implementation of appropriate technology, energy facility siting, building technology, and the invention of new data management systems. The L.A.P. also helps to disseminate the ideas generated by the D.U.S.P. faculty and students through its continuing education program.

Professor Richard Larson assumed the post of co-director of the Operations Research Center. Students and faculty in the D.U.S.P. were part of research projects at the O.R. Center aimed at applying operations research techniques to the improvement of public service systems. Professors Donald Schon and Martin Rein continued their affiliation with the Division for Study and Research in Education. The DSRE connection allows students and faculty to devote time and energy to theories of professional practice and ways of enhancing the capacity of public organizations. Professor Gakenheimer played an important role in the implementation of a new Transportation Studies curriculum in the Center for Transportation Studies and in maintaining the joint S.B. that the D.U.S.P. and Civil Engineering offer in Environmental Studies. Professor Bacow headed the Institute-wide Environmental Studies Colloquium, sponsored by the Program in Science, Technology, and Society. Professors Bacow and Michael O'Hare developed a collaborative research project with the Center for Energy Policy in the Energy Laboratory. Professor Susskind served as a member of the Advisory Committee to the Engineering School's Technology and Policy Program. Professors Gakenheimer and William Wheaton were part of M.I.T.'s T.A.P. Project.

Almost one-quarter of the subjects offered in the Department of Urban Studies and Planning this past year were jointly listed with other departments or centers at M.I.T. Eight members of the tenured faculty hold joint appointments with other departments. All of these efforts to tie the D.U.S.P. more closely to other departments and centers at M.I.T. will continue.

THE SCHOLARLY COMMUNITY

One complaint about the D.U.S.P. over the past several years has been that too many of the faculty and students have centered themselves intellectually outside the Department. In part, this is unavoidable given the explicitly interdisciplinary and applications-oriented faculty we have selected. A number of steps, however, were taken this year to counter the centrifugal forces that aggravate the problem of fragmentation. Several student-faculty groups planned and implemented lecture series and discussion groups. One student group organized a well-attended film/discussion series on Race, Ethnicity, and Poverty. A second student group organized a

year-long seminar on New Perspectives on Urban Economic Development which brought such distinguished speakers and city administrators as Norman Krumholz from Cleveland to debate current city development policies and approaches. A third student group, organized by William Ronco and Mary Doebele, continued the discussions on planning practice initiated last year by Professors Schon and Rein. This group attracted an excellent array of practitioners who were pleased to reflect on their practice. Finally, Philip David organized a speakers' series on Public-Private Partnerships in City Development that brought some of the top real estate developers on the East Coast to engage students in discussions about the ways in which planners and public policy makers can better serve the private sector.

These lecture series and discussion groups were supplemented by the publication of a biweekly D.U.S.P. Newsletter. Also, the Department initiated the D.U.S.P. Alumni Newsletter and the D.U.S.P. Program Guide under the able editorship of Jeffrey Cruikshank. These new communication tools, in conjunction with the space remodeling on the third floor of Building 7 (creating the D.U.S.P. Common Room and Student Reading Room) have provided new opportunities for student-faculty interaction and Department-wide exploration of issues of common concern.

SPONSORED RESEARCH

The volume of sponsored research in which D.U.S.P. faculty are involved has grown to \$1,150,000 annually. Much of this research flows through the various centers and laboratories with which our faculty members are associated. About \$250,000 in contract research funds flows directly through the Department each year.

Ten research projects with annual budgets of more than \$50,000 were in operation this year. These projects provided 25 research assistantships. Project funding came from the US Department of Housing and Urban Development, the Economic Development Administration in the US Department of Commerce, the US Department of Transportation, the Department of Energy, the Rockefeller Foundation, the Ford Foundation, the German Marshall Fund of the United States, the US State Department, the Agency for International Development (AID), and the Federal Trade Commission. Projects focused on energy facility siting, environmental impact assessment, urban impact assessment, regional input-output analysis, policies for center city revitalization, citizen participation in Western Europe, national growth and development policies for Egypt, discrimination in mortgage lending in the banking industry, economic development in New England, mediation of environmental disputes, family and social welfare policy, institutional obstacles to the implementation of photovoltaic technologies, evaluation of criminal justice plans and programs, and public support for the arts. The volume of sponsored research in which our Department is involved is growing, in part, because of the administrative support and space provided by the Laboratory of Architecture and Planning, the M.I.T.-Harvard Joint Center for Urban Studies, and other centers and laboratories.

PUBLIC PERCEPTIONS OF THE PLANNING PROFESSION

Members of the Department's faculty were involved this year, as in the past, with the work of various professional organizations concerned with planning. The merger of the American Institute of Planners and the American Society of Planning Officials will make it easier for students and faculty to follow the current debates in the planning field. Two of the most controversial issues concern the registration (licensing) of planning practitioners and the formal accreditation of university planning programs. The D.U.S.P. played a major role in the fight to keep the review of educational programs firmly under the control of university faculty.

D.U.S.P. students and faculty were heavily involved in neighborhood and city-wide activities in the Boston region as well as in other parts of the country. Members of the faculty served as advisors, consultants, and board members to a variety of public interest groups, neighborhood advocacy groups, as well as city, state, and national agencies on questions of urban and environmental policy. Student-faculty teams worked on projects in Cambridge and Boston supported in part through the HUD Intern Program and the Office of Education's Public Service Intern Program. Through these client-centered activities as well as fieldwork and internship programs, students and faculty at M.I.T. help to shape public perceptions about the planning profession.

A number of key books and articles published by D.U.S.P. faculty this past year also contributed to the Department's ongoing effort to help shape public thinking about key policy issues: Robert Fogelson's *Big City Police* (Harvard University Press), Bernard Frieden's *The Environmental Protection Hustle* (MIT Press), Alan Altshuler's *The Urban Transportation System* (MIT Press), Donald Schon's *Organizational Learning* (Jossey-Bass Publishers), and Ralph Gakenheimer's *The Automobile and the Environment: An International Perspective* (MIT Press).

OTHER DEVELOPMENTS

There were several additions to and departures from the D.U.S.P. faculty this past year. Professor Bacow joined the faculty as Assistant Professor of Law and Environmental Policy. Thomas Willemain, Associate Professor of Urban Studies and Planning, has left the faculty. Three distinguished visitors -- David Wheeler, Assistant Professor of Urban Studies and Economics, Paolo Cecerrelli, Visiting Professor of Urban Studies and Planning, and Bernard Gifford, Visiting Associate Professor of Public Policy -- came to the Department for one term or for the year.

The D.U.S.P. has initiated a postdoctoral fellows program that will expand the number of top-notch young researchers associated with the faculty in the years ahead. This past year, Dr. Harry Minor held a postdoctoral appointment. Next year there will be four postdoctoral fellows. These appointments, as well as those of approximately 10 graduate student instructors, were facilitated by the largest gift the Department has ever received, a \$1.2 million gift from an alumnus.

Finally, the Department has initiated its own job placement service under the direction of Nancy Smith (Class of 1977). Ms. Smith has organized a counseling and job search program that will aid D.U.S.P. alumni as well as current students. Recent graduates of our program continue to find extremely desirable teaching, research and public management positions throughout the world.

LAWRENCE SUSSKIND

Laboratory of Architecture and Planning

With guidance from the School Council, the Laboratory of Architecture and Planning (L.A.P.) continued to provide a variety of support services to research and community service projects carried out by faculty, L.A.P. research staff, and students of both departments. The L.A.P. also launched several development efforts to shape new initiatives in research and curricula.

The L.A.P.'s overall objective continues to be to: further the state of the art of practice and teaching in the fields of architecture and planning; link the School with the activities of practice; and encourage research about areas of emerging concern to society and the professions. The L.A.P.'s mission within the School continues to be one of experimentation and incubation of new ideas and approaches.

Michael L. Joroff became the director of the Laboratory in January. John Klensin rejoined the L.A.P. staff as principal research scientist. His field of expertise is computer methodology and its application to complicated social policy issues. Douglas Mahone joined the L.A.P. staff as a research associate. He will continue work begun last year, for the Department of Architecture and the Energy Laboratory, to shape a broad program of research about energy and buildings. The L.A.P.'s new Practitioner Affiliates Program brought six accomplished practitioners into the L.A.P. to help initiate research about matters of high priority. These affiliates, who work on L.A.P.-based projects while continuing to pursue their professional activities, bring additional strength to the Laboratory in the fields of: architectural criticism, community development, and communication.

Lois Craig, a professional writer about architecture and urban issues, recently completed a major study about Federal architecture for the National Endowment for the Humanities. This was published by the MIT Press. Rolfe Goetze (1975 D.U.S.P. Ph.D. recipient), a senior staff member

of the Boston Redevelopment Authority, has published major studies about neighborhood development. Ralph Hansen, an inventor and retired executive of the Monsanto Corporation, collaborated with M.I.T. architects in the 1960s to design prototype houses and educational classrooms. Thomas Piper (1975 M.Arch. recipient) has frequently collaborated on video projects with researchers in the School. Michael Sand, an industrial designer, specializes in the design of educational environments and children's museums. Mark Waltch (1976 D.U.S.P. Ph.D. recipient) has broad experience in development and housing research.

Dr. Judith Johnston, a Harkness Fellow from New Zealand, joined the L.A.P. as a visiting scholar. Donna Herlehy, formerly an assistant director of the Office of Sponsored Programs, became the L.A.P.'s administrative officer.

Newly funded and ongoing research projects in the Laboratory include the following:

The M.I.T. Solar Demonstration Building is directed by Research Associate Timothy Johnson. This project, funded by the Department of Energy, private industry, and generous and timely support from the Cabot Fund, resulted in the construction of M.I.T. Solar House 5, completed in April 1978. Eight hundred square feet of experimental building was created at the west end of Briggs field, along Vassar Street. The building demonstrates passive solar heat and cooling using new building materials developed at M.I.T. and by several industrial concerns. New experiments in cooling were initiated this year, and detailed material testing continues.

The Energy Impacts Project, directed by Professor Michael O'Hare, is funded by the Department of Energy. The project continued its work to develop: 1) a facility siting process that reveals social costs and compensates people for them; 2) an information process that packages information which facilitates various types of decision making; and 3) six case studies of previous energy facility siting efforts. The project presented several workshops for interested participants from around the nation.

Relating Transportation to Neighborhood Change is directed by Senior Research Scientist and D.U.S.P. Lecturer David Birch. Funded by the Department of Transportation, the project is to assess the effects of changes in transportation technology and energy costs on neighborhood change.

The ACCESS Project, directed by Dr. Birch, is funded by a wide array of public and private agencies. This project provides studies through an innovative data system (available nationwide) for analyzing large social science data files. The system now contains data for 4.5 million firms, 1.5 million members of the work force, 2 million individuals, 55,000 households, and 30,000 consumers as well as extensive measures of counties and our metropolitan areas over time. Individual clients request special studies.

Firm Behavior as a Determinant of Economic Change is funded by the Department of Commerce and directed by Dr. Birch. The project's basic goal is to understand how employment change takes place. Our approach is to focus at the micro level (with a data file of 5.6 million business establishments) and to build up and explain change in terms of the activities of these individual parts. The work has proceeded along two levels: 1) national and regional patterns, and 2) changes within the metropolitan areas. In addition, we have been developing special methodologies to deal with the massive data sets involved in this kind of effort.

The Economic Role of Small Business Project, directed by Dr. Birch and funded by the Small Business Administration (SBA), prepared material for a White House conference on small business. The project analyzed the role that small businesses play in creating jobs and bringing about economic change. The project has led to the production of extensive tabulations for each of the 10 SBA regions as well as for each of the 50 states.

Economic Change Within Minnesota, directed by Dr. Birch, is funded by Dun and Bradstreet. This project analyzes employment change in detail by county within the state of Minnesota in an effort to understand and explain why different parts of the state are growing as they are. In addition, the project is comparing Minnesota's experience to that of surrounding states to judge relative performance.

Urban Patterns of Change is directed by Professor Anne Vernez-Moudon and funded by the National Endowment for the Arts. The project describes the growth of San Francisco, and the

influence of zoning and public policy on changes in land and built open space patterns which have taken place over the past 100 years. A national conference was held to discuss the project's significance to researchers and city officials.

Boston Neighborhood Network, directed by Professor Hollister and funded by a planning grant from the National Science Foundation, is an innovative project which aims to make university-based research useful to leadership of neighborhood organizations. The Network, directed by a board composed of university researchers and Boston neighborhood leaders, presented workshops, seminars, and conferences about such diverse subjects as mortgage lending patterns, use of appropriate technology, and social indicators as tools for guiding neighborhood development. Researchers from several of the area's universities and a number of state and local government officials joined the Network staff in the year's efforts.

An agenda for environmental design research was prepared by Professor Sandra Howell for the National Science Foundation. "Independent Living in Boston for the Handicapped", "Trash" (a program about waste management), and "Copley Square" were three successful video films prepared by L.A.P. Research Affiliate Thomas Piper. The projects were funded respectively by the Boston Center for Independent Living, the Environmental Impact Assessment Project (funded by the Rockefeller Foundation), and the Massachusetts Office of State Planning. The first film is being used for staff training in the United States and Europe; the second was shown as a three-part series on WGBH-TV news; and the latter has been used for community meetings and will be developed as a case study for national distribution.

The L.A.P. now serves as the overall administrative home for the new Aga Khan Program in Islamic Architecture. In addition to professorships which will be located in the Department of Architecture and a documentation project centered in the Rotch Library which will build the collection of written and visual materials, there will be summer institutes, a faculty exchange program, and other activities to strengthen the Program, and to link it with its counterpart program at Harvard, with other programs here at M.I.T., and with institutions and individuals throughout the world.

In addition to these research efforts, the L.A.P.'s staff, working with interested faculty, began development efforts to help the School broaden research, teaching, and continuing education efforts for several areas of concern of high priority as identified by the School Council. In each case, advice was sought from practitioners in the field, including members of the School's Visiting Committee, and representatives of client organizations.

Our primary development effort this past year focused on the area of energy and buildings. Efforts, in part supported by the Cabot Solar Fund, were closely coordinated with the Energy Laboratory, and were guided by an advisory committee which brought together faculty from throughout the Institute, members of the School's Visiting Committee, and renowned practitioners. The School established a developmental strategy, and our work in the field was given significant recognition when M.I.T. was chosen to host the annual American Institute of Architects/Department of Energy Summer Institute to train teachers of architecture about energy-conscious design. We are now completing arrangements with the US National Park Service to create a Cooperative Parks Study Unit at M.I.T. to carry out a five-year research effort to focus on energy-conscious design and application of appropriate technology in the nation's national parks.

Similar development efforts were begun concerning environmental design for special needs groups, and the use of the media by public agencies. Planning also has begun to develop a major program of Architectural Case Studies, a unique effort with potential impact on all of the nation's professional and continuing education programs. The L.A.P. continues to provide support to research staff working in already established areas of priority interest, including environmental management, neighborhood development, and the development of methodologies used by our professions.

The L.A.P. continues to use the Continuing Education Program both as a way of providing a service to alumni and practitioners and to promote the School's research agenda. Regular faculty and local professionals teach the courses. The summer programs are run jointly with the Office of Special Programs at the Harvard Graduate School of Design. This collaboration is one of the most active public areas of joint venture between the two schools. We share a brochure with Harvard, but run our courses at M.I.T. facilities. In the summer of 1978, M.I.T. offered seven courses to which we attracted several hundred people. The courses offered were: Realities of Historic

Laboratory of Architecture and Planning

Preservation, Design of Street Furniture, The Planning Process, Issues of Environmental Design, Neighborhood Planning, Japanese Gardens, and Environmental Impact Assessment.

During M.I.T.'s Independent Activities Period, the L.A.P. offered seminars open to practitioners and alumni. Costs are low and the courses are not given for credit.

In 1979 the L.A.P. began an organized publications program in order to provide wide circulation to reports and papers prepared by School-based research efforts. The program distributes a variety of publications dealing with architecture, public policy, planning, and design.

MICHAEL JOROFF



School of Engineering

The past year was one of great activity and accomplishment in the departments that constitute the School of Engineering. Elements of this activity include continued growth in engineering enrollments, new leadership in several departments and in the Dean's Office, initiation of new academic and research programs, and the continued success of existing programs.

The number of undergraduates selecting careers in engineering continues to increase, albeit at a slower pace than in previous years. Overall undergraduate enrollment increased from 2,013 in the 1977-78 academic year to 2,068 in the 1978-79 academic year. This is an increase of slightly less than three percent as contrasted with growths of 10 percent or more in the previous three years. Indeed, the growth rate this past year was the smallest since 1972. This suggests that enrollments in engineering may be peaking and will level off or even decrease in the future. However, at present more than 61 percent of the designated undergraduates at M.I.T. are enrolled in engineering departments. Departments that are particularly affected by this latest increase include: Aeronautics and Astronautics, up 14 percent; Chemical Engineering, up 10 percent; Materials Science and Engineering, up 56 percent; and Mechanical Engineering, up 17 percent.

Graduate enrollments in engineering are holding steady at about 1,830 students, or 47 percent of the total graduate student population. There have been very small changes in the number of students in each department within the School. The foreign student fraction of graduate students is also holding steady at about 35 percent for the School as a whole.

Efforts at recruitment of minority students are slowly paying dividends and enrollments continue to improve, albeit very slowly. In the past year there were 232 minority members in their second, third, or fourth year of study in the School. This represents 11.2 percent of the designated undergraduates, and is an increase of 24 students over the previous year. The minority graduate population increased from 67 to 82 full-time degree candidates, and minorities are now 4.5 percent of the graduates in engineering. It is doubly difficult to attract qualified, minority group undergraduates to graduate school. First, the pool size is small, much smaller than the pool for undergraduate admissions. Secondly, opportunities in industry for minority engineers are extraordinary in terms of job attractiveness and starting salary. As a result, it is very difficult to convince a young person of the personal benefits of further expensive education.

There has been very little change in the enrollment of women in undergraduate engineering programs. At present, women constitute 12.5 percent of designated engineering undergraduates. The number for 1978-79 was 258, up 6 from 1977-78. We do not expect any dramatic increases in the future as other fields remain very attractive to women students. Conversely, our graduate programs are attracting more women and enrollment is up from 118 in 1977-78 to 146 this past year. We believe this trend will continue with the advent of greater interest in applied science and technology in present-day society. Thus, more and more graduates of science programs are attracted to graduate study in the engineering professions.

The increasing enrollments in the School are very gratifying in that they indicate the relevance and quality of our programs. Indeed, a recent poll of educators published in the January 15, 1979 issue of the *Chronicle of Higher Education* ranked M.I.T. as number one in engineering. This perception is obviously shared by our students. Nevertheless, the high enrollments also place a considerable burden on the faculty and other resources of the School.

The faculty size in the School has remained essentially constant for the last seven years, at about 330 members. The designated undergraduate student-to-faculty ratio is now at 6.3 to 1, while the graduate student-to-faculty ratio is 5.5 to 1. These ratios are higher than desirable if we are to maintain the quality of the education we offer. The continued maintenance of quality is a tribute to the dedication of the faculty.

School of Engineering

In order to relieve the pressure of high enrollments, a great deal of emphasis has been placed upon increasing the size of the faculty, particularly the junior faculty. We have worked in close cooperation with the Development Office to generate industrial support for endowed and/or career development professorships. In addition, we have actively sought support for curriculum development. With the limited budgets of past years, we have not been able to sponsor adequate faculty effort at developing new subject matter at both the graduate and undergraduate levels. To assist in this vital area of education, we have made curriculum development a cornerstone of our program within the Leadership Campaign. We are pleased that we have received support from several generous sponsors, and hope to continue this trend in the last year of the campaign.

The School of Engineering initiated a special Engineering Internship Program in 1977-78 under the direction of John Martuccelli, and reporting to the Office of the Associate Dean for Educational Programs. Reports follow on the Internship Program, the other areas reporting to the Associate Dean for Educational Programs, and the Committee on Engineering Education.

EDUCATIONAL PROGRAMS

The 1978-79 academic year was one of substantial activity for the Office of the Associate Dean for Educational Programs. A number of new programs were undertaken and several ongoing programs experienced healthy growth. In addition, the Associate Dean for Educational Programs served as the representative of the School of Engineering in a number of areas and committees. This report summarizes the major activities of the Office over the past year.

Engineering Internship Program

This academic year marked the second year of operation of the School of Engineering Internship Program. This program combines traditional on-campus academic experience with off-campus experience in industry and government. It is designed principally as a joint undergraduate-graduate program that leads to the simultaneous award of the Bachelor's and Master's degrees.

Students in the School of Engineering may participate in the Program by registering in the appropriate department. Programs have been established in the Departments of Aeronautics and Astronautics, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, and Ocean Engineering. Students will normally enter the Program in the summer following their sophomore year and typically spend three summers and one graduate term in residence at a participating company or government agency, receiving academic credit while earning a salary to help defray their educational expenses.

The second class of 43 sophomores started their summer work assignments at 22 participating companies in June 1979. In addition, most of the first year's class of 32 students returned for their junior year work experience. This year's 43 students were selected from an applicant pool of 110 on the basis of student-company interviews held during March. Starting salaries range from \$783.00 to \$1,100.00 per month.

The Engineering Internship Program provides a small number of places for students in the Department of Electrical Engineering and Computer Science; four of the 43 students placed this year came from the Department. However, students from E.E. & C.S. are usually placed through the ongoing and very successful Course VI-A Program, which runs parallel with E.I.P. If we consider all participating departments, excepting E.E. & C.S., 33 percent of the sophomore class applied to the Program, with 14 percent accepted to and participating in E.I.P.

The 22 companies currently participating in the Program are: American Can Co., Greenwich, Connecticut; Barkan Construction Co., Chestnut Hill, Massachusetts; Boeing Vertol, Philadelphia, Pennsylvania; Boston & Maine Railroad, North Billerica, Massachusetts; Brown & Root, Inc., Houston, Texas; Chrysler Corporation, Detroit, Michigan; Commonwealth Edison Co., Chicago, Illinois; Computervision Corporation, Bedford, Massachusetts; C.S. Draper Laboratory, Cambridge,

School of Engineering

Massachusetts; E.G. & G. Idaho, Idaho Falls, Idaho; General Electric Co., Philadelphia, Pennsylvania; General Motors Technical Center, Warren, Michigan; Gruman Aerospace Corp., Long Island, New York; Hazeltine Corp., Braintree, Massachusetts; Hughes Aircraft, Los Angeles, California; Lincoln Laboratory, Bedford, Massachusetts; Northrop Corporation, Norwood, Massachusetts; Philips Laboratories, Briarcliff Manor, New York; Sikorsky Aircraft, Stratford, Connecticut; Transportations Systems Center, Cambridge, Massachusetts; Weyerhaeuser Company, Tacoma, Washington; Yankee Atomic Electric Company, Westboro, Massachusetts.

Efforts to enroll several new companies for participation beginning in summer 1980 will begin this fall, following an evaluation of department and current company requirements.

In keeping with the procedures set up in summer 1978, each of the 22 participating companies will be visited this summer by the companies' faculty representative (a faculty member assigned to each company to provide a liaison among the company, students, and M.I.T.) and the administration of the Engineering Internship Program.

School-Wide Elective Program

This year the Engineering School's five School-Wide Electives were offered for the first time. These five subjects, selected by an ad hoc faculty committee from the School of Engineering, are as follows: 1) Computer Models of Physical and Engineering Systems I, taught by Professors Roy Kaplow and M. Elizabeth Schumaker; 2) Management in Engineering, taught by Professors Robert T. Lund, David P. Hoult, and George C. Newton, Jr.; 3) Introduction to Technology and Law I, taught by Professor J.D. Nyhart; 4) Dynamics of Physical and Social Systems, taught by Professors Jay Forrester, Joel P. Clark, and B. Shawn Buckley; and 5) Entrepreneurship, taught by Professors Newton and Y.T. Li.

The first set of subjects was selected with evaluation of the School-Wide Elective concept in mind, and hence these subjects are an attempt to represent the broad range of interdepartmental interests in the School of Engineering. Several of these subjects were originally created through School of Engineering funding provided in the recent past.

The program is primarily concerned with subjects that typically are not central to the core of any departmental program, but rather are important elective subjects of interest to students throughout the School of Engineering. The goal of the Program is to provide an intellectual and administrative mechanism for the development and evolution of such subjects, while not interfering with the traditional department curricula development process.

The S.W.E. program is being conducted as a two-year experiment authorized by the Committee on Educational Policy (C.E.P.). In June 1980, the ad hoc committee will make a recommendation to the C.E.P. as to whether or not S.W.E. should become a permanent part of the M.I.T. curriculum. Toward this end, there is a substantial effort to evaluate the impact and value of the program. Questionnaires have been distributed to students taking those subjects and it is expected that selected faculty and student interviews will be conducted as well.

Based on the judgement of the faculty committee, two new potential S.W.E. offerings will be planned and conducted in the coming year.

In cooperation with Information Processing Services, a two-week Computer Programming Mini-Subject will be offered during January Independent Activities Period. Offered on a non-credit basis, the subject would provide an alternative path for students who are interested only in learning to program. Currently, many such students take formal full-term computer subjects which include material not along the lines of their primary interests.

A potential new risk assessment subject will be developed in fall 1979 for offering in spring 1980. The subject dealing with risk assessment and evaluation will be taught by Professor Marie-Elisabeth Paté of the Department of Civil Engineering. It will build upon an experimental subject she offered this past year. Offered in conjunction with this course will be a mini-subject in probability for those students not adequately prepared in this area. The ad hoc committee feels that this subject matter is of substantial importance to the School of Engineering and that no current subject adequately covers the broad issue of risk in engineering project analysis. For this reason, it was deemed appropriate to develop this subject within the S.W.E. experimental program.

Dual Major Program

Based on a proposal submitted to the National Science Foundation Comprehensive Assistance to Undergraduate Science Education program by the office of the Associate Dean for Educational Programs and the Committee on Engineering Education, M.I.T. was awarded three years of support to investigate the feasibility of undergraduate dual majors. The project began in September 1978.

A dual major is defined as a Bachelor's program in which the degree is recommended by two departments and the student meets the spirit of the degree requirements in each of the two departments. The specific need addressed is that of designing educational programs in engineering *at the undergraduate level* which provides the student with more career options and more broadly based training than currently exists. Several important instances of this are the training of engineers with competence in several engineering disciplines, the training of engineering managers, and the training of engineers with a special interest in the societal impacts of science and technology.

The project is under the direction of Professor Joseph M. Sussman, Associate Dean for Educational Programs in the School of Engineering. In addition, four other faculty members have played important roles in the project: Professor Leon Trilling of the Department of Aeronautics and Astronautics and the Program in Science, Technology, and Society; Professor B.J. Wuensch of the Department of Materials Science and Engineering; Professor Hermann Haus of the Department of Electrical Engineering and Computer Science; and Professor Michael Meyer of the Department of Civil Engineering and the Program in Science, Technology, and Society.

The first three faculty members currently serve on the Committee on Engineering Education, which is the continuing focus point for the research in the School of Engineering. In addition to these faculty members, several students have been involved in the data analysis aspect of this research.

The project is composed of six activities: 1) Study of "Dual Competency" and "General Engineering" programs at other institutions and accreditation procedures for dual competency programs; 2) Examination of programs currently taken by M.I.T. engineering undergraduates; 3) Review of and coordination with existing and related activities at M.I.T.; 4) Development of dual majors between cooperating departments in the School of Engineering; 5) Development of dual majors between an engineering department and the Sloan School of Management; and 6) Development of dual majors between an engineering department and another academic program in societal impacts of science and engineering. The emphasis thus far has been on the first three activities. Of particular interest is our extensive analysis of the transcripts of the Engineering School's Class of 1978.

Engineering/Writing Program

The Office of the Associate Dean for Educational Programs played a substantial role in the administration of the Cooperative Engineering/Writing program. This program involves faculty members from the Writing Program (housed in the School of Humanities and Social Science) working in cooperation with the departments in the School of Engineering to enhance the writing skills of engineering undergraduate and graduate students.

The undergraduate program integrates the teaching of writing skills with engineering material, typically in required engineering projects subjects. Writing faculty members conduct lectures in these subjects, and students are graded on both their technical and writing skills. Graduate teaching assistants for these subjects participate in a twice yearly seminar on evaluation of written exercises. All eight departments in the School of Engineering participate in the undergraduate program.

In the graduate program, incoming graduate students take a diagnostic examination to test writing skills. This exam is administered by the Writing Program faculty. Those students who do not perform up to standard must take remedial work (such as an Independent Activities Period subject, a full semester subject, or an individual writing project). The program is under way in the Department of Mechanical Engineering. Next year, it will be implemented in the Departments of Aeronautics and Astronautics and Ocean Engineering. In subsequent years, it may be possible to expand it throughout the School of Engineering.

Scholarships and Awards

The Office of the Associate Dean for Educational Programs continued to coordinate the award of the General Motors scholarships to engineering students. Six new scholarships to students from the Departments of Electrical Engineering and Computer Science, Mechanical Engineering, and Aeronautics and Astronautics were awarded this year.

In addition, this office coordinated the award of Kodak scholarships to our second class of three Kodak scholars. Currently, there are six Kodak scholars in residence.

The Honeywell Company sponsored an award for the second year. M.I.T. was chosen as one of 12 schools nationwide to receive the Honeywell Award for Outstanding Achievement in Engineering, consisting of a plaque and \$300 check to an engineering student selected by M.I.T., and a permanent plaque and \$300 check to the School of Engineering. The School's check was presented to the selected student's Department. This was coordinated through this office and was awarded to Lorraine Olson, a junior in the Department of Mechanical Engineering.

Finally, the Office of the Associate Dean for Educational Programs coordinated the Electric Connector Study Group's award for \$2,000 to be applied toward tuition. William J. Warner, a junior in the Department of Electrical Engineering and Computer Science, was the recipient

Miscellaneous

The Associate Dean for Educational Programs participated in a variety of other activities and functions during the past academic year. Among these were the following: member of the Committee on Engineering Education; member of Engineering Council; member of Faculty Council; member of the Steering Committee for the Mineral Resources Engineering and Management program; member of the Advisory Group for the prospective College of Science, Technology, and Society; Chairman of ad hoc tenure committee for transportation faculty; served on Faculty Committee for Operations Research; member of Planning Committee for the Alumni Officers Conference; served on Committee on S.M. Program in Management of Technology; served on Faculty Advisory Committee for Center for Advanced Engineering Study; member of Science Requirements Group chaired by Dean Robert Alberty of the School of Science; served on the Center for Transportation Studies Committee on Academic Program; participated in a number of meetings at M.I.T. with delegations from the People's Republic of China; in cooperation with the Placement Office and in support of the Engineering Internship Program, met with a number of industrial firms interested in employment of M.I.T. engineering students; served as the School of Engineering representative at Academic Midway in September 1978; coordinated M.I.T. response to First National Solar Energy Education Survey; initiated and coordinated meetings of undergraduate and graduate officers in the School of Engineering; participated in series of luncheons for junior faculty; coordinated School of Engineering letter to Education Counselors; and gave a presentation on the School of Engineering to prospective freshmen from the New England area.

COMMITTEE ON ENGINEERING EDUCATION

This year, Professor Leon Trilling completed three years as a member of the Committee on Engineering Education, including a year and a half as its Chairman, and has summarized herein some present and likely future Committee activities.

The freshman seminar entitled What is Engineering? aims to introduce freshmen to the various fields and aspects of the engineering professions through discussions presented by our engineering departments and study in some depth of three major engineering tasks or projects -- including their technical, and some of their social, economic, and political contexts. Students are asked to report on an interview with an engineer at mid-term and on one of the projects at the end of the term. In 1977, the enrollment was 40 students and in 1978, it was 80 (with an initial 115). Most sessions have been videotaped, and a proposal is pending before the

National Science Foundation (NSF) to train some high school teachers to use the tapes in either science, or better still, social science courses.

The Committee on Engineering Education retains an interest in the School-wide Electives experiment. It promoted and strongly supports the joint activity of the School with the Writing Program. (Both of these programs are described in detail under "Educational Programs.") The program's newest task (sparked by Professor Ain Sonin of the Department of Mechanical Engineering) is to provide the support needed for graduate students in engineering as an English proficiency doctoral requirement begins to replace the foreign language requirement; this is already in effect in Mechanical Engineering and will be in Aeronautics and Astronautics in the fall of 1979.

Under the leadership of Professor Sussman, the Committee on Engineering Education formally oversees and several individual members have participated in developing a project for dual degrees (between two engineering departments, with the Sloan School and with the Program in Science, Technology, and Society) which would broaden the options available to engineering undergraduates. That project is funded by NSF.

The Committee on Engineering Education has a continuing interest in the development and growth of the Engineering Internship Program led by John Martuccelli. The Committee is particularly interested in learning how standards may be maintained off campus, since such techniques have great potential importance.

The Committee has held occasional informal meetings with the undergraduate chairmen of the eight engineering departments, to exchange views and experiences. We will no doubt continue this practice, and extend it to meetings with departmental (and laboratory) graduate officers. The Committee is also represented at the bi-monthly meetings on the Science Requirements (Mathematics, Physics, Chemistry) chaired by Dean Alberty.

The Committee on Engineering Education is now participating in (or has undertaken) several initiatives with longer-range implications. It is in close contact with the Program in Science, Technology, and Society to help develop a dual undergraduate major (see above), and also to explore how joint activity with the Program can help M.I.T. and the School develop a pattern of studies capable of providing a substantial number of our undergraduates with a broadened perception of the origin, implications, and consequences of technology on human lifestyle in our industrial society and in developing nations.

The Committee is anxious to revitalize the concept of Disciplinary Area Committees (such as Structural Dynamics, Fluid Mechanics, Thermodynamics, and Control Systems) as centers of discussion among colleagues with common disciplinary interests in different departments. Such committees could act as informal coordinating groups for course scheduling and definition; they could act as sponsors for new subjects useful to the School, but not of critical demand in any department; and they could help coordinate the operation of undergraduate project laboratories.

Last December, the Committee on Engineering Education began to consider some issues of graduate education -- namely, some aspects of the role of centers and laboratories -- and issued a report to the Dean and to the Engineering Council. A number of other graduate education issues should still be considered, including supervised leaves for study-related work in local high technology establishments and other forms of articulation with continuing education schemes. The Chairman of the Committee on Engineering Education is a member of the ad hoc committee appointed by the Dean to study the relation between centers/labs and the engineering departments.

The Committee on Engineering Education has discussed some of the implications for the School of Engineering of the proposals of the Press report on non-faculty staff positions (most recently in its report on graduate study and the centers and laboratories). A number of further points about the relationship between untenured faculty and staff require study.

SCHOOL APPOINTMENTS AND FACULTY AWARDS

There were several major appointments and changes in the School in the past year. Dr. Robert C. Seamans, Jr. became Dean of Engineering on July 1, 1978. He brings to the position long experience in engineering practice and administration, as well as a distinguished career in public service. Prior to his appointment, he was the Henry R. Luce Professor of Environment and Public Policy at M.I.T., and retains that post. His public service has included positions as Administrator of the Energy Research and Development Administration, Secretary of the Air Force, President of the National Academy of Engineering, and Deputy Administrator of the National Aeronautics and Space Administration (NASA).

On January 1, 1979, Professor James D. Bruce became the Director of the Industrial Liaison Program and left the position of Associate Dean of Engineering, where he had served with great effectiveness for nearly eight years. His contributions to engineering education and administration were many and long-lasting. During his stewardship, the School had its period of greatest growth and, hence, greatest stress. In spite of the turmoil of the times, Dean Bruce was able to meet the pressure of the moment and continue planning and development for the future. The School is in a strong position today because of his able leadership.

On January 1, 1979, Professor Kent F. Hansen became the new Associate Dean of Engineering. He was the first chairman of the Committee on Engineering Education and is also a professor of nuclear engineering. On the same date Frederick J. Quivey became the Assistant Dean of Engineering for Administration. Prior to this appointment, he was Manager of Financial Information and Planning at the Sloan School of Management.

Professor Joseph M. Sussman completed his two-year appointment as Associate Dean for Educational Programs on June 30, 1979. His effectiveness in the office has been outstanding, as indicated by the report of activities of his office. Professor Leon Trilling resigned as Chairman of the Committee on Engineering Education effective June 30, 1979, after two years of vigorous and stimulating leadership. He will be succeeded by Professor James W. Mar of the Department of Aeronautics and Astronautics.

Professor Jack L. Kerrebrock, Richard Cockburn Maclaurin Professor of Aeronautics and Astronautics, became Head of the Department of Aeronautics and Astronautics on July 1, 1978. He succeeds Professor Rene L. Miller in this post.

On September 1, 1978, Professor Gerald L. Wilson became Head of the Department of Electrical Engineering and Computer Science, succeeding Professor Wilbur B. Davenport, Jr. In addition, Professor Richard B. Adler became Associate Department Head for Electrical Science and Engineering, and Professor Joel Moses became Associate Department Head for Computer Science and Engineering. They succeeded Professors Paul Penfield, Jr., and Fernando J. Corbató, respectively.

Professor Daniel Roos of the Department of Civil Engineering became the Director of the Center for Transportation Studies on July 1, 1978.

The faculty in the School have received many honors from within the Institute, as well as externally. Recognition from within M.I.T. has come to the following:

Professor James M. Becker of the Department of Civil Engineering was appointed the Class of 1922 Associate Professor for a two-year period.

Professor Rafael L. Bras was selected as the fourth holder of the Gilbert W. Winslow Career Development Chair in Civil Engineering.

Professor Corbató was appointed Cecil H. Green Professor of Computer Science and Engineering.

Professor Joao M. Gomes de Oliveira of the Department of Ocean Engineering was awarded a General Electric Foundation Young Faculty Grant.

School of Engineering

Professor Sheila E. Widnall of the Department of Aeronautics and Astronautics was elected Chairman of the M.I.T. Faculty effective July 1, 1979.

Professor Frederick A. Putnam held the Joseph R. Mares Career Development Chair in Chemical Engineering.

Professor Costas G. Vayenas was named Du Pont Assistant Professor of Chemical Engineering.

Professor David J. Rose of the Department of Nuclear Engineering was selected for the 1979 James R. Killian Faculty Achievement Award.

Recognition of achievement of the faculty in the School from external organizations includes the following:

Professors Peter Elias and Robert G. Gallagher of the Department of Electrical Engineering and Computer Science were elected to the National Academy of Engineering.

Professor Norman C. Rasmussen, Head of the Department of Nuclear Engineering, was elected to the National Academy of Science.

Dean Seamans was the recipient of the 1979 Professional Engineer Award of the National Society of Professional Engineers.

Professor Donald R.F. Harleman of the Department of Civil Engineering received the 1979 Distinguished Alumni Award of the College of Engineering of Pennsylvania State University.

Professor Keith D. Stolzenbach received the 1979 Huber Research Prize of the American Society of Civil Engineers.

Professor Stephen H. Crandall of the Department of Mechanical Engineering was awarded the Trent-Crede Medal of the Acoustical Society of America.

Professor Woodie C. Flowers of the Department of Mechanical Engineering received the Western Electric Fund Award.

Professor Robert W. Mann was renamed Whitaker Professor of Biomedical Engineering in the Department of Mechanical Engineering. He was also recipient of the 37th Engineering Societies of New England Award, and elected a Fellow of the Institute of Electrical and Electronics Engineers.

Professor Frank A. McClintock received the Nadai Award of the American Society of Mechanical Engineers.

Professor Ascher H. Shapiro of the Department of Mechanical Engineering received the degree of Doctor of Science honoris causa from the University of Salford, England. He also received the Townsend Harris Medal from the City College of New York.

Professors Mildred S. Dresselhaus, Sanjoy K. Mitter, and David H. Staelin, all of the Department of Electrical Engineering and Computer Science, were elected Fellows of the Institute of Electrical and Electronics Engineers.

Professor Alan S. Willsky of the Department of Electrical Engineering and Computer Science was named recipient of the 1979 Alfred Nobel Prize of the American Society of Civil Engineers.

Professor János M. Beér of the Department of Chemical Engineering was elected to the Fellowship of Engineering of the Council of Engineering Institutions of Great Britain. He was also elected a Fellow of the American Society of Mechanical Engineers.

Department of Aeronautics and Astronautics

Professor Lawrence B. Evans of the Department of Chemical Engineering was elected a corresponding member of the National Academy of Engineering of Mexico.

Professor Gordon L. Brownell of the Department of Nuclear Engineering was elected a Fellow of the American Nuclear Society.

ROBERT C. SEAMANS, JR.

Department of Aeronautics and Astronautics

Consistent with the current general health of the aerospace industry, the Department of Aeronautics and Astronautics is enjoying a growth in undergraduate enrollment and in funding for its graduate research programs. This year's sophomore class of 51 was slightly larger than that of last year and projections are for a five to ten percent growth again in the coming year. If it stabilizes at this level, the undergraduate population will be about optimum for best use of the Department's faculty and facilities. The current research volume more than adequately supports the present faculty and graduate student population with, however, the usual problems of uneven distribution of funding over various research areas, some being lean on faculty and students, others short of support.

On the whole, the Department is in an expansive and innovative mood, with several initiatives under way. These include continued development of Unified Engineering as the undergraduate core, an Avionics Option for students wishing to concentrate on electronics within the aerospace context, a major commitment to improve computational capabilities through participation in the Joint Computer Facility, the development of a substantial undergraduate and graduate research program in Space Engineering, and a general upgrading of facilities for undergraduate research.

With the growing undergraduate enrollment there has been a renewed emphasis on the undergraduate program. It seems likely that this trend will continue. Many of our best graduates (and those of other aerospace departments) find very attractive positions in the aerospace industry upon completion of their S.B. and opt to delay graduate work or continue only through an S.M. program. This does not necessarily imply a degradation of research activities, as we find that our undergraduates and S.M. students are fully capable of carrying on excellent and relevant research under the guidance of the faculty, staff, and advanced graduate students.

These points will be elaborated in further discussion of the undergraduate and graduate teaching and research programs, but it must be noted here that our objective is to blur the distinction between these to achieve a fully interactive and cooperative instructional and research community including undergraduates, graduates, faculty, and staff.

Undergraduate Program

Unified Engineering has matured over some five years to an undergraduate core which introduces the students as sophomores (some as juniors) to the disciplines and approaches of aerospace engineering and also brings them into close contact with the faculty. Students and faculty interact some 10 to 12 hours a week in lectures, laboratories, and tutorial sessions. This year, Professors James Mar, Shaoul Ezekiel, Sheila Widnall, Harold Wachman, Jack Kerrebrock, Henry Whitaker, and Rene Miller lectured in Unified Engineering. Most of them also conducted weekly tutorials in which they helped students with all the lecture material and problems. In addition, Professors John Dugundji and Manuel Martinez-Sanchez conducted tutorials. They will replace Professors Mar and Kerrebrock as lecturers next year, and Professor Leon Trilling will replace Professor Sheila Widnall.

This dispersion of the undergraduate teaching responsibility presents the faculty to undergraduates as engineering generalists, and makes more reasonable our demand that they become

such. It also greatly facilitates the students' involvement as juniors and seniors in the research activities of the faculty. We are pleased with the results of Unified Engineering and intend to continue to develop it as a major unifying influence in the Department.

In the coming year we plan to devote considerable effort to coordination of the content of our more advanced undergraduate subjects with that of Unified Engineering. Professor Emmett Witmer has been in charge of the undergraduate program this year and will continue in this important position next year.

Undergraduate research involvement has increased markedly as a result of the Undergraduate Research Opportunities Program (UROP) as well as faculty-student interaction. For example, some 18 undergraduates conduct basic research in Professor Mar's Technology Laboratory for Advanced Composites. The Space Systems Laboratory also has a large undergraduate involvement. Carolyn Major, a junior in this laboratory, won the American Institute of Aeronautics and Astronautics (AIAA) National Award for her paper entitled "Manual Alignment of Structural Components in Space." A group of students in this laboratory has been studying human productivity in space via the assembly of structures in the M.I.T. Alumni Pool which simulates the weightlessness of space. They presented this and work on space manufacturing to the entire National Aeronautics and Space Administration (NASA) Management Council on May 7, 1979. The presentation was so well received that substantial institutional support may result for our Space Engineering effort.

The Undergraduate Projects Laboratory, managed by Allan Shaw, is the focal point of technical and logistic support for the undergraduate research activities of the Department. The Laboratory also contributes significantly to the graduate research program. Al Shaw has for years been the main driving force behind the Laboratory, to the extent that "ask Al" has become an automatic response to most student queries. We were delighted by Al's receipt this spring of the James N. Murphy Award. Under his management we are making a substantial investment from our development fund in modern equipment for the Laboratory.

The Department was pleased to receive this year from Detroit Diesel Allison Division of General Motors Co. a GM-250 turboshaft engine, which is being installed on a dynamometer in Building 17A to be used for familiarization of students with gas turbine technology and for research. It will be operational this summer.

The Department is committed to extensive use of computation in its undergraduate program. To enable this at acceptable cost and also to reduce the cost of its research computing, it is participating as one of four M.I.T. departments in the Joint Computer Facility (J.C.F.). Terminals accessing the J.C.F. are being installed in Buildings 33 and 37, and undergraduates will use these facilities routinely in Unified Engineering and in more advanced subjects.

An Avionics Option was organized by Professor Walter Hollister in 1976, and the first degrees were awarded under this option this June. It now attracts a sizable percentage of our undergraduate population (31 students in 1978-79) and must be regarded as one stimulus to increased enrollment.

The Department's second-generation human-powered airplane *Chrysalis* flew successfully in June as the culmination of a three-month design and construction program which came in on schedule and under cost (\$2,500). It was built by Robert Parks, Harold Youngren, Hyong Bang, Marc Drella, and John Langford with guidance from Professor Elmer Eugene Larrabee, and has now been flown at least 50 times by many individuals. The propeller design and construction methods developed for the first generation *BURD* and for *Chrysalis* by Professor Larrabee, Edward Crawley, and these five students were transferred to Paul MacCready and contributed in a major way to Bryan Allen's successful crossing of the English Channel. The Luis De Florez Award was presented to Messrs. Parks, Youngren, Bang, Drella, and Langford in recognition of this achievement, which we consider an example of excellence in engineering.

Graduate Program

Graduate enrollment is presently limited more by the number of applicants meeting the Department's standards than by faculty supervisory capacity or by financial support, although as already noted, neither the financial support nor the faculty distribution is well matched to the distribution of student interest. We continue to receive large numbers of applications from foreign students, many of whom are well qualified; we select from these very rigorously to maintain a reasonable balance between foreign and US students. Job placement has been a problem for foreign students who elect to stay in the US. Many US students who might some years ago have gone on to the Ph.D. program are now attracted by the excellent salaries and exciting job opportunities in the aerospace industry. A significant number also are electing graduate work in management. There is some tendency to fill the gap in the research work force with postdoctorals, but this approach too is limited by industrial competition for the best people. The situation is not yet critical, but could become so in a year or two if the trend continues. We therefore have begun more aggressively to make known the opportunities for graduate study in the Department to potential students in US universities. Professor Wachman is in charge of the graduate program of the Department and is leading this effort.

The research activities of the Department are diverse, ranging from classical fluid mechanics and structures to physiology, psychology, and operations analysis. To stimulate crosslinking (and hopefully constructive polymerization) a luncheon is held every Wednesday at which a faculty member gives a brief presentation on his or her research. This was well attended last year and will be continued in the coming year.

RESEARCH

Because of its great diversity, it is not possible to give a comprehensive account of the Department's research; some highlights will be described which suggest the direction of events.

Dr. Dean Chapman, Director of Astronautics at NASA Ames Research Center, was Hunsaker Professor for fall term 1978. His Minta Martin Lecture was entitled "Computational Aerodynamics -- What Is Yet To Come." In addition, he organized with the help of Professor Judson R. Baron a series of lectures by outstanding computational fluid mechanicians which were well attended by the whole Institute community. His visit to M.I.T. has added momentum to our computational fluid mechanics initiative, which was already well established in application to turbomachinery. Assistant Professor William T. Thompkins has developed the only three-dimensional inviscid transonic code for application to compressors, and is spending the summer of 1979 at Ames Research Center adapting the Ames three-dimensional viscous codes to turbomachinery. Professor Thompkins and D. Alan H. Epstein have pioneered in the application of dedicated minicomputers to computational fluid mechanics. The M.I.T. Gas Turbine Laboratory now is preeminent in computation of flows in turbomachinery. Our capability is being extended to external flows by Professor Baron, who will offer a new course, "Introduction to Numerical Aerodynamics," in the fall of 1979.

Professors Laurence R. Young and Charles M. Oman are preparing an experiment on vestibular adaptation for Spacelab I. It is directed at the problem of motion sickness in space, which may pose serious problems for manned operations with the Space Shuttle. A high point of the spring term was the visit of all seven Shuttle Payload Specialists to M.I.T. for training in our Man-Vehicle Laboratory. They shared their experiences and perceptions with the Department at a Wednesday luncheon which was enthusiastically attended by faculty and students alike.

The Man-Vehicle Laboratory has one of the most active research programs in the Department, involving 16 staff members and 20 students. This year the faculty consisted of Professors Young and Oman and Visiting Professor Raphael Sivan of the Technion-Israel Institute of Technology. There is a need for additional faculty capability in this area. Fortunately, Dr. Robert Kenyon has accepted our offer of an assistant professorship and will be joining us in September; but Professor Sivan will be leaving and Professor Oman will be shifting to the position of principal research scientist, so that the problem remains acute.

The growth of research activities in aircraft engines continues, with M.I.T. now well established as the US center of academic excellence in this area. Professor James E. McCune had succeeded Professor Kerrebrock as director of the Gas Turbine and Plasma Dynamics Laboratory, and Dr. Epstein is associate director. New funding of about \$400,000 per year has been obtained from the Air Force Office of Scientific Research as a Multi-Investigator Grant with Professor Edward M. Greitzer as principal investigator. The Laboratory has also attracted funding from industrial sponsors: Pratt & Whitney, General Electric, and Teledyne CAE for a total of about \$150,000 per year. The Laboratory's research is also supported by the NASA Lewis Research Center, with which an excellent working relationship has been established.

In the Aeroelastic and Structural Research Laboratory, Professor Witmer has carried on a comprehensive program of theoretical and experimental research on containment of high-speed fragments such as result from burst of jet engine rotors. This work is supported by NASA Lewis Research Center, and by the Electric Power Research Institute.

The Space Systems Laboratory has grown rapidly during the past year under the joint directorship of Professors Mar and Miller. Research is supported by NASA Headquarters, Marshall Space Flight Center, and the Slater Transportation Fund. The Laboratory is fortunate in having enthusiastic participation by undergraduates through UROP, and this has been responsible for much of the productivity and creativity of the Laboratory. In addition, a dedicated group of graduate students have provided continuity and no small measure of supervision of the Laboratory activities which have included determination of human productivity in space, design of a space manufacturing facility, development of new and novel space structures, and space systems analyses. The Laboratory is now funded at about \$200,000 per year.

Another element in the Department's space engineering program is the course 16.851 Satellite Engineering which was offered again this year. Professor Hollister was again in charge and delivered the bulk of the lectures. He was fortunate to have the assistance of Dr. Raymond L. Bisplinghoff, who delivered six lectures. Professor Wallace E. Vander Velde gave two lectures on control aspects of satellites.

Professors Martinez-Sanchez and Kerrebrock and several students are conducting research on satellite thruster feed systems in cooperation with the TRW Company and with support from Ford Aerospace. This project, while small, is interesting as another case of industrial support for research which is quite fundamental but directed at an urgent need of the industry. In this case the problem is plugging of the very fine capillary tube used to meter hydrazine propellant.

Professor Norman D. Ham and his colleagues in the VTOL Laboratory have for some years studied feedback control systems for mitigating the structural problems due to gust loading in tilt rotor aircraft. This work is assuming increasing importance as the tilt rotor emerges as one of the most effective answers to the vertical takeoff and landing requirements of the Department of Defense.

The Laser Systems Laboratory under Professor Ezekiel continues an aggressive program of research on optical gyroscopes using fiber optics and passive resonators, and on the interaction of intense fields with atoms and molecules. This work is done in cooperation with the Research Laboratory of Electronics. Professor Ezekiel visited Armenia for a week in June as a guest of the Armenian Academy of Sciences, and presented invited papers at the Vavilov Conference on Nonlinear Optics at Novosibirsk and at the Fifth International Conference on Laser Spectroscopy in Munich, also in June.

Draper Fellows, who are in effect research assistants supported by Draper Laboratory and pursuing thesis work in the Laboratory, have constituted a major fraction of the Department's graduate students in instrumentation, guidance, and control since the separation of the Draper Laboratory from M.I.T. We strongly desire to preserve and in fact develop this resource for the Department. To this end, four senior staff members of the Laboratory, Drs. John J. Deyst, Jr., Albert L. Hopkins, Jr., Donald C. Fraser, and Rudrapatna V. Ramnath, have been designated to act as doctoral thesis supervisors when other aspects of their relationship to students makes this appropriate. Three faculty members, Professors Vander Velde, Whitaker, and William Widnall, maintain a close connection with the Draper Laboratory through supervision of Draper Fellows, and in Professor Whitaker's case through part-time research in the Laboratory.

FACULTY AND STAFF

The Department is honored by the appointment of Professor Sheila E. Widnall as Chairman of the M.I.T. Faculty (effective July 1, 1979). She is the first woman to serve in this position. Professor Widnall is also a member of the Corporation Joint Advisory Committee and the Faculty Advisory Committee to the Corporation Presidential Search Committee, and was appointed this year to the Board of Governors of the US Air Force Academy.

Dr. Richard H. Battin accepted an appointment as adjunct professor of Aeronautics and Astronautics in January 1979. He will continue to offer a course in astronautical navigation, advise graduate students, and add his great expertise to our research and teaching in astronautics.

Professor Robert L. Halfman has assumed responsibilities as Acting Dean for Student Affairs with the resignation of Dr. Carola Eisenberg from the position of Dean.

Edward M. Greitzer and Manuel Martinez-Sanchez were promoted from assistant to associate professor of aeronautics and astronautics effective July 1, 1979. Professor Greitzer received the American Society of Mechanical Engineers (ASME) Gas Turbine Award for the best paper of 1977, for the second consecutive year.

William Tilton Thompkins, Jr., formerly research associate, was appointed assistant professor of aeronautics and astronautics effective July 1, 1978, and Robert Kenyon has accepted an appointment as assistant professor effective July 1, 1979.

Consistent with M.I.T.'s new research appointments structure, Dr. Charles W. Haldemann has been appointed principal research engineer effective July 1, 1979. Associate Professors Charles M. Oman and Nawal K. Taneja have accepted appointments as principal research scientist and engineer respectively in order to concentrate on research activities.

Four faculty members were on leave this year: Professor Eugene E. Covert as scientific director at the European Office of Aerospace Research and Development; Professor Wesley L. Harris, Sr., as manager of computational methods for the Fluid Physics Branch of the Office of Aeronautics and Space Technology at NASA Headquarters; and Professor Amedeo R. Odoni for the spring term to conduct research. Professor Rene H. Miller was on a well-earned sabbatical at the University of Bristol for the fall term.

Professor Leon Trilling has resigned as chairman of the Committee on Engineering Education (C.E.E.) to return to more active teaching in the Department in the fall. He will continue as chairman of the Committee on the Humanities, Arts, and Social Sciences Requirement.

Professor Trilling is replaced as chairman of the C.E.E. by Professor James W. Mar. Professor Mar also will continue as chairman of the Athletic Board and will be chairman of the Committee for Undergraduate Admissions and Financial Aid.

Professor Laurence R. Young was elected a fellow of the Institute of Electrical and Electronics Engineers (IEEE) on January 1, 1979, and has been appointed to the United States Air Force Scientific Advisory Board. He became president of the Biomedical Engineering Society in April 1979.

Professors Yao Tzu Li and Theodore H.H. Pian have both participated extensively in the cultural exchange with the Peoples Republic of China, both making extended visits to China and organizing visits of delegations to M.I.T. Four Chinese visiting scholars will be in residence in the Department during the 1979-80 academic year.

The Department regrets the loss this spring of two of its most valued staff members. Thorwald Christensen retired on June 30 after many years of service to M.I.T. and the Department as engineering aide in the Gas Turbine Laboratory. He set an admirable example of professionalism for students, faculty, and staff. Roxanna Billings resigned as administrative assistant in the Graduate Office, where she coordinated all graduate admissions and functions with remarkable skill and aplomb. We are delighted to have Susan M. Fennelly as her replacement.

JACK L. KERREBROCK

Department of Chemical Engineering

Departmental activities increased again to higher levels during the past year. Larger enrollment and expanded research activity placed heavy demands on faculty and laboratory facilities. The Department now has the highest ratio of students to faculty of any department in the Institute. The excellent response of the faculty to these demands maintained the high standards set by the Department.

Undergraduate Program

Total enrollment in the undergraduate program increased slightly this past year over last year. A combination of lecture presentations and multiple recitation sections for core subjects, instituted last year to accommodate the large classes, continued to provide effective student-faculty interaction. The following table shows the trends in Chemical Engineering enrollment.

	<u>Undergraduate Enrollment</u>				
	<u>1974-75</u>	<u>1975-76</u>	<u>1976-77</u>	<u>1977-78</u>	<u>1978-79</u>
Sophomore	47	79	103	107	98
Junior	39	60	97	106	114
Senior	<u>38</u>	<u>45</u>	<u>51*</u>	<u>99</u>	<u>106</u>
TOTAL	124	184	251	312	318

* Does not include students in the five-year program who transferred to the graduate school.

A new curriculum for the Bachelor of Science in Chemical Engineering, with additional specified requirements in chemistry and in design and economics, was approved by the Institute Committee on Curricula and will become effective in 1979-80. A large fraction of the senior class took advantage of the new curriculum in selecting elective subjects.

A faculty committee headed by Professor Frederick A. Putnam recommended the purchase of a computer with many terminals for easy access by undergraduates and the enrichment of the undergraduate curriculum with more computer usage.

Graduate Program

Graduate enrollment increased to a total of 202 full-time students. Seventy-four students were enrolled in the doctoral program. Offers for graduates at all degree levels continued to be attractive. The following table shows the trends in graduate enrollment.

	<u>Graduate Enrollment</u>				
	<u>1974-75</u>	<u>1975-76</u>	<u>1976-77</u>	<u>1977-78</u>	<u>1978-79</u>
Total Graduate Students	149	163	181	185	202
Doctoral Students	49	46	49	70	74

Twenty-nine students attended the Practice School Stations. One station is sponsored by the General Electric Company at the Silicone Products Department and the Plastics Department plants near Albany, New York. The other station is at the Oak Ridge National Laboratory.

They complement each other to provide a wide range of experience in the practice of chemical engineering. A new subject, entitled "The Structure of the Chemical Processing Industries: Function and Economics," was organized by Professors James Wei and Raymond F. Baddour to provide graduate students the opportunity to develop broad perspectives on the chemical industry. Guest lecturers include Samuel Bodman, President of Fidelity Management and Research Company, Robert J. Richardson, Vice President of E.I. DuPont de Nemours & Company, Robert Siegfried, Chairman of the Badger Corporation, and John Deutsch of the US Department of Energy. Professor Putnam in collaboration with Professor Ronald M. Latanision of the Department of Materials Science and Engineering offered a new graduate elective entitled Solid State Surface Science.

Professor Christos Georgakis organized the Visiting Faculty Lecture Series. Lecturers in this series were: Professors Andreas Acrivos of Stanford University; Richard C. Alkire of the University of Illinois; George R. Gavalas of the California Institute of Technology; Keith E. Gubbins of Cornell University; Walter May of Exxon Research and Engineering; Hajime Nishimura of the University of Tokyo; John A. Quinn of the University of Pennsylvania; and Theodore Vermeulen of the University of California at Berkeley. Professors Putnam, Robert A. Brown, Costas G. Vayenas, and Preetinder S. Virk of our Department also participated in the series. Professor Wei reported on his experience as a member of the American Chemical Society delegation which visited the People's Republic of China in May 1978.

The Department established the Warren K. Lewis Lectureship to honor the first Head of the Department. Professor Neal R. Amundson of the University of Houston was the first W.K. Lewis Lecturer.

The Dreyfus Foundation provided the Department with a special lectureship. Professor John H. Seinfeld of the California Institute of Technology was the Dreyfus Lecturer.

FACULTY

Professor James Wei, Department Head, concluded a three-year term as chairman of the American Institute of Chemical Engineer's Awards Committee. He also was on the AIChE Dynamic Objectives Committee, and a founder of the China Relations Committee. He was vice chairman of the Environmental Pollutant Movement and Transformation Committee of the Science Advisory Board of the Environmental Protection Agency. He served as editor of the McGraw-Hill Book Company series on chemical engineering, and on the boards of *Chemical Engineering Communications*, *Chemical Technology*, *Industrial and Engineering Chemistry Reviews*, and the *Journal of Bioengineering*. He was chairman of the board of judges of the 1979 Kirkpatrick Chemical Engineering Achievement Award, sponsored by McGraw-Hill. He was Philips Lecturer on Chemical Engineering Education at the AIChE and Oklahoma State University in 1979. He is Chairman of the International Symposium for Chemical Reaction Engineering-7 for Boston in 1982. He published a book, *The Structure of Chemical Processing Industries*, with the McGraw-Hill Book Company in 1978. As a member of the first US chemistry delegation to visit China, he contributed to the book *Chemistry and Chemical Engineering in the People's Republic of China*, edited by John Baldeschwieler. He gave seminars at Rice University and the University of Houston, and gave research papers at the Joint Automatic Control Conference, Catalysis Club of New England, and at the annual meeting of the AIChE. Professor Wei also served on the visiting committees of the Departments of Chemical Engineering at the University of Houston and the Georgia Institute of Technology.

Professor Robert C. Armstrong was promoted to associate professor of Chemical Engineering.

Professor Janos M. Beér was elected to the Fellowship of Engineering of the Council of Engineering Institutions of Great Britain in February. The Fellowship was founded in 1976 as the institution in Britain corresponding to the National Academy of Engineering in this country. He also was elected fellow of the American Society of Mechanical Engineers for "research of outstanding quality on fossil fuel utilization." He gave the inaugural lecture

at the Combustion Institute Canadian Section Spring Technical Meeting at Queen's University, entitled "Application of Basic Studies to the Design of Fluidized Bed Combustor." As chairman he organized the Industrial Liaison Program (I.L.P.) Symposium on Fluidized Combustion and gave one of the lectures. The Symposium was attended by 170 I.L.P. members from the US, Japan, and several European countries. The Symposium included visiting the Institute's newly commissioned Fluidized Combustion Facility.

Professor Robert Brown joined the Department as DuPont Assistant Professor of Chemical Engineering in January after completing doctoral research at the University of Minnesota. He attended the Second International Conference on Computational Methods in Nonlinear Mechanics at Austin, Texas, and gave an invited lecture on drop stability at the University of Massachusetts at Amherst.

Professor Robert E. Cohen gave an invited lecture at the Winter Gordon Conference on Deformation and Fracture in Polymeric Composites in Santa Barbara, California, and has been invited to lecture at the Summer Gordon Conference on Elastomers at New London, New Hampshire in July 1979.

Professor Clark K. Colton spent a sabbatical year in the Department of Applied Mechanics and Engineering Sciences at the University of California at San Diego.

Professor Lawrence B. Evans was elected a corresponding member of the National Academy of Engineering of Mexico, and was installed at the annual meeting of the Academy in Merida, Mexico in October. He also was the Merck, Sharp and Dome Lecturer at the University of Puerto Rico.

Professor Christos Georgakis, who was the Esther and Harold E. Edgerton Assistant Professor of Chemical Engineering, was promoted to associate professor of Chemical Engineering. He chaired a symposium on Dynamics and Control of Chemical Reactors at the Joint Automatic Control Conference in Philadelphia, and gave invited seminars on "Order-of-Magnitude Approach to Process Dynamics" at the University of Pennsylvania and the Celanese Company. He also gave invited lectures on the modeling of fluidized bed coal combustors at New York University and the Research Application Conference organized by the Institute of Mathematics and the Society of Industrial and Applied Mathematics.

Professor Ronald A. Hites has been named professor of Chemistry and professor of public and environmental affairs at Indiana University.

Professor Jack B. Howard was chairman of the 1978 Gordon Research Conference on Fuels Science, and organized the colloquium on coal combustion at the Seventeenth International Symposium on Combustion. He was a member of the National Academy of Science Panel on Energy Programs of the National Bureau of Standards.

Professor John P. Longwell was a member of the National Research Council Panel on refining of coal and shale liquids. The Panel recommended continuing and additional support by the Department of Energy of basic and exploratory research as well as support for demonstration programs. He was also a member of the Hydrogen Panel of the Committee on Advanced Energy Storage Systems of the National Research Council. The Panel concluded that use of hydrogen as a fuel is quite limited, but recommended continuing research on storage. Professor Longwell was appointed chairman of the Committee on Advanced Energy Storage, and attended the International Assembly on Energy Storage in Yugoslavia sponsored by the National Academy of Sciences and the Yugoslavia Council of Academics. He was a member of the Advisory Committee of the National Aeronautics and Space Administration (NASA), serving as advisor on aircraft fuels.

Professor Frederick Putnam held the Joseph R. Mares Career Development Chair. He organized and chaired a session at the 70th annual meeting of the AIChE, and was day-chairman at the Summer Gordon Conference on Chemistry of Interfaces.

Professor Adel F. Sarofim was appointed to the Chevron Visiting Energy Professorship at the California Institute of Technology for the winter quarter of 1979. He gave invited lectures at the International Heat Transfer Conference, the Combustion Institute Symposium, California Institute of Technology, University of Southern California, and University of California at Berkeley.

Professor Kenneth A. Smith was named the Joseph R. Mares Professor of Chemical Engineering. He was a member of the editorial board of the *AIChE Journal* and gave an invited seminar at Princeton University. He also was associate director of the M.I.T. Arteriosclerosis Center.

Professor Charles N. Satterfield was van Winkle Lecturer at the University of Texas at Austin and invited lecturer at the University of Liège, Belgium. He also gave a course on heterogeneous catalysis for the Exxon Research and Development Company as a part of their in-house technical education program. His book, *Mass Transfer in Heterogeneous Catalysis*, published by the MIT Press, was recently translated into Russian. His new book "Heterogeneous Catalysis in Practice" has been completed and will be published by McGraw-Hill in early 1980.

Professor Costas Vayenas was named DuPont Assistant Professor of Chemical Engineering and received the Outstanding Faculty Award for teaching and research given by the Graduate Student Committee of the Chemical Engineering Department. He gave invited lectures at the Monsanto Company, the Yale University Catalytic Symposium, and the I.L.P. Symposium on Catalysis.

Professor J. Edward Vivian continued to serve as executive officer of the Department and director of the School of Chemical Engineering Practice. He gave an invited seminar at Hercules Incorporated, and served as chairman of the General Arrangements Committee for the 87th National Meeting of the AIChE to be held in Boston in August 1979.

Professor J. Theodoor G. Overbeek of the University of Utrecht, Holland, visited the Department in the spring. He was preparing a videotape lecture series on "Electrochemistry" in cooperation with the Center for Advanced Engineering Study. Professor Ralph A. Troupe, chairman of the Department of Chemical Engineering at Northeastern University, was a visiting scholar to study the history of the Practice School.

AWARDS

The Department gave the following awards to seven Chemical Engineering students at its annual awards presentation in May.

The Robert T. Haslam Cup, awarded annually to a senior for outstanding professional promise in chemical engineering, was presented to David E. Ortman.

The Roger de Friez Hunneman Prize, provided by a fund established in 1927 by William Hunneman in honor of his son, and awarded for outstanding originality in chemical engineering, was given to senior Laura B. Rees.

The American Institute of Chemists Award, offered to a senior in chemistry and/or chemical engineering who displays outstanding promise, was given to Bowei Lee.

The American Institute of Chemical Engineers Annual Scholarship Award went to junior Marcus A. Whitley.

The Chemical Engineering Special Service Award, presented in appreciation of unselfish contributions to the success of Department activities, was given to Sharon Sullivan, Regina Shuck, and Bowei Lee.

Other Chemical Engineering award winners were: Wu-Cheng Cheng, who received the F.M. Becket Award of the Electro-Chemical Society for outstanding research in the field of electrochemistry under the direction of Professor Vayenas.

David Mead, a senior, received a Churchill Scholarship for a year of graduate study in engineering, mathematics, and science at Churchill College, Cambridge University.

Timothy Morgenthaler, a junior, received the Scott Paper Company Leadership Award for his contributions to student affairs while vice president of the Undergraduate Association. He also received a William L. Stewart Award for these contributions.

Barry Newman, a senior, received a Karl Taylor Compton Prize for his contributions as a leader in the Institute community.

RESEARCH

The research volume of the Department was approximately \$1.7 million in 1978-79. Research volume was \$1.7 million in 1977-78, and \$1.6 million in 1976-77. When interdisciplinary research activity for which Department faculty are responsible is included, the volume was approximately \$5.4 million compared to \$4.1 million in 1977-78 and \$2.4 million in 1976-77. The Department's research extended over a wide range of activity with energy and fuel projects, reactor performance studies, polymer studies, and biochemical and biomedical research accounting for the major portion.

The Combustion Research Facility under the supervision of Professor Beér was fully commissioned with gaseous and liquid fuels, and research was started on several projects related to the reduction of polycyclic aromatic hydrocarbon and nitrogen oxides emission from turbulent flames and on advanced combustion diagnostics for turbulent flame studies. This new research facility provides unique opportunities for the application of results of basic studies to industrial combustion systems, and for the rigorous experimental testing and further development of mathematical models of the combustion, heat transfer, and pollutant formation processes in flames.

Professor Brown supervised research aimed at fundamental understanding of the roles of fluid mechanics, heat transfer, and interfacial phenomena in the processing of materials such as films and coatings, melting and molten polymers, and semiconductors. A related study in collaboration with Professor Armstrong was directed toward the numerical simulation of non-Newtonian polymer flows.

Development of a computer-based process simulator and economic evaluation system called ASPEN (Advanced System for Process Engineering) continued for the third year under the direction of Professor Evans and Paul Gallier. The 150,000-line computer program simulates the flowsheet of a proposed or operating chemical plant and provides preliminary estimates of capital and operating costs. ASPEN completed a successful test simulation of a commercial version of the Donor Solvent Coal Liquefaction Process in May. A two-year continuation of the project in partnership with industry is planned to test ASPEN for public release in 1981. During the past year, about 12 full-time staff members, many on loan or on leave from industry and other universities, participated with about 25 students on the project.

Professor Evans and Professor D.I.C. Wang of the Department of Nutrition and Food Science continued their research on the dynamics, design, and control of industrial fermentation systems.

Professor Evans carried out research on the hydraulic behavior of plate columns in controlled cyclic operation. Experiments were performed in a three-plate laboratory column under cyclic flow conditions and the results were incorporated into computer models to predict the behavior of larger columns. With good hydraulic design, overall efficiencies of 140 to 160 percent can be obtained.

Professor Evans with Joseph Boston and Herbert Britt of the ASPEN Project continued their investigation of the optimization of complex chemical processes using a modular simulation system. In a related project, research on an improved technique for modeling and simulation of processes involving electrolytes was continued.

Professor Georgakis conducted research on the development of an order-of-magnitude approach to process dynamics and control in which a mini-computer was used to control a gas absorption pilot plant. He also conducted research on modeling fluidized bed combustors to relate sulfur dioxide emission to operating parameters.

Professor Howard conducted research on the mechanism of soot formation in the combustion of coal and coal-derived fuels. A molecular beam sampling device with an on-line mass spectrometer was used to probe the oxidation and soot-forming zones in laminar pre-mixed fuel flames. He also supervised a research team studying the effects of important process variables on the rate and extent of pyrolysis and hydrolysis of coals such as Pittsburgh Seam bituminous coal and Montana lignite.

Professor Howard in collaboration with Professor Sarofim studied the soot problem from the point of view of more efficient burnout. A laser technique was used to investigate the inadequately understood burnout problem. They also investigated the kinetics of the important step of char gasification in the coal conversion processes under consideration.

Professors Longwell and Howard conducted research on the pyrolysis of coal in the presence of hot dolomites in a fluidized combustor to control pollutant emission. This research has attracted considerable attention for further industrial development.

Professor Michael Modell studied the unusual and relatively unexplored properties of water in the range of its critical conditions (374°C, 220 atm) when water becomes an excellent solvent for organic compounds, such as benzene and naphthalene. Two applications of potentially broad significance were explored: the reforming of organics as a potential biomass-to-fuel and waste treatment process, and the liquefaction and gasification of coal. A third application, funded by the Sea Grant Program, explored the technical feasibility of using supercritical water to decontaminate dredge spoils.

Professor Robert C. Reid carried out research on vapor explosions resulting from the impaction of two liquids such as liquified natural gas (LNG) rich in methane impacting on water. He initiated a project to study a new type of vapor explosion which could occur when a high pressure saturated liquid is suddenly depressurized. Some recent industrial accidents appear to have resulted from this type of accident. He carried out research on boiling heat transfer to model the boiling/spreading phenomenon which would occur if LNG or LPG were spilled on water as a result of an accident. He supervised a project to measure the partition coefficients for supercritical fluids used as selective solvents in a variety of systems. Preliminary mathematical modeling correlates well with data obtained by earlier investigators.

Professor Sarofim in collaboration with Professors Beér, Howard, and Longwell carried out research on the modeling of coal combustion with particular emphasis on pollutant formation in fluidized beds and in suspension flow. Other modeling studies included the kinetics of vaporization of selected mineral constituents in coal to predict the amount and composition of aerosols in the respirable size range produced in practical combustors, the formation of polycyclic aromatics under different fuel/air ratios, the kinetics of the gas phase reactions leading to the formation of nitric oxide, and the heterogeneous reactions leading to its destruction. The kinetic parameters derived from the experimental studies have been incorporated into comprehensive models of fluidized bed combustors which are finding use for evaluation of designs by both government and industry.

Professors Smith and Colton, in collaboration with Professor Robert S. Lees of the Arteriosclerosis Center and Professor M.B. Stemerman of the Beth Israel Hospital, continued research related to factors which may cause arteriosclerosis. The single layer of endothelial cells normally offers the dominant resistance to the transport of proteins within the arterial wall, but rates increase tenfold if this single layer of cells is damaged. They also studied the process of ultrafiltration, and developed an optical technique for the determination of diffusivity in concentrated solutions. The ultrafiltration rate has been shown to be sensitive to the dependence of osmotic pressure upon concentration, to the value of the diffusivity, and to Nernst-Planck electrical effects.

Professors Smith and Sarofim investigated methodologies used to determine the rate of secondary nucleation in a batch crystallizer, which is required for the design of a continuous crystallizer.

Professors Smith, Reid, and Virk supervised laboratory work directed at safety problems which arise in the context of liquified natural gas (LNG) handling operations: the rate at which LNG boils when spilled upon water, land, or a variety of insulating materials; self-generated electrostatic hazards; the response of stored liquid to a change in atmospheric pressure; and the phenomenon of roll-over due to composition induced density gradients in storage tanks. Flameless vapor explosions, which are associated with spontaneous nucleation in superheated liquids, were also under investigation.

Professors Satterfield and Modell studied catalytic hydrodenitrogenation (HDN) and its interaction with the catalytic hydrodesulfurization of liquid fuels, using model compounds representative of the less reactive compounds found in synthetic fuels from coal and oil shale, to explain the intricate role of sulfur compounds in HDN reactions.

Professors Satterfield and Longwell supervised a study of the Fischer-Tropsch reaction in a liquid-phase slurry reactor with particular attention to the effects of mass transfer on activity and selectivity.

Professor Vayenas carried out research on an important new fuel cell concept in which ammonia is electro-oxidized quantitatively to nitric acid with the simultaneous production of electrical energy. He also supervised a project on the application of solid electrolyte potentiometry to study catalytic oxidation reactions on metals.

Professor Wei supervised research on the catalytic hydrometallation process for the removal of metallic components from residual fuel oils, using autoclave and continuous high pressure fixed-bed reactor techniques. He also continued in the mathematical modeling of coal gasification reactors, both for simulation of existing plant data and for predicting performance in new design and operations. The simulation has been very successful in moving bed reactors, such as the Lurgi dry ash and slagging reactors; it is being extended to entrained bed reactors, such as the Texaco and Bi-Gas reactors.

JAMES WEI

Department of Civil Engineering

A renewed and increased emphasis on educational programs highlighted the many activities of the Department during the past year. An ad hoc curriculum revision committee carried out an extensive analysis of our undergraduate core program and proposed major revisions that will be developed during the coming year and implemented in the fall of 1980. Each of the Department's three Divisions reviewed their undergraduate primary and elective offerings, and subsequently began to develop a more coherent and structured set of undergraduate subjects. At the graduate level several new subjects have been developed as a direct result of research initiatives. In addition, many faculty members of the Transportation Systems Division (T.S.D.) played a major role in development of subjects for the new Master's degree program of the Center for Transportation Studies (C.T.S.) and are directing the implementation of this program.

Research projects continue to play a key role in the Department's development and in the evolution of our academic programs. The impact of these research efforts is perhaps most notable in the Department's rapidly evolving programs in offshore engineering, underground construction, rail freight transportation, and aquatic ecology. Each of these programs represents initiatives begun several years ago in response to perceived societal needs, which are now coming to fruition at an opportune time. Their active presence among other longer-standing programs emphasizes the breadth of the Department's activities and helps account for its acknowledged leadership position.

Undergraduate Programs

During the past year, the Undergraduate Committee undertook a major review of the undergraduate program of the Department. For this purpose, the membership of the committee was augmented by additional students and faculty, thus forming the Ad Hoc Curriculum Revision Committee under the leadership of Professor Robert Whitman.

This expanded committee first reviewed in detail the content of the existing undergraduate subjects and programs and solicited opinions and suggestions from other faculty members and students. It detected a quite general sentiment favoring a more structured curriculum which would ensure that students studied in depth in some subject area.

During January and February, the Ad Hoc Committee developed several alternate proposals which were presented to students and faculty at the end of February and early March. These discussions showed strong support for the addition to the core of further subjects in mathematics and the physical sciences and a desire to explore further possible ways for teaching the core subjects so as to heighten students' awareness of the thrust and broad scope of the work of civil engineers.

Based upon this feedback from the faculty, the Ad Hoc Committee prepared specific recommendations which were brought before the faculty in May, and which received approval from the faculty. The main features of the revised program are:

- 1) A core of six subjects: economics, linear algebra plus differential equations, and two subjects each in physical sciences and systems analysis.
- 2) A "sophomore experience" built about the four subjects in physical sciences and systems analysis. While these subjects will be taught separately, approximately one-quarter of the units in each subject will be used for: a) lectures of broader scope by other faculty and engineers from practice and government, and b) mini-projects cutting across subjects. The instructors of the four subjects, plus a fifth faculty member, will constitute a team to coordinate the content of the subjects and the mini-projects. It was recommended that a small cluster of rooms, including offices for teaching assistants and a seminar room, be dedicated to these core subjects.
- 3) Primary programs involving at least 75 units, to be built upon the core subjects and involving some pyramiding of subjects with sequential prerequisites.

Other recommendations cover minimum competence in the use of computers and communication skills. The new program is to go into effect in September 1980, with the 1979-80 academic year to be used to finalize details of the program and to develop the new and/or altered subject offerings.

The Constructed Facilities Division (C.F.D.) instituted a single primary program consistent with the recommendations of the Ad Hoc Curriculum Revision Committee. This consists of required subjects in structures, materials, and soil mechanics plus secondary options in structures, geotechnical engineering, or construction engineering. The Water Resources and Environmental Engineering Division (W.R.E.D.) adopted a similar format for their primary with principal subjects in fluid dynamics, ecology, and water resources to be followed by options which include new subjects in water and wastewater treatment engineering, free surface hydraulics, hydrology, and aquatic chemistry. As noted later, the Transportation Systems Division (T.S.D.) has concentrated primarily on development of the new C.T.S. Master's degree program; therefore, development of a new primary was postponed until the coming year. The thrust of that effort will be to broaden and make more explicit the multi-modal nature of the program and to build more on the freight transportation expertise of the Division.

Both the C.F.D. and W.R.E.D. successfully expanded and improved their laboratory subject offerings. Professor James Becker's revitalization of the structures laboratory in collaboration with the Department of Architecture was highly successful. Professor Michael Fardis totally revamped our concrete laboratory activities. Dr. E. Eric Adams and Professor Harold Hemond emphasized fieldwork in the Charles River and nearby ponds and wetlands.

The senior capping subjects continued to provide students with an opportunity to confront important "real-world" design problems. Topics and instructors for the past year were:

C.F.D. - Support of Foundation Excavation, Federal Reserve Bank of Boston - Professor Thomas Lambe.

T.S.D. - Traffic and Transit Operations on Massachusetts Avenue: Analysis and Design - Professor Michael Meyer.

W.R.E.D. - Sewage Disposal in Boston Harbor - Professors Donald Harleman and David Marks.

Enrollment of undergraduates dropped for the second year in a row to 153 students. This drop of 23 students (from the peak level in the 1976-77 academic year) at a time when enrollments in the School of Engineering are at an all-time high is a source of concern to the Department. Faculty members have responded to this concern with increased efforts to make themselves and the Department's programs more visible to first-year students.

Graduate Program

The most significant changes in the Department's graduate programs were initiated in the transportation area. A T.S.D. task force recommended in the spring of 1978 that the Division's strong program in systems analysis be expanded to include new thrusts in transportation management and institutional analysis and policy. The discussions underlying these recommendations served as valuable inputs to the planning of a new master's degree in transportation to be offered for the first time in the coming year by the Center for Transportation Studies.

The faculty of the Department participated extensively with colleagues from other departments in a variety of meetings and discussions to develop the concepts of this program, begin planning for it, and develop specific course material. Professor Nigel Wilson is chairman of the standing faculty committee for the Transportation Master's Program. Other T.S.D. faculty serving on this committee include Professors Steven Lerman, Ralph Gakenheimer, Henry Marcus, and Joseph Sussman. In addition, numerous faculty of the division have responsibilities for developing and teaching subjects designated as part of the core requirements in the new C.T.S. master's degree program. Professors Wilson and Marvin Manheim will be responsible for teaching the first subject in transportation systems analysis; Professor Ann Friedlaender will teach transportation economics; Professor Yosef Sheffi, together with Professor J. Karl Hedrick of the Department of Mechanical Engineering, is developing a new subject in transportation performance and technology; Professors Lerman and Moshe Ben-Akiva will teach a revised and expanded version of their transportation demand subject; Professors Marcus and Paul Roberts will offer a new subject in transportation management; and Professor Meyer will be teaching a new course in transportation institutional analysis and policy.

Thus, the division's academic program and the Center for Transportation Studies program are evolving in highly complementary fashion to produce a significant broadening and diversification of the transportation educational activities at the graduate level at M.I.T.

Several new and revised graduate subjects were developed by C.F.D. and W.R.E.D. These include a new subject on the design and construction of offshore structures to be offered jointly with the Department of Ocean Engineering. This subject is the outgrowth of a joint seminar series offered by the two departments during the past year. New subjects dealing with advanced structural analysis, reliability, loads, and safety were also introduced. A revised sequence of advanced fluid mechanics subjects was developed as well as new subjects in limnology and wetland ecology, and the physics of natural water bodies.

Graduate enrollment rose by 11 percent to 243 students this year, an all-time high. This increase was made possible by an increase in the number of active faculty members and increased use of lecturers and research staff members serving as part-time instructors, coupled with continued success by the faculty in generating substantial amounts of sponsored research support for graduate assistants.

RESEARCH

The Department's research program continues to grow in terms of size, diversity, importance, and quality. A representative sampling of projects under way during the past year will serve to define the character of this program.

Professors Mohsen Baligh and Charles Ladd, in collaboration with Dr. Robert Martin, have developed an improved Dutch cone penetrometer which promises to be a major advancement in *in-situ* testing of soil properties. During May 1979, the M.I.T. team participated in an off-shore exploration program in the Orinoco Delta, and the device was used offshore for the first time. Funding has been provided by the M.I.T. Sea Grant Program and the INTEVEP (Instituto Venezolano Tecnológico del Petróleo) Project.

Professor Herbert Einstein's research on rock mass behavior has led to the development of an analytical model relating rock mass deformability to the geometry and stiffness of discontinuities. This stochastic approach is a major improvement over the empirical methods that are most frequently used and newer finite element analyses for which the input parameters are often lacking. His research on rock slope stability has produced the first rational treatment of joint persistence -- one of the major problems in rock mechanics. Professor Einstein also has developed a methodology by which tunnel designers and contractors can select the best approach in regard to tunnel design and construction methods.

Professor Hilary Max Irvine has recently completed a study of peak ductility demands in simple eccentric buildings responding to earthquake excitation, and extensions are planned for an investigation of the seismic response of set-back, or staggered buildings. Work also began on questions of stability and dynamic response to ocean waves and earthquakes of tall guyed offshore production platforms.

Professor Oral Buyukozturk conducted research for the Nuclear Regulatory Commission involving the investigation of shear transfer mechanisms in reinforced concrete containment walls and simulation of test specimens performed at the Portland Cement Association. Research supported by the Department of Energy (DOE) involved the analysis of coal gasification process vessels and simulation of model vessels tested at Babcock and Wilcox Research Center.

Professor Becker continued his work on the seismic resistance of precast concrete panel buildings. This major project sponsored by the National Science Foundation (NSF) is aimed at developing a fundamental understanding of the potential seismic response of large panel building construction in order to help guarantee their safe and economic use in earthquake regions.

Participation in international water resources programs continued through the State Department-AID project involving M.I.T., the University of Cairo, and Egyptian Ministries dealing with irrigation and water resources of Egypt. Faculty members involved are Professors Marks, Peter Eagleson, Rafael Bras, and John Wilson.

Professor Chiang Mei, under an NSF grant, has developed a theoretical approach for the dynamics of poro-elastic solids that has application to soil and rock mechanics under cyclic loading.

Professor Ole Madsen has been actively engaged in field investigations of surf zone hydrodynamics. Other field studies include the measurement and modeling of tidal circulation in salt marshes under a new Sea Grant project conducted by Professors Hemond and Keith Stolzenbach.

Professor J. Wilson is developing a finite-element model for the prediction of seawater intrusion in coastal aquifers. Professor Sallie Chisholm participated in cruises, in collaboration with Harvard University and the Woods Hole Oceanographic Institution, to study photosynthesis in ocean algae; and Professor Francois Morel is studying trace metal and plankton interactions under an NSF grant.

School of Engineering

Professor Harleman, together with Drs. Adams and Robert Barbera, are investigating various issues of water management related to the electric power industry under DOE sponsorship.

A major research study of freight car utilization has been under way in T.S.D. for several years under the direction of Professor Sussman, and since 1977 has focused on development and implementation of an operating/service plan designed to improve freight service and car utilization on the Boston & Maine Railroad. The plan defines, for the first time on any major railroad, standards for both trip times and reliability that are explicitly related to train schedules and standards for yard performance. Implementation of the plan, which began in December 1978, has improved service in several important corridors and has improved system car utilization by more than five percent; it is a cornerstone of the B & M's reorganization efforts. Funding of this project was provided by the Federal Railroad Administration.

More recently, support was obtained from the United States Railway Association and the Union Pacific Railroad for research on empty freight car distribution. This marked the first instance in many years in which a railroad has directly funded sponsored research at M.I.T.

Through the Technology Adaptation Program, Professors Fred Moavenzadeh and Terry Friesz conducted extensive research on transportation planning in developing countries. Particularly noteworthy was completion of a transportation planning framework for evaluation of highway investment decisions in Egypt.

Equipment and Facilities

The Department continues to occupy essentially the same space in Buildings 1 and 48 that have been its home for many years. In fact, available space was somewhat reduced due to the movement of C.T.S. headquarters and the World Coal Study into Building 1 offices. Plans for making more effective use of the constrained space in Building 1 were proposed during the past year, but funds for accomplishing this have not yet been made available.

The Department joined with the Departments of Mechanical and Ocean Engineering, and Aeronautics and Astronautics to obtain and support a new joint computer facility. A new computer structured around the VAX 11-78 system was installed in January and became operational shortly thereafter. The new system includes four remote terminals located in Department laboratories.

Improvements were made in the concrete, structures, geotechnical, and water quality laboratories through the development and acquisition of new equipment including a mobile facility for fieldwork.

FACULTY

Faculty Changes

The Department was fortunate in attracting two new faculty members who will begin their duties in the fall. Dr. Roman Krzysztofowicz, who received his doctorate from the University of Arizona, will work in the area of water resource systems. Clifford Winston, who expects to receive his doctorate in economics from the University of California at Berkeley in August, will join our transportation faculty.

Visiting faculty members for the coming year include: Dr. Hans C. Bjornsson, senior lecturer at the Chalmers University of Technology in Sweden who will join the staff of our construction engineering and project management program as a visiting associate professor; Dr. Paul Kruger, professor of Nuclear Civil Engineering at Stanford University, who will join our Water Resources and Environmental Engineering Division as a visiting professor.

Faculty Honors and Awards

Faculty members of the Department have been engaged in many leadership positions in the American Society of Civil Engineers, the Transportation Research Board, and numerous other professional organizations. These are too extensive to list here; however, the following special recognitions are noted:

Professor Becker was appointed as the Class of 1922 Associate Professor for a two-year period.

Professor Bras was selected as the fourth holder of the Gilbert W. Winslow Career Development Chair in Civil Engineering.

Professor Eagleson was a US delegate to the 1979 World Climate Conference in Geneva.

Professor Friedlaender was appointed to the board of CONRAIL.

Professor Harleman received the 1979 Distinguished Alumni Award of the College of Engineering of the Pennsylvania State University.

Professor Meyer received a Danforth Fellow Award effective for a six-year period.

Professor Daniel Roos was appointed director of the Center for Transportation Studies, succeeding Professor Roberts who had served as the director during the Center's critical first five years.

Professor Stolzenbach received the 1979 Huber Research Prize of the American Society of Civil Engineers.

Professor Whitman was elected vice president of the board of directors of the Earthquake Engineering Research Institute.

FRANK E. PERKINS

Department of Electrical Engineering and Computer Science

Leadership of the Department of Electrical Engineering and Computer Science changed hands this year as anticipated in last year's report. The new team, which took office effective September 1, 1978, comprises Professors Gerald L. Wilson, Department Head, Richard B. Adler, Associate Head for Electrical Science and Engineering, and Joel Moses, Associate Head for Computer Science and Engineering.

Two new common-core subjects developed a year ago were offered for the first time to all undergraduate students in the Department: 6.002 Circuits and Electronics by Professor Stephen D. Senturia and 6.003 Signals and Systems by Professor William M. Siebert to replace 6.011 and 6.015 respectively. Three other exciting educational developments also took place during the year.

A new undergraduate elective minicomputer subject, 6.911 Real-Time Computing and Control Laboratory, developed and extensively equipped through the efforts of Professors Francis Lee and Edward Fredkin, was taught by Professor Lee for the first time in the fall. A sequel to that subject, 6.915 Microcomputer Project Laboratory, focusing on experiments with microprocessors and their applications, developed by Professors Lee and Timothy Johnson, was first offered by them in the spring; and a new graduate subject on the design of Very Large Scale Integrated (VLSI) Circuits was introduced and taught during the fall by Lynn Conway, Visiting Associate Professor from Xerox Parc, following a plan and a text of which she is a coauthor.

Professor Jonathan Allen, who will continue the VLSI Circuit Design subject in the future, was heavily involved in developing the local design facilities required for the extensive student chip-design projects in which the subject culminates. These projects were carried from initial conception through actual wafer fabrication, and were returned to students for testing, between about November and mid-January (during I.A.P.). This was accomplished by using the US Advanced Research Projects Agency (ARPA) NET for data communication to Xerox Parc (which arranged for mask making) and Hewlett Packard-Deer Creek, Palo Alto (which actually processed the final wafers). Professor Dimitri Antoniadis separated and packaged the returned chips for testing. These arrangements are expected to continue in the future under Professor Allen's leadership.

In research, the Department's deliberate thrust into integrated circuits was started last year with the programs of Professors Allen (in automated custom VLSI circuit design) and Henry I. Smith (in submicron structures and technologies); this direction has been pursued very actively by the development of a much larger coordinated program. Spanning several interdepartmental laboratories and the whole Department, from Complexity Theory in Computer Science to Submicron Technology in Electrical Engineering, the research program development is under the leadership of Professor Paul Penfield, Jr. It already involves other departments at M.I.T. (explicitly), and is expected to do so increasingly in the future.

Undergraduate Program

Enrollment of undergraduates averaged 925 in 1978-79, and is expected to stay at about the same level next year. Increases in the size of the Department's faculty have helped to alleviate some of the pressure produced by the enrollment growth of past years.

However, because of increased difficulty in recruiting graduate students to become teaching assistants (in part a result of the increased number of research assistantships available) we have not been, and do not expect to be able to, return to the small-size tutorial mode in our large undergraduate subjects in the near future.

The two new common-core subjects 6.002 and 6.003 mentioned above are more physically based than 6.011 and 6.015, which they replaced. The new subjects include an added laboratory component, and have been praised enthusiastically by the students. The faculty involved felt that the students were more strongly motivated than in the past because of the laboratory experiences, which are closely tied to the subject material.

As part of our continuing effort to improve our educational program, a Committee on Undergraduate Laboratory Policy chaired by Professor Leonard A. Gould was appointed. The Committee's task is to reexamine the philosophy and objectives of our undergraduate laboratory programs and to make appropriate recommendations for change.

The Ernst A. Guillemin Prize for the outstanding undergraduate thesis in Electrical Engineering was awarded to Jeffrey D. Macklis of Phoenixville, Pennsylvania. The Computer Systems Prize for the outstanding undergraduate thesis in Computer Systems was awarded to Gail Kaiser of Westboro, Massachusetts. The Electronic Connector Study Group Award was won by William J. Warner of West Orange, New Jersey.

Graduate Program

In September 1978, there were 492 graduate students enrolled in the Department. Of this number, 146 were newly admitted students. About 20 percent of the total were foreign nationals. The Department supported 211 research assistants, 86 teaching assistants, and awarded 16 fellowships. In addition there were 11 National Science Foundation Fellows and 15 Hertz Fellows. The remaining students had industrial or foreign government support or were using their own funds.

During 1978-79 the Department awarded the following graduate degrees: 122 S.M.s, 21 E.E.s, and 46 Ph.D./Sc.D.s.

The Department received over 1,150 applications for the 1979-80 year, the largest number ever. The applicants were generally excellent, and about 250 were admitted, of whom we expect 160 to register next fall.

Graduate students Monson H. Hayes, Mark A. Clements, and Steven C. Webster were given Supervised Investors Services, Inc. Awards for outstanding teaching performance by graduate students in the Department of Electrical Engineering and Computer Science. The Carlton E. Tucker Award for Excellence in Teaching, which carried the same citation, was won by Kaigham J. Gabriel. Professor Jeffrey H. Shapiro received an award from the Graduate Student Council for outstanding graduate teaching.

Cooperative Program (VI-A)

This year's VI-A class of 100 students topped last year's record-breaking class of 78, thus making it the largest entering class in the 62-year history of the Program. Companies participating on the Program listed 124 openings for the 141 students who applied for admission. One hundred twenty of these students finally appeared on company preference lists following the on-campus interviews held in March -- a much higher percentage than usual.

This year's increased number of openings, up from 89 last year, is attributable to: 1) companies' increasing the number of openings at their regular locations, 2) the addition by several companies of new divisions to the Programs, and 3) Fairchild Camera & Instrument Company's return to active participation in the Program this year.

The Fairchild Company will have openings at its facilities in both California and Maine. The General Electric Co. has added its Special Purpose Computer Center in Bridgeport, Connecticut, and its Electronics Park operation in Syracuse, New York. Motorola, Inc. has added its Semiconductor Group operation in Phoenix, Arizona.

A significant first for the Program, this year, was the complete computerization of the selection process from the initial interview sign-up procedure to the final matching of company and student interests after the interview process is concluded. This has made it possible for the present staff of the VI-A Office to handle the growth in the number of students applying for the Program, and the proliferation of company assignment locations and corresponding interview schedules.

Total enrollment in the VI-A Program, including juniors, seniors, and graduate students, will be at an all-time high during the 1979-80 academic year, and will represent 18 percent of the total enrollment in the Department.

RESEARCH

Most research is performed in departmental or interdepartmental laboratories. Information on the work of the following laboratories appears in other portions of this Report: the Electric Power Systems Engineering Laboratory (E.P.S.E.L.), the Research Laboratory of Electronics (R.L.E.), the Laboratory for Computer Science (L.C.S.), the Artificial Intelligence (A.I.) Laboratory, the Energy Laboratory, the Laboratory for Information and Decision Systems (L.I.D.S.) [formerly the Electronics Systems Laboratory (E.S.L.)], the Operations Research (O.R.) Center, and the Center for Materials Science and Engineering (C.M.S.E.).

The following research groups are otherwise unaffiliated: Continuum Electromechanics Laboratory, High Voltage Research Laboratory, Laboratory for Insulation Research, and M.I.T. Stroboscopic Light Laboratory. Highlights of this year's research from some of these groups is reported here.

Continuum Electromechanics Laboratory

In the Continuum Electromechanics Laboratory, Professor Alan J. Grodzinsky and his students are examining the contribution of electrical forces to the structure, function, and health of connective tissues. An ongoing project in collaboration with the Department of Orthopedic Surgery at Children's Hospital Medical Center, Boston has shown that electromechanical interactions play a significant role in the properties of normal articular cartilage. Degenerative wear of this biomaterial leads to arthritis. Other projects concern the connective tissue protein collagen. A new device has just been patented based on the use of collagen or other polyelectrolyte membranes. When an electric field is applied across the membrane, its permeability to solutes and water can be changed. This mechanism has important applications in commercial filtration and drug delivery devices.

Laboratory for Insulation Research

The Laboratory for Insulation Research has finished its excursion "From Atoms Toward Living Systems" with a final summarizing analysis (Technical Report 18, new series) and a Ph.D. thesis by Keith W. Kawate (Electrical Surface Studies on Hexagonal Ice and Their Interpretation), the 63rd Ph.D. thesis connected with the L.I.R. The remaining year before closing down will be used to study the fundamental basis of electroacupuncture.

Stroboscopic Light Laboratory

Several immediate applications of electronic flash photography have been found for the study of plankton in the ocean. One method is direct shadowing (silhouette) of the animal onto fine grain blue sensitive film, exposed by a distant small strobe lamp. This has been extremely useful while at sea where the ship's vibrations, together with the motion of the small animals, have made photographic recording difficult.

A second method involves a pressure resisting case for a camera, plus another for a strobe lamp, and an optical system similar to a backlighted microscope. The device is capable of taking 1,600 pictures on each sea emersion, which is necessary since the animal populations may be scarce. The camera is currently being tried in the sea on several problems.

In June two books, *Moments of Vision* and *Electronic Flash, Strobe* were published by the MIT Press; they illustrate the variety of work that is accomplished in the Strobe Lab.

FACULTY

Faculty promotions included Drs. Richard C. Larson and Stephen D. Senturia to professor; and Drs. Stephen A. Ward and Harold Abelson to associate professor.

Professor Fernando J. Corbató was appointed Cecil H. Green Professor of Computer Science and Engineering; he has been concentrating on computer operating systems, time-sharing systems, and knowledge-based application systems.

Joining our faculty this year are Dr. Dimitri A. Antoniadis, formerly a research associate and instructor in the Department of Electrical Engineering at Stanford University, now assistant professor in Electrical Engineering; Dr. Arvind, formerly on the faculty of the University of California at Irvine, more recently visiting assistant professor of Computer Science at Indian Institute of Technology, and now assistant professor of Computer Science and Engineering; Dr. Dimitri P. Bertsekas, formerly of the University of Illinois at Urbana, appointed associate professor of Electrical Engineering; Dr. John V. Guttag, formerly of the University of Southern California, appointed associate professor of Computer Science and Engineering; Dr. Pierre A. Humblet, formerly a research associate in the M.I.T. Laboratory for Information and Decision Systems, appointed assistant professor of Electrical Engineering; Dr. Jae S. Lim, who received his Ph.D. at M.I.T. and has been on leave of absence at

Lincoln Laboratory, now assistant professor of Electrical Engineering; Dr. Christos H. Papadimitriou, formerly of the Center for Research in Computing Technology at Harvard University, now assistant professor of Computer Science and Engineering; Dr. David P. Reed, who received his Ph.D. at M.I.T., now assistant professor of Computer Science and Engineering; and Dr. George C. Verghese, who received his Ph.D. from Stanford University, now assistant professor of Electrical Engineering.

Professors Mildred S. Dresselhaus, Sanjoy K. Mitter, and David H. Staelin were elected fellows of the Institute of Electrical and Electronics Engineers, and Professors Peter Elias and Robert G. Gallager have been elected members of the National Academy of Engineering. Professor Elias was cited for his pioneering work in the field of information theory and leadership in electrical education and Professor Gallager was cited for "contributions to coding and communications theory and practice." Dr. Harold E. Edgerton ("Doc"), Institute Professor Emeritus, has been elected to the Photo Marketing Association's Hall of Fame. Professor Alan S. Willsky has been named the recipient of the American Society of Civil Engineers' 1979 Alfred Nobel Prize; he was selected for his paper, "Relationship Between Digital Signal Processing and Control and Estimation Theory."

The Department was happy to welcome the following visiting faculty during the academic year. Lynn Conway was on leave as manager of the LSI research group at the Xerox Palo Alto Research Center. She was appointed visiting associate professor and in that capacity taught a subject on large-scale integrated circuits and performed research with Professor Allen's newly initiated LSI research project. Visiting Professor Robert W. Floyd, an eminent researcher in programming language and algorithms, spent his sabbatical from Stanford collaborating with Professors Vaughan Pratt and Ronald Rivest. Visiting Professor John Proakis was on leave from Northeastern University and was affiliated with Professor Alan Oppenheim's research group; Professor Proakis also assisted in teaching a graduate level subject in our Department. Dr. Hugh R. Outhred was on sabbatical leave from the University of New South Wales. He participated in research activities at E.P.S.E.L. and interacted with the Department faculty and students via seminars and guest lectures. Dr. Kenan E. Sahin was on sabbatical leave from the School of Business Administration at the University of Massachusetts; while here he collaborated with Professors William Martin and Peter Szolovits on their work on medical decision making. Finally, Professor Mahmood Nahvi was on sabbatical from Arya Mehr University in Tehran, Iran; here he was appointed visiting professor. He conducted investigations on the function of the cerebellar cortex in motor control, and interacted with faculty and students in R.L.E., the A.I. Lab, and the Department of Psychology.

Department faculty who were away during this year included Professors Arvind, Lim, Gerald P. Dinneen, Murray Eden, Roger G. Mark, James H. McClellan, Albert R. Meyer, Ronald R. Parker, and Jack M. Wozencraft. Professor Arvind returned from India to the University of California at Irvine, to finish his research before coming to his post as assistant professor here. Professor Dinneen is continuing as Assistant Secretary of Defense under President Jimmy Carter. Professor Eden extended his leave of absence again to continue as chief of the Biomedical Engineering and Instrumentation Branch of the National Institutes of Health's Division of Research Services in Washington, DC. Professor Lim spent his first year on the faculty on leave doing research at Lincoln Laboratory. Professor Mark spent his sabbatical leave this past spring visiting the Royal Post Graduate Medical School at Hammersmith Hospital, London. Professor McClellan was on leave this spring, engaged in research in the area of two-dimensional signal processing at the Lawrence Livermore Laboratory in California. Professor Meyer has been partially on leave from M.I.T. so that he could visit and teach in the Division of Engineering and Applied Physics at Harvard University. Professor Parker continued his leave from academic duties to further pursue his plasma fusion research at the Francis Bitter National Magnet Laboratory. And finally, during his leave of absence from M.I.T., Professor Wozencraft continued heading the establishment of a master's degree program at the Naval Postgraduate School at Monterey, California.

The following persons resigned from the Department: Professors Flora Y.-F. Chu, Madhu S. Gupta, Cyril S.K. Leung, Nils R. Sandell, Jr., and I. Theodore Young.

Professors Eden, Claude E. Shannon, and Henry J. Zimmermann have chosen early retirement. Professor Zimmermann will continue here at M.I.T. as a senior lecturer.

GERALD L. WILSON

Department of Materials Science and Engineering

Students and Programs

There were more graduate and undergraduate students registered in the Department in the past academic year than there have been for more than a quarter of a century. There were 163 graduate students and 110 undergraduates. From the preregistration figures, we expect this number to increase to 180 graduate and more than 130 undergraduate students in 1979-80. The increase in the number of undergraduates during the past year has been particularly dramatic, the total increasing by 48 percent between September 1977 and September 1978.

The number enrolled in our undergraduate subjects increased even more rapidly than the departmental enrollment. The total number of undergraduates enrolled in Course III subjects in the fall of 1978 was 737, compared with 553 in the fall of 1977. The enrollment in 3.091 Introduction to Solid State Chemistry, was 456. More than half of the freshmen at M.I.T. will satisfy the Institute chemistry requirement by attending 3.091 lectures given by Professors August Witt and Robert Rose and the recitations conducted by 12 members of the faculty assisted by six teaching assistants. Eight other subjects this past fall had more than 30 students in class; a few reached 50 which made classrooms and laboratories overcrowded. This was particularly true in 3.081 Materials Laboratory I. This undergraduate laboratory, supervised and taught by Professor Robert Ogilvie, reached a peak of 70 students in the spring term. The laboratory was designed more than 30 years ago for 15 students and much of the equipment dates back to those years. To meet the unexpectedly large increase in enrollment we had to use a number of makeshift arrangements. Plans to re-equip this important laboratory are under way.

A team selected by the Engineers' Council for Professional Development (ECPD) to report on the accreditation of the first degrees (S.B.) in Courses III, IIIA, and IIIB stated in their "Preliminary Conclusions and Findings" that "the faculty of the Department of Materials Science and Engineering is superb. The combination of numerical strength and individual qualifications makes this easily one of the outstanding materials departments in the country." The only criticism of substance in the report was that "... serious considerations should be given to making differential equations a required course..." The same point had been made earlier by the M.I.T. Corporation's Visiting Committee to the Department. In the past year the departmental curriculum committee has proposed, and the appropriate Institute committees have approved, changes in our undergraduate curriculum which allow us to include an appropriate mathematics subject in our list of required subjects.

The Cooperative Work-Study Program, Course IIIB, has prospered greatly, due to the enthusiasm and hard work of Professor Thomas King. This past term there were 44 students in the program, five of whom were placed through the School-wide Engineering Internship Program.

The number of undergraduate students from minority groups has risen steadily in recent years, reaching 13 percent of the population in the fall of 1978. This past academic year, there were more women undergraduates in Course III than in any earlier year. Thirty-five percent of our undergraduates are women, a higher percentage than in any other department in the School of Engineering and the second highest amongst all the departments of the Institute.

The number of graduate students in the Department in 1978-79 reached the all-time high of 163. Of these, 103 (65 percent) are supported by Research Assistantships. Close to 70 percent of our graduate students are citizens of the United States. Most of the foreign students, representing 16 different countries, bring their own financial support. At Commencement, 45 students were awarded graduate degrees.

FACULTY

In the past year Professors John Vander Sande and Ronald Latanision were awarded tenure. Three assistant professors, Joel Clark in Materials Engineering, C.S.P. Sung in Polymers, and Harry Tuller in Ceramics, will be promoted to associate professor (untentured).

Professor Robert W. Balluffi, Francis Norwood Bard Professor of Metallurgy at Cornell University, joined the Department as Professor of Physical Metallurgy. An assistant professor working in materials engineering was added to the faculty of the Department in September 1978. Professor Donald Sadoway, who received his doctorate from the University of Toronto in 1977, was working with Professor Julian Szekely as a research associate at the time of his appointment to this position.

Professor John Cahn, who was on leave at the National Bureau of Standards, resigned from M.I.T. for personal reasons. Professor Arden Bement, who held a joint appointment with the Departments of Nuclear Engineering and Materials Science and Engineering, decided to remain in Washington, DC at the Advanced Research Projects Agency of the US Department of Defense.

During the 1978-79 academic year, four search committees were established to nominate suitable people for untenured faculty positions. One, under the chairmanship of Professor Balluffi, nominated Dr. Samuel Allen to fill the vacancy in physical metallurgy; he will be appointed in the coming year. The second, chaired by Professor John Elliott, has nominated a person for the position in minerals engineering. The other two committees have not yet completed their searches. These additions to our junior faculty have become necessary because of the sharp increase in the commitments of the Department in both teaching and research. In making these appointments we are sensitive to the fact that a number of our senior faculty will be phasing out their research activities in the coming decade. Thus, we are planning to add junior faculty with research and teaching interests in those subject areas which we believe will be of the greatest importance in the future.

RESEARCH

In the academic year 1978-79 there was a further marked increase in research activity within the Department. As in the past few years, the major emphasis has been on the processing of materials and on other materials problems of importance to energy conservation or the search for new sources of energy. The research carried out by the faculty of the Department, their postdoctoral associates and, most importantly, their graduate and undergraduate students covers a very wide range of topics. It includes virtually every material of engineering importance and all manner of approaches from fundamental science to analysis of problems of large-scale industrial production.

In the past year the Department administered research grants and contracts to a total value of \$17.7 million, a significant increase in real terms over the previous year. More than half of our research support comes, directly or indirectly, from the US Department of Energy and agencies of the Department of Defense concerned with materials processing and productivity. At the same time our effort in basic materials science is being maintained at a high level. About a quarter of our research resources is devoted to this effort. We obtain substantial support from the National Science Foundation directly and through the Center for Materials Science and Engineering at M.I.T.; a number of our faculty contribute to the work of the Center through their participation in cooperative research groups, their supervision of research facilities, and their service on committees of the Center.

We continue to enjoy excellent support from a wide range of industries, through direct support of specific research projects, student fellowships, and by cooperation with us in joint research activities. The interaction with industry is particularly strong in materials processing. Work on the processing of metals and alloys from the primary extraction from the ore through the secondary thermo-mechanical processing of the semi-finished product

has been a major interest of metallurgists ever since the establishment of the Department. The magnitude and fruitfulness of our research in this broad area have increased strikingly in the last five years, largely because of the important impact this work has on energy-related problems.

In parallel with this resurgence in activity in metallurgical engineering there has been a major shift in the focus of research in ceramics towards the study of the development of new processing techniques for ceramics and the understanding of the science of ceramics on which they depend. Three years ago we established a ceramics processing laboratory which has prospered under the leadership of Professor Kent Bowen. Before developing the laboratory we set up an ad hoc advisory committee of eight leaders of ceramic processing research in industry. The advice and guidance of this committee from industry has been invaluable, and we have been able to develop many working relationships with industry as a result of their support.

Research on the processing of metals, ceramics, polymers, superconducting materials, and glasses is now so extensive that we felt the need for an organization which would facilitate communication and interactions between the various groups in the field, providing a central organization to plan policy and nucleate new initiatives, and to deal with the increasingly complex problem of working with Federal agencies and industry on national, and even international, projects. During the past year a charter for a Laboratory for Materials Processing has been drawn up by Professor Merton Flemings in collaboration with professors in the Department and in other departments concerned with various aspects of materials processing. The charter has been approved by the appropriate Institute committees and in the coming academic year the laboratory will be a working organization.

In the past year, on the initiative of the Center for Materials Science and Engineering, a major effort has been made to encourage the development of coordinated research in polymers throughout the Institute. Five members of the faculty of the Department participated enthusiastically in this activity and we look forward to playing a full part in the development of a strong, visible, interdepartmental research effort in polymers in the near future. These Institute-wide activities coincided with an unexpected, but welcome, upsurge in the level of research activity in polymers within the Department. In the past year, 20 students enrolled in the graduate program in Polymers, doubling the enrollment of the previous year. Early registrations suggest that the increase will continue in the coming year.

In earlier reports, concern was expressed at the disproportionate rate of growth of project-oriented research in materials engineering. This concern caused us to make unusual efforts to ensure the continued strength of our work in materials science and, most importantly, to expand our undergraduate teaching to maintain a balance between the research and teaching activities within the Department. We were, therefore, very pleased to discover that in the past year healthy growth occurred in teaching and in research. The balance between the two is important because each activity nurtures the other. We encourage our students to become involved with research as soon as they enter the Department as sophomores, and there can be no doubt that the exciting research environment in the Department adds greatly to the vitality of the educational experience which all of our students enjoy.

WALTER S. OWEN

Department of Mechanical Engineering

The Department of Mechanical Engineering, as well as the profession as a whole, enjoyed another year of unprecedented demand, reflecting the continuing importance of this broad engineering field. Mechanical Engineering is central to the solution of many of the most critical problems of today and of the future such as energy, transportation, health and rehabilitation, environmental quality, and manufacturing. Moreover, the broad disciplinary background and design orientation of the field provide excellent background for careers in fields such as management, law, public policy, and medicine.

Department of Mechanical Engineering

Undergraduate enrollment increased further this year by 18 percent following an 11 percent rise last year and a record 37 percent the previous year. Graduate enrollment also increased by 14.6 percent following a 24.5 percent increase in 1977-78. Graduate enrollment had remained nearly constant over the past decade at an average of about 230. Much of the recent increase in graduate population has been due to an increase in industrial support and the rapid growth of the Department's recent initiatives in manufacturing.

Competition for graduates of the Department was even keener than last year at all levels. The nationwide increases in undergraduate interest in Mechanical Engineering resulted in numerous openings for assistant professors, with demand particularly acute in systems and design, and manufacturing and thermal systems. High starting salaries in industry for S.B. and S.M. graduates continued to deter some of the best students from continuing graduate study, particularly in the case of women and minorities. Industry continued to be aggressive in establishing stronger ties with the Department through new fellowships, grants from cooperative research, gifts of equipment, support for junior faculty, and participation in the Engineering Internship Program.

The Internship Program, which was initiated as a School of Engineering program in 1977-78, has proven especially attractive both to industry and to M.E. undergraduates. The program leads to a combined S.B./S.M. degree with thesis, in cooperation with a participating company. Mechanical engineering students now represent almost half of the School-wide enrollment of 73 students and are placed in 13 of the 23 participating companies.

Total research volume and volume administered through the Department are estimated to reach \$8.5 and \$5.2 million, respectively, for 1978-79. The total volume includes research performed by mechanical engineering faculty through interdisciplinary centers and laboratories. The Department has strong interactions with the Energy Laboratory, the Center for Policy Alternatives, the Center for Transportation Studies, the Harvard-M.I.T. Division of Health Sciences and Technology, and the Center for Materials Science and Engineering.

The Department received some budgetary relief this year, following five years of sharply increasing enrollments and faculty workloads, which permitted a net increase of one junior faculty member in September and three more in January. Several more junior faculty will be added this fall.

Several important developments occurred this year in terms of research programs and facilities. A major gift from Evelyn E. and Eric P. Newman, Class of 1932, will make possible early completion of the Eric P. and Evelyn E. Newman Biomechanics and Human Rehabilitation Laboratory. This laboratory will include about 8,000 square feet of space and special equipment and computational facilities for research and teaching in human mobility. Specific research to be conducted in this new laboratory includes mobility aids for the blind, lower-limb prostheses, mechanics of human gait, and *in vitro* study of hip joint pressure distribution.

Through gifts from several corporations, the Department acquired a complete state-of-the-art Computervision computer-aided design system which has been installed in space contiguous to the design classrooms and is playing a major role in expansion of research and education in computer-aided design (CAD). Experiments in the integration of CAD methods into the undergraduate curriculum, including a novel personal CAD concept are being supported by a foundation grant and research is continuing in automatic drafting. The Department, together with cooperating industries, sponsored the First Annual Conference on Computer Graphics in CAD/CAM Systems which attracted more than 500 participants to M.I.T. for technical sessions.

Another important new development this year was the acquisition and installation of a major new computer facility centered around a Digital Equipment Corporation VAX 11/780 machine. The new facility includes interactive terminals, dial-in lines, interactive graphics, remote job entry to the M.I.T. Information Processing Service Center, dedicated real-time computation, and analog/hybrid capability. This local facility is a cooperative venture servicing teaching and research needs of the Departments of Aeronautics and Astronautics, and Civil, Mechanical, and Ocean Engineering.

The Department's initiatives in mining and mineral resources of the past three years continued to develop successfully, and activities in teaching and research helped M.I.T. to be selected as one of the new national Mining and Mineral Resources Research Institutes. Three subjects have been developed covering mining machinery design and the fundamentals of porous/geological materials. A successful industry/government/academic Working Conference on New Technology commercialization in the Mining Industry was organized by the Department and held at M.I.T. in January. A new M.I.T. research program in coal mine automation is currently being planned.

The Laboratory for Manufacturing and Productivity, formed by the Department in 1977 to provide new emphasis on research and education in manufacturing, has grown rapidly, continuing to involve faculty and students from several M.I.T. departments and centers. Effective January 1, 1979, the Laboratory became a School of Engineering laboratory reporting to the Dean of Engineering, reflecting its broad role at M.I.T.

In cooperation with the Laboratory for Information and Decision Systems and the Energy Laboratory, the Department initiated a new program in electronic control of automotive engines (diesel and spark ignition) with industrial and government support, thus expanding the traditional scopes of the departmental Sloan Automotive and Vehicle Dynamics Laboratories.

The continuing expansion of the Department in both enrollment and in new research areas of national importance is exciting and rewarding, but continues to produce intense pressures on limited space and outmoded laboratory facilities, as well as on the faculty. Modest growth in the number of faculty will begin to relieve workloads next fall but the Department remains critically in need of additional and refurbished space and new laboratory equipment for research and teaching.

UNDERGRADUATE PROGRAM

Enrollment Trends

Undergraduate enrollment increased by about 18 percent this year following an 11 percent rise last year and a record 37 percent in the previous year. In the fall of 1978, 130 sophomores registered compared with 99 in 1977. Total undergraduate enrollment reached 412 which is more than twice the population in 1974 and triple that of 1971. From 1971 to 1977, the faculty was reduced from 56 to 49. Thus the pressures on the faculty to accommodate this increase have been particularly acute. Further, the space and facilities to accommodate these large numbers of students have become totally inadequate. These factors currently threaten the leading position of the Department in mechanical engineering education.

Course II-A, which leads to the nonaccredited S.B. without departmental specification, continues to attract around 12 percent of mechanical engineering undergraduates. This program, administered by Professor Thomas B. Sheridan as registration officer, permits students to design interdisciplinary programs based in the mechanical engineering disciplines. Biomedical engineering was the most popular area of concentration, followed closely by computers, management, and acoustics.

The student honorary society, Pi Tau Sigma, conducted a comprehensive survey of the classes of 1978 through 1981 to determine the primary factors in their choice of mechanical engineering as their field of study. This survey was led by senior Bonnie G. Mason and resulted in a written report to the faculty. The four most important factors were found to be: prior interest in the field, the freedom and variety of the Department's program, the excellent job prospects, and previous exposure to mechanical engineering. Less significant were the influence of friends in campus living groups and exposure to the Department through core courses taken. Undergraduate seminars, UROP (Undergraduate Research Opportunities Program), and the freshman advisor were perceived as having relatively little influence on the choice of mechanical engineering.

Engineering Internship Program

The Engineering Internship Program has proven especially attractive to mechanical engineering undergraduates. Students are selected by participating companies during the sophomore year and spend the summers following the sophomore and junior years working at the companies. Students qualifying for graduate work carry out a single thesis for the S.B. and S.M. in cooperation with the participating company, with the thesis research normally conducted at the company. In the first year of the program, 11 mechanical engineering sophomores were among the 31 students selected by 12 participating organizations. During the past year, the number of companies increased to 23. Mechanical engineering student applications increased from 20 last year to 46 this year and 22 were placed with 13 companies, representing about 15 percent of the 148 eligible registered sophomores in the Department. The two-year total mechanical engineering student participation of 33 represents almost half of the total School-wide enrollment of 73 students. All of these students are still in the undergraduate portion of the Engineering Internship Program. A departmental subcommittee will be making recommendations to the faculty on the curricular and administrative requirements for the mechanical engineering graduate portion of the Internship Program. A policy of providing the Department with new funding to support the added thesis supervision load of this new program has been established; as a result, it appears that a more than adequate number of mechanical engineering faculty members are interested in supervising students' off-campus projects to make the graduate portion of the program an educationally sound experience. Professor Igor Paul administers the Program for the Department.

Undergraduate Office

The Undergraduate Office, which serves as a focus for all undergraduate matters, completed its sixth year of invaluable service to undergraduates. The leadership of the office was transferred to Professor David Gordon Wilson, the new undergraduate officer, while Peggy Garlick continued as administrative assistant. The Office administers all teaching assignments; provides communication between the Department and the Registrar's Office, the Schedules Office, and the Committee on Academic Performance; lists job opportunities; coordinates UROP projects and undergraduate theses; and supports the student-operated Pi Tau Sigma course and instructor evaluations. Owing to the major expansion of enrollment, it was necessary to remove the function of teaching assignments from the undergraduate officer. The new position of schedules officer was established which will be responsible for faculty load management, teaching assignments, and planning. Professor Ernest Rabinowicz is the first holder of the new position.

Undergraduate Enrollment Committee

The Undergraduate Enrollment Committee, which is responsible for presenting the Department and its programs to prospective students, was continued under Departmental Instructor James E. Hubbard, Jr. Major activities included participation in the Freshman Academic Midway in September, the Department's contribution to M.I.T.'s Open House, and organization of the second annual FITME Day (Freshman Introduction to Mechanical Engineering). During Open House, visitors crowded enthusiastically into many of the Department's laboratories to see the interesting and informative demonstrations.

Undergraduate Committee

The Undergraduate Committee, chaired by Professor James A. Fay, and composed of nine faculty and 12 representative student members, provides an effective policy forum for all issues affecting undergraduate life. It also fosters mutual understanding of problems faced by undergraduates and by faculty who must work under the severe pressures of M.I.T. As appropriate, the Committee recommends action by the Department administration, the faculty or its committees, or student groups. During the year the Committee emphasized the need for improvement in undergraduate laboratories such as 2.671 Measurement and Instrumentation and 2.14 Control System Principles; reviewed the survey completed by Pi Tau Sigma of the factors affecting the choice of mechanical engineering as a major by M.I.T. undergraduates; discussed the merits of a lecture/recitation mode of teaching core subjects; and encouraged the undergraduate student organizations to undertake projects to advise other students on registration and opportunities within the Department.

Undergraduate Laboratories

Mechanical engineering education is laboratory-intensive, requiring extensive facilities including machine tools, mechanical testing machines, electromechanical and chemical/mechanical energy conversion devices, computers, and sophisticated instrumentation. The Undergraduate Laboratory includes four basic core subjects: 2.86 Manufacturing Processes Laboratory, 2.671 Measurement and Instrumentation, 2.30 Mechanical Behavior of Solids, and 2.672 Projects Laboratory, in addition to one restricted elective, 2.14 Control Systems Principles. An extremely severe problem exists in all of these laboratories owing to overcrowding and obsolescence of equipment, most of which is at least 20 years old and is subject to an increasing frequency of breakdowns which frustrate students and, in some cases, present safety hazards. A major infusion of equipment funds and additional space is urgently needed.

Limited funds were allocated this year which made possible the purchase of several items of equipment for 2.671. Plans have been made for major refurbishing of the 2.30 laboratory and a relocation of part of the laboratory has resulted in greatly improved space utilization. Foundation support was sought for the approximately \$150,000 needed for modern equipment for this laboratory.

The integration of the 2.671 and 2.672 laboratories into a common location in the basement of Building 3, completed in 1977-78 under the direction of Professor Adam C. Bell and Technical Instructor Edward E. Fischer, has proven very successful in making more effective use of instrumentation, space, and supervisory personnel. This summer the instrument room will also be relocated to contiguous space.

The student shop was heavily overloaded with undergraduates working on undergraduate research and design projects and on senior theses. Numerous complaints led to limited evening hours of operation.

Subjects of Instruction

One of the major ongoing efforts in the undergraduate core curriculum is a comprehensive review and revision of the basic sequence in mechanics and materials which includes 2.86 Manufacturing Processes, 2.01 Mechanics of Solids, 2.30 Mechanical Behavior of Solids, and 2.34J Deformation and Failure of Engineering Alloys in Service. Professor Robert O. Ritchie, series professor for this sequence, has led a faculty group which has proposed major changes in the scope and content of this part of the curriculum.

During the past two years, Professor Frank A. McClintock, with the assistance of Postdoctoral Associate and Lecturer John L. Bassani, has been experimenting with revisions of 2.01; they are writing class notes in anticipation of a revised textbook. The principal changes involve presenting solid mechanics in a way that leads naturally into modern finite-element methods and the introduction of computer-based problems. A plan for major restructuring of 2.30 has been developed which involves splitting the subject into two new subjects, 2.31 and 2.32, and a coherent laboratory extending through two semesters. The present 12 units will be expanded to 18 and the content revised to provide strong integration of fundamental materials behavior with the engineering performance (fatigue, fracture, creep, etc.) of macrostructures. This plan has been endorsed by the Mechanics and Materials faculty and will be presented to the Department faculty this fall. This development is expected to lead to a new basic text which may have a substantial impact on mechanical engineering curricula in the mechanical behavior of materials.

The subject 2.071J Introduction to Structural Mechanics was revised to include topics concerning thick walled spheres, compound cylinders, beam design and optimization, mooring cables, introduction to classification rules and introduction to plastic analysis and plastic buckling of columns. These changes were coordinated by Professor James H. Williams, Jr., and the Department of Ocean Engineering.

Professor Peter W. Huber introduced the new subject 2.21 Applications in Fluid Mechanics in the spring of 1979. The course, which is a second-level undergraduate subject, is intended as a sequel to 2.20 Fluid Mechanics. It covers a variety of applications including advanced

topics in compressible flow, wave propagation, and turbulence. The course has been broadened and will become a new restricted elective for Mechanical Engineering undergraduates next year.

Student Organizations

The student chapter of the American Society of Mechanical Engineers (ASME) was unusually active under the leadership of its officers: Suzanne M. Burzyk (president), Warren J. Manning (vice president), Lorraine G. Olson (treasurer), and Gerald P. Dyer (secretary). Professor David C. Gossard continued as Faculty Advisor.

Guest speakers at the Chapter's meetings included Professor Peter Griffith discussing career opportunities, Professor Robert W. Mann, who spoke on engineering ethics, and Sarah Simon, from the Boston Society of Women Engineers, who talked about experiences of women in engineering.

During the January Independent Activities Period, ASME sponsored a well-attended series of plant visits to expose students to engineering activities in the Boston area, and in the spring hosted the "First Annual Make Your Own Ice Cream Sundae Social." This year also marked renewal of participation in the Boston section of ASME. M.I.T. students attended the Student Night meeting of the Section and Ms. Burzyk participated with the Board of the ASME Executive Council in discussions of the directions of ASME in its second century which begins in 1980. The president and vice president of the Chapter, sponsored by the Department and a special gift from the Proctor and Gamble Company, attended the ASME Annual Meeting in San Francisco.

Pi Tau Sigma, the mechanical engineering honorary society, continued its tradition of service to the Department, the most important of which is the student evaluation of courses and instructors. In addition to the survey of factors in the choice of mechanical engineering by undergraduates described earlier, the Society sponsored a highly successful series of biweekly Friday afternoon student-faculty social hours and two steak frys. Professor Ernest G. Cravalho was faculty advisor and the elected officers were Mark H. Stern (president), Scott W. Lewis (vice president), Marc B. Brewster (secretary), and Gilbert S. Godbold (treasurer).

Black ME, the organization of black students in mechanical engineering, provides academic help and facilitates communications among black students and the faculty. The organization was revitalized in 1976 by a small group of black students led by Mr. Hubbard to provide service to the Mechanical Engineering Department as a whole and to serve minority students within the Department. Black ME is active in recruiting minorities into the Department and provides study aids, personal tutoring, and career guidance for its members. Membership has grown in the past three years from 13 to 32. Activities during 1978-79 included revision of the HoToGAMED Guide ("How To Get Around the Mechanical Engineering Department"), expansion of study guides for Department subjects (filed in the Libraries and in the Black ME Lounge), organization of an Open House program for minority freshmen, interaction with the M.I.T. Student Section of ASME and the National Society of Black Engineers, and organization of career guidance and technical seminars. In addition, fund-raising activities, such as bake sales and T-shirt sales, and social activities such as faculty-student dinners, were also sponsored. Officers for 1978-79 were: Garry W. Perkins (president), Gail O. Hayes (secretary), and Herbert C. Buchanan (treasurer). Professor Stephen H. Crandall continued to serve as Faculty Advisor.

Student Awards

Beth Doll of Patterson, North Carolina was one of seven women at M.I.T. who were awarded Ida M. Green Fellowships. Ms. Doll is a senior in mechanical engineering at M.I.T. and will continue in the S.M. program in the Department.

Beth A. Marcus, president of the senior class, was awarded a Marshall Scholarship and will study at London University. She also received the prestigious Scott Paper Company Foundation Award which is given to individuals who have demonstrated strong leadership qualities, as well as academic excellence.

The M.I.T. Mining and Minerals Resources Research Institute presented grants to sophomore Joseph C. Maher and senior John-Thomas Amenyo for research in this field. Mr. Maher will be

working with Professor Michael P. Cleary on "Some Special Thermomechanical Tests on Oil Shale;" and Mr. Amenyó with Professor Carl R. Peterson on "Computer System Organizations for Automated Control of Coal Mining Machinery."

Two sophomores were selected as General Motors Scholars for their junior and senior years. Annie L. Murray will work with the Detroit Diesel Allison Division and Bert M. Vermeulen with the Oldsmobile Division.

Sophomore David Kang was selected for a Kodak Scholarship which provides partial tuition for the junior and senior years and an unrestricted grant to the Department.

Competition for the lucrative DeFlorez Awards for "outstanding ingenuity and creativity" was particularly keen this year, reflecting strong student interest in design and innovation. First prize was awarded to J. Randolph Andrews for his design and fabrication of a numerically controlled lathe, while second prize went to Donald Jue for his design of a residential water-heating system utilizing refrigerator waste heat.

Thirteen awards from the Wunsch Foundation Silent Hoist and Crane Company were won by mechanical engineering undergraduates for outstanding work in the fields of production and materials handling. Among the awards, several were in the area of algae harvesting/processing for Nahant Bay, and one project resulted from the junior design subject 2.73 Design Projects.

The annual Mechanical Engineering Department Student Service Award was presented to senior Mark H. Stern for leadership in student-faculty relations.

Senior Warren J. Manning received a William L. Stewart, Jr. Award for outstanding contributions to extracurricular life, and junior Jason J. Tong received the Harold J. Pettegrove Award for outstanding service to intramural athletics.

GRADUATE PROGRAM

Enrollment Trends

Graduate enrollment increased by 14.6 percent to 314 students following a 24.5 percent increase in 1977-78. This year the Department was the second largest in the Institute in graduate (and in undergraduate) population. Graduate enrollment had remained at an average of about 230 (not including special students) over the past decade. The substantial growth in the past two years reflects both an increase in industrial fellowships and the rapid growth of the Department's program in manufacturing. For example, the number of graduate students in manufacturing has increased by about an order of magnitude to more than 50 during the past three years.

Currently, the national competition for excellent mechanical engineering graduate student applicants has never been more acute, in light of the financial inducements for students to enter industry following the S.B. or S.M. (especially in the case of women and minorities). In spite of this trend, the Department attracted more than its expected share of outstanding graduate students. The most impressive response was in the Systems and Design area where 78 percent of the offers of graduate admission to the very top applicants were accepted.

In 1978-79, the Department awarded 79 S.M. degrees, 2 combined S.B./S.M. degrees, 3 Mechanical Engineer, and 24 doctoral degrees.

New Subjects of Instruction

The Department collaborated with the M.I.T. Center for Transportation Studies in the development of curricula for the newly approved interdisciplinary S.M. degree in Transportation. The new degree program involves a new core graduate subject, 2.120J/CTS 140 Transportation Performance and Technology, which is being jointly developed by Professor J. Karl Hedrick and Professor Yosef Sheffi of the Department of Civil Engineering. The objectives of this new sub-

ject, to be offered in 1979-80, are to expose students to transportation system performance measures (energy, noise, safety, etc.), vehicle technology, and system analysis (networks, terminal design, etc.)

Professor Richard H. Lyon collaborated with the Department of Ocean Engineering to combine and restructure courses 2.06 Mechanical Vibration and 13.80 Mechanical Vibration and Noise for Ocean Engineers, forming a new graduate level joint course, 2.06J Mechanical Vibration.

A new course, 2.094 Theory and Practice of Continuum Mechanics, developed by Professors Cleary and Klaus-Jürgen Bathe, will be offered for the first time in the spring term of 1980. The objectives of the new course are: to teach the basic important continuum mechanics principles with their unifying aspects and show how the special problems of strength of materials, fluids, etc., derive from these general principles; and to show how these general principles can be used in practice to obtain solutions to complex problems.

Professor Myron Tribus of the Center for Advanced Engineering Study, together with Professor J. Edward Vivian of the Department of Chemical Engineering and Professor James C. Keck, will offer a new subject, 2.453J/10.807J The Maximum Entropy Formalism, in which the principle of maximum entropy is developed for a range of applications including thermostatics, irreversible processes and reliability engineering.

Professor Padmakar P. Lele and Professor Gordon L. Brownell of the Department of Nuclear Engineering, developed the new course 2.761J/22.56J/HST 561J Principles of Medical Imaging. This subject will cover the principles of medical imaging including X ray, nuclear medicine, ultrasound, nuclear magnetic resonance, emission and transmission-computed tomography, and other modalities. Medical applications, biological hazards, and cost-benefit analysis of imaging modalities also will be explored.

Student Awards

The prestigious Goodwin Medal, given for "conspicuously effective teaching" by a graduate student instructor, was presented to the Departmental Instructor for 1978-79, James E. Hubbard, Jr., who will return to full-time doctoral study next year. Mr. Hubbard also was elected a member of Sigma Xi. Scott W. Lewis received a Marshall Scholarship which will allow him to study for the Ph.D. at Balliol College, Oxford. His thesis will be in the area of fault imaging, a new kind of computerized mapping technique. M.I.T. students received three of the 30 Marshall Scholarships, two of which went to students in this Department -- Mr. Lewis and an undergraduate, Ms. Marcus.

MAJOR NEW FACILITIES

A development of major importance was the acquisition of a new time-sharing computer system to replace the outdated system of Interdata minicomputers which have served the local computing needs of the Departments of Civil and Mechanical Engineering for the past several years. Following a series of meetings of the Heads of the Departments of Civil, Ocean, and Mechanical Engineering last year, an interdepartmental planning group was formed under the chairmanship of Professor Derek Rowell. A Herculean effort by this group resulted in an excellent proposal for a new facility to serve the local educational and research needs of the three departments. Subsequently, the Department of Aeronautics and Astronautics joined the consortium. Following approval of the proposal by the four Department Heads, the Dean of Engineering, the Provost, and the Chancellor, capital funds were loaned to the departments for acquisition of the facility. The facility will support operating expenses and retirement of capital debt through charges to academic and research users.

The new facility, which was installed and brought on-line in January, is designed around the new Digital Equipment Corporation (DEC) VAX-11/780 with an initial two megabytes of memory, 500 megabytes of on-line disk storage, approximately 30 interactive terminals in the facility, and 10 dial-in remote lines. The system also includes a DEC PDP 11/34 for dedicated real-time operations

(including interactive computer graphics) linked to the VAX, and provision for linking of remote laboratory computers to the facility. A remote-job-entry link to the IBM computer at the central M.I.T. Information Processing Services allows users to transfer files and share the resources of the two facilities. The facility also includes an Electronics Associates Incorporated analog computer with hybrid interface which has yet to be linked to the new digital machine. During the coming year, a decision will be made on whether or not to upgrade the analog/hybrid aspect of the facility or to eliminate this capability.

The facility has been extremely well received during its first semester of operation and has attracted more research users than expected. This increased use, together with a heavy undergraduate teaching load (about 150 students) in introductory programming, saturated the facility during the spring and has led to plans for expanding the machine capacity this fall.

A major gift from Evelyn E. and Eric P. Newman, M.I.T. Class of 1932, will fund a long-sought reconstruction of space on the first floor of Building 3 to form the Eric P. and Evelyn E. Newman Biomechanics and Human Rehabilitation Laboratory. The Laboratory, to be completed by fall 1980, will provide the Department with internationally unique facilities for real-time determination of the position of individual body segments and the dynamic joint loading during normal and pathological human movement. The Laboratory will provide prosthesis simulation capability for amputees and for mobility aids for the blind. Testing capabilities related to studies of synovial joints, particularly the human hip, will also be expanded to support the goal of understanding normal joint behavior and how and why joints degenerate in the disabling disease of osteoarthritis. When completed, this Laboratory will clearly be the premier research facility of its kind in the world. Leadership for this development was provided by Professor Robert W. Mann, Whitaker Professor of Biomedical Engineering. The Laboratory will enhance the research of Professors Mann, Rowell, Paul, and Woodie C. Flowers.

The Department's evolving program in Computer-Aided Design received a boost from the acquisition, through a gift from an alumnus and from unrestricted gifts from several corporations, of a complete state-of-the-art Computervision computer-aided design system and associated software. This acquisition, made possible through the efforts of Professor David C. Gossard, is making possible exciting new educational and research developments in the rapidly expanding field of computer-aided design.

RESEARCH

Research Volume

The total volume of sponsored research and the volume administered through the Department are projected to reach \$8.5 and \$5.2 million, respectively, for fiscal year 1979, representing a research volume per faculty member of about \$170,000. These figures represent increases of 13.3 percent and 15.5 percent over the previous year. Total research volume includes research conducted by mechanical engineering faculty and staff through the interdisciplinary laboratories, centers and programs. The bulk of this research was supported by agencies of the Federal government although progress continues to be made in increasing research support from industry.

Unrestricted funds which enable the Department to enter new fields of research not currently popular with government agencies, to enhance career development of junior faculty, and to acquire new research equipment continued to be scarce. Several corporations and foundations made modest unrestricted grants to the Department which proved extremely valuable. In the past such grants have typically had large leverages in the subsequent development of externally funded research programs.

Scope and Trends

The scope of the Department's research is very broad, reflecting the wide spectrum of disciplinary skills of the faculty and the range of interests from fundamental research to engineering development. This breadth is one of the unique strengths of the Department and provides a rich educational environment for both undergraduate and graduate students.

Applications-oriented research conducted by faculty, staff, and students can in most cases be grouped in four major functional areas: energy and environment; manufacturing, materials and materials processing; biomedical engineering; and systems including transportation. The largest activity is in energy and environment, with over 40 percent of all faculty involved. Research in this area involves strong collaboration with the Energy Laboratory, particularly in combustion and energy conservation, and with the Electric Power Systems Engineering Laboratory in electro-mechanical energy conversion. Manufacturing, materials and materials processing research has grown recently owing to the Department's emphasis on manufacturing and polymer processing, and now involves 32 percent of the faculty. Biomedical engineering and systems including transportation each involve 28 percent and 20 percent of the faculty respectively, and have also grown significantly in the past few years.

Basic research is also conducted in each of the three major fundamental disciplines which form the scientific and intellectual base of the profession: mechanics and materials, thermal and fluid sciences, and system dynamics and control. In spite of stated federal intentions to strengthen basic research, support for fundamental research in engineering continues to be scarce. Examples of ongoing basic research in the Department during the past year include: fatigue, deformation, and fracture of metals, glassy polymers, composites and porous/geological materials (Professors Cleary, McClintock, Ritchie, Williams, Ali S. Argon, and David M. Parks); ignition, combustion of gas/fuel mixtures, combustion instability, turbulence modeling and smoldering (Professors Keck, John B. Heywood, Stephen B. Pope, Tau-Yi Toong, and William C. Unkel); tribology (Professors Rabinowicz and Nam P. Suh); fluid flow, flutter and wave propagation in collapsible tubes (Professors Roger D. Kamm and Ascher H. Shapiro); heat transfer in fluidized beds, in nucleate boiling and between immiscible fluids (Senior Research Scientist Leon R. Glicksman and Professors Borivoje Mikic, Michael G. O'Callaghan, and Warren M. Rohsenow); random vibration (Professor Crandall); computational mechanics (Professor Bathe); and nonlinear control (Professors Hedrick and Henry M. Paynter).

New Programs and Notable Accomplishments

In *Biomedical Engineering*, Professor Lele achieved exciting results in his research on the use of hyperthermia induced by ultrasonic radiation to treat tumors. Experiments with animals have demonstrated that malignant tumors can be drastically reduced through hyperthermia, promising a new and effective means of treating certain classes of human cancer. In a related effort, Professors Paynter and Rowell continued research on the optimal planning of X-radiation dosage using interactive computer graphics.

Professors Cravalho, Mikic, and O'Callaghan completed research on cryogenic preservation of, and heat transfer in, living tissue.

Professor C. Forbes Dewey, Jr., while on sabbatical leave as visiting professor of pathology at Harvard Medical School, established a long-term research program with Drs. R. Cotran and M. Gimbrone of Peter Bent Brigham Hospital on the influence of blood flow on arterial endothelium (the "pavement" lining human arteries). This program should help to elucidate the causes of arteriosclerosis.

Professors Flowers and Rowell collaborated in the further developments of the M.I.T. Knee, a microprocessor-controlled above-knee prosthesis which closely simulates normal gait.

Professor Mann and collaborators completed important research on the mechanics and configuration of normal, pathological, and artificial hip joints. He also continued research on the kinematics and dynamics of human mobility.

Professor Rowell, Director of the Center for Sensory Aids Evaluation and Development, developed a new system which enables blind persons to function as telephone operators. The system was highly successful in field tests conducted in the Southern Bell System (where blind operators out-performed normal operators).

Professors Kamm and Shapiro collaborated in researching applications of fluid mechanics to cardiovascular problems. They are applying the results of basic work on flow in blood vessels to systems for external cardiac assist and prophylaxis of deep venous thrombosis. New research also

was initiated on the aqueous outflow from the anterior chamber of the eye which influences the incidence of glaucoma.

Professor Ioannis V. Yannas and his medical collaborators made further progress toward the development of artificial skin for treatment of severe burns and blood-compatible tubes for blood vessel replacement.

In *Manufacturing, Materials and Materials Processing*, the Laboratory for Manufacturing and Productivity (L.M.P.), established in January 1977, made exceptional progress under the continued direction of Professor Suh. The Laboratory incorporates the highly successful M.I.T.-Industry Polymer Processing Program which this year had 24 active projects in cooperation with 12 sponsoring companies. Included are such topics as friction and wear of polymers, fiber orientation in injection molding, and sequential forming of plastic parts. Other representative research in the Laboratory includes Federally supported programs in manufacturing axiomatics, sequential computer-controlled sheet metal forming, and geothermal energy in manufacturing.

A new activity in Replication Technology (conversion of feedstock into product by reference to an existing prototype) was initiated by Professor Paynter. A successful workshop will result in a proceedings report "Critical Assessment of Replication Technology." Seed funds were acquired to initiate a new program on "Flexible Materials Processing" under the leadership of Professor Stanley Backer which will consider the paper, textile, plastics, and other industries which deal with flexible materials. In cooperation with the Acoustics and Vibration Laboratory, Professor Lyon has initiated a new research activity in machine dynamics which will develop technology needed for the future generations of microprocessor-controlled high performance machines. Professor Warren P. Seering is collaborating in this development.

Professor Nathan H. Cook developed COSMOS, a computer model for the optimization of small parts manufacturing, and Professor Günther Werner continued research on precision grinding.

Professor Gossard continued development of the field of computer-aided design and computer-aided manufacturing (CAD/CAM). He completed research in symbolic dimensioning for automatic drafting and continued development of computer-controlled brake forming.

The L.M.P. has reached a total research volume well above \$1 million annually, with about 50 graduate students and 15 faculty involved from several departments and Schools. Reflecting its broadening role at M.I.T., the Laboratory was designated in January as an Engineering School Laboratory reporting to the Dean of Engineering.

Notable new developments in Energy and Environment included expansion of the Department's initiatives in mining and recovery of oil from shale, broadening of Sloan Automotive Laboratory programs in internal combustion engines and extension of fluidized bed combustion work to solve the key problem of scale-up relationships.

In the mining area, Professors Cleary and Peterson were involved in research ranging from fundamental thermomechanical and fracture mechanisms in oil shale (leading to improved hydraulic fracturing methods) to design-oriented work on basic cutting methods for shale excavation, hydraulic hammer design, mine roof-fall warning systems, and coal mine ventilation. In the area of policy, M.I.T. hosted a "Working Conference on New Technology Commercialization for Mining" chaired by Professor Peterson, which produced recommendations for accelerating commercialization of new concepts and led subsequently to suggestions for updating health and safety regulations to enhance application of new technology. An interdepartmental planning group was established at M.I.T. to develop a program of research in coal mine automation.

In the Sloan Laboratory, Professors Heywood, Keck, Pope, and Drs. Joe M. Rife, and David P. Hoult expanded research in spark ignition and diesel engines. Work was completed on the modeling of turbocharged engine performance, and new programs on soot formation and the health effects of diesel particulates were initiated in cooperation with the Energy Laboratory, the Department of Chemical Engineering, and the Department of Nutrition and Food Science.

Dr. Glicksman is leading the construction of a 16 ft² area fluidized bed facility which will be used with an existing coal burning 4 ft² bed to establish flow modeling rules and scaling laws for large-scale fluidized bed combustors. He also is developing several new programs to expand the Department's research in energy conservation.

Professor Thomas P. Bligh initiated research on thermal storage systems for buildings and reverse Stirling heat pumps for district heating using lakes as the heat sources.

Professors Huber and Ain A. Sonin are investigating fluid-structure interactions in nuclear reactor containment systems, including steam condensation instabilities in loss of cooling accidents. Professors Mikic and Griffith are studying heat transfer effects in fusion reactors and in avoiding accidents in liquid metal fast breeder reactors.

Professor Fay continued research on long distance transport of air pollutants and scale effects in liquefied natural gas (LNG) spills. Professor Ronald F. Probststein investigated the hydrodynamics and fouling of pressure-driven membrane desalination and water treatment systems and developed a new model of high-rate sedimentation devices known as lamella settlers.

Professors Joseph L. Smith, Jr., and Michael E. Crawford, in cooperation with the Electric Power Systems Engineering Laboratory, continued work toward the demonstration at M.I.T. of a 10 MW superconducting generator.

Professor Wilson initiated research on the feasibility of treating and recycling demolition wastes.

Activity in Systems Including Transportation grew significantly in magnitude and scope. Professor Sheridan extended his research in man-machine systems in several areas: supervisory control of undersea teleoperators, which have the potential of replacing human divers in hostile ocean environments; the control and navigation of undersea semi-robotic unmanned vehicles for oceanographic research; flight management and supervisory control for future generations of commercial aircraft, and studies of pilot mental workload; and human operators in nuclear reactor safety.

The Vehicle Dynamics Laboratory continued its rapid development of the past several years under the leadership of Professors Hedrick and David N. Wormley. One of the major thrusts of the Laboratory at present is the dynamics of conventional and advanced rail systems for intercity freight and passengers including: track error characterization and standards, nonlinear dynamics of freight trucks, the optimal design of passenger trucks and determination of rail passenger vehicle performance limits. Work also continues on advanced intercity and automated guideway transit systems and on the dynamics of highway trucks. A major new initiative of the Laboratory this year was the development of new research in electronic control of internal combustion engines in cooperation with the Sloan Automotive Laboratory and the Laboratory for Information and Decision Systems. A new faculty member, Professor Paul K. Houpt, is leading this effort in collaboration with Professor Wormley, Dr. Rife, and Professor Michael Athans (Department of Electrical Engineering and Computer Science).

FACULTY AND STAFF

Size and Composition

In spite of the sharply increasing enrollment of the past five years, budget stringencies made it impossible to increase faculty size, which had remained at about 49 regular and one adjunct faculty. At the end of 1977-78, the Department had the lowest ratio of budget allocated to credit units taught (\$37.76) at the Institute. A modest budget increase in 1978-79 permitted the net addition of one junior faculty member in September and three more in January.

In spite of an aggressive affirmative action program, the distribution of women and minorities throughout the faculty and staff remains substantially unchanged. The faculty includes three orientals, one black, and two women. Among the 57 research staff, lecturers, and technical instructors, are nine minorities (seven orientals, one black, and one hispanic) and three women. The supporting staff (consisting of sponsored research and administrative staff, secretaries, and hourly workers) numbers 69, among whom are four minorities (including three blacks on the hourly staff) and 35 women. Women are in the majority in administrative positions and fill most of the 30 secretarial positions, although two secretaries are males.

Notable Accomplishments and Awards

Professor Backer, Head of the Department's Mechanics and Materials Division, was named Honorary Member of the Groupe Europeen D'Experience sur la Direction de la Recherche Textil and was also selected to deliver the Edward P. Schwartz Memorial Lecture entitled, "Inelastic Deformation and Fracture in Metallic, Oxide and Polymeric Glasses" at London University.

Professor B. Shawn Buckley received two IR-100 awards from *Industrial Research and Development* magazine for two of the top 100 industrial innovations of the year for his Thermic Diode Solar Panels and his development of a Phase Monitored Inspection System. Professor Buckley is believed to be the only person in the history of these awards to be cited for two innovations in a single year.

Professor Cleary was named the second Carl Richard Soderberg Assistant Professor in Power Engineering, following an Engineering School-wide competition. The objective of the Soderberg chair is to provide a promising young faculty member with an opportunity to enhance his or her career in teaching and research in the general area of power engineering. Professor Cleary, together with his colleagues, provided the impetus for the formation of a group within the Department concerned with the recovery and processing of fossil fuel.

Professor Crandall was awarded the Trent-Crede Medal by the Acoustical Society of America for outstanding contributions to the science of mechanical vibration and shock. He was cited for his contributions to education, research and professional development in vibrations, "especially those aspects of random vibration associated with components and structural failure." Professor Crandall was also elected Chairman of the American Society of Mechanical Engineers' Policy Board, Basic Engineering. He was the Keynote Speaker at the American Society of Civil Engineers' Conference on Probabilistic Mechanics and Structural Reliability in Tuscon in January and the Southwest Mechanics Lecturer at Oklahoma University, Louisiana State University, the University of Texas, and the Shell Development Company. He was also an invited lecturer at the Canadian Congress of Applied Mechanics in Sherbrooke, Quebec.

Professor Fay is a director of the Boston Harbor Associates and of the Union of Concerned Scientists and a member of the National Research Council committees on Urban Waterfront Lands and Radioactive Waste Management.

Professor Flowers received the Western Electric Fund Award in October. He was cited "for leadership, innovation, and excellence in the instruction of undergraduates in engineering design and entrepreneurship; and for his personal example which has inspired in students a sense of the challenge, excitement, and satisfaction of the art and science of design."

Professor Mann received the 37th Engineering Societies of New England Award which is given to a living engineer in New England who has displayed outstanding contributions to the engineering profession. The citation read, "Through two decades of pioneering work you have synthesized engineering and medicine to aid the physically handicapped." Professor Mann, who was the first holder of the Whitaker Professorship of Biomedical Engineering, has just been re-appointed to a second five-year term. He was also elected a fellow of the Institute of Electrical and Electronics Engineers and was cited for leadership in biomedical engineering research and education and in the application of technology to the problems of the handicapped.

Professor McClintock received the Nadai Award of the ASME at this year's winter annual meeting for his contributions to the understanding of fatigue and fracture of metals and for his contributions to engineering education. The award was established in 1975 to recognize distinguished contributions to the field of engineering materials.

Professor Paynter served last year as a Sigma Xi National Lecturer and will continue in this capacity next year. He delivered lectures at eight universities and research groups on the subjects: "Can Ockham's Razor Work?" "Positive/Negative Feedback: Catastrophe or Control?" and "Chemical and Biological Oscillators: How and Why." This December, he will receive the ASME Rufus Oldenburger Medal for meritorious contributions to the field of automatic control. The citation reads: "in recognition of your creative accomplishments in all aspects of dynamic systems theory and practice -- especially fluid transients, simulation methodology and the bond graph language -- your inspiring example to students and colleagues, and your supreme enthusiasm."

Professor Probst is a councilor of the American Academy of Arts and Sciences and gave the Vollmer W. Fries Energy Lecture at Rensselaer Polytechnic Institute. He also lectured on "Water in Synthetic Fuel Production" at the annual meeting of the National Academy of Engineering.

Professor Ritchie received the ASME Journal of Engineering and Materials 1977 Best Paper Award for his paper entitled, "Near-Threshold Fatigue Crack Propagation in Ultra-High Strength Steels: Influence of Load Ratio and Cyclic Strength." In November 1979, he and Ronald M. Horn will receive the American Society of Metals' Marcus A. Grossman Young Author Award for their paper entitled, "Mechanisms of Tempered Martensite Embrittlement in Low Alloy Steels."

Professor Shapiro received the Doctor of Science *honoris causa* from the University of Salford in England. He received the Townsend Harris Medal from the City College of New York, which symbolizes the recognition by the Alumni Association and the College of the exemplary contributions he has made in his chosen field of endeavor.

Professor Suh was elected the 14th US member of the exclusive International Institution for Production Engineering Research.

Professor Emeritus C. Fayette Taylor, who is not only a distinguished engineer, but also a well-known artist, presented the Department with a handsome metal sculpture.

Professor Yannas received a Certificate of Achievement from the Hellenic Medical Society of New York "in recognition of outstanding contributions to the medical profession" for his work on developing an artificial skin.

New Faculty

Dr. Elias P. Gyftopoulos, Ford Professor of Engineering in the Department of Nuclear Engineering, was appointed jointly in the Department of Mechanical Engineering. He will provide leadership and collaboration with the Department's thermodynamics faculty in fostering research and graduate curriculum development.

Dr. Thomas P. Bligh joined the systems and design division as an associate professor of the Department in January from the University of Minnesota. His current research interests include energy conservation in buildings and efficient rock fracture through controlled detonation.

Dr. Paul K. Houpt also joined the systems and design division as an assistant professor in January from the M.I.T. Laboratory for Information and Decision Systems where he had been conducting postdoctoral research in real-time traffic control. He will collaborate with Professor Rowell in the development of curricula in automatic control and microprocessor-based control of mechanical systems.

Dr. Roger D. Kamm was appointed assistant professor in the thermal and fluid sciences division. His research is in the area of the dynamics of blood flow with applications to the prevention of thrombosis.

Dr. Michael P. O'Callaghan joined the thermal and fluid sciences division as an assistant professor and will be working in the Heat Transfer Laboratory. His interests are in cryogenic preservation of living tissue and in the fouling of heat exchanges.

Dr. David M. Parks became an assistant professor in the mechanics and materials division. His special interests are in fatigue and fracture with current emphasis on crack growth in the elastic-plastic region.

Dr. Stephen B. Pope joined the thermal and fluid sciences division as an assistant professor and will be working on the analytical modeling of turbulence and turbulent combustion. He also will be collaborating with Professor Heywood and colleagues in internal combustion engine research.

Dr. Warren P. Seering was appointed assistant professor in the systems and design division. He is teaching the Department's basic subject in computation and will be developing new research in kinematics, design, and machine dynamics.

Visiting Faculty and Staff

A number of distinguished faculty and professionals from US and foreign institutions held visiting appointments in the Department. Among the most notable were: Associate Professor Haim Gerhsoni of the Technion-Israel Institute of Technology, who worked with Professor Backer in developing a program of productivity in the clothing industry.

Associate Professor Nai-Chien Huang, from the University of Notre Dame also worked with Professor Backer in the area of flexible materials and taught a core undergraduate subject in dynamics.

Dr. Neville P. Moray, who holds the chair in Psychology at Stirling University in Scotland, was a visiting professor working with Professor Sheridan in the general area of supervisory control as applied to undersea teleoperators, nuclear safety, and air traffic control.

Dr. Gerald Schneberger, who is a professor of materials science and chairman of the Department of Mechanical Engineering at the General Motors Institute, held appointments as visiting lecturer and visiting scientist. This year Dr. Schneberger collaborated with Professor Suh and his colleagues in the Laboratory for Manufacturing and Productivity, primarily in the polymer processing area.

Resignations

The resignations of Professors Adam C. Bell, B. Shawn Buckley, and Nak-Ho Sung were accepted with regret. Professor Bell is establishing a private practice in design engineering and will continue service to the Department as a lecturer, part-time. Dr. Sung has joined the faculty of the Chemical Engineering Department at Tufts University and Dr. Buckley will be commercializing his solar panel concepts. He also will continue service to the Department as a lecturer, part-time.

HERBERT H. RICHARDSON

Department of Nuclear Engineering

This has been a year of conflict for nuclear energy on both the national and international scenes. The growing international oil shortages and oil's rapidly increasing price suggest that nuclear power should have an expanding role as an energy source. However, the unfortunate accident at Three Mile Island has increased the strength of anti-nuclear movements. The future of nuclear energy in the US will depend in part on the outcome of the Three Mile Island investigations. Today there are about 70 operating plants and about 130 more in various stages of construction. These 200 plants, when completed, will replace the equivalent of about 7 million barrels of oil per day. Given the present outlook for international oil supplies, it does not seem likely that the nation can afford to forego the use of nuclear energy in meeting our energy problems.

Despite the climate on the national and international scenes, the Department of Nuclear Engineering has had another good year. The funding level of Department research has remained high and student interest has remained high as well. The number of graduate applications decreased by about 15 percent but has remained high enough so that the supply of well-qualified candidates exceeds the vacancies. In addition to the decrease which puts applications at about the 1972 level, we noted a decided shift in interest from fission to fusion among those students who applied. It should be further noted that most of the decrease in applications was among domestic students; the number of foreign applications remains essentially unchanged. Presently, slightly more than one-third of the Department's students are from foreign countries. The interest in the undergraduate program has not diminished, and again this year about 20 freshmen have elected to pursue nuclear engineering. The graduate enrollment during the year was about 160 students -- close to our goal of about 155 students. The undergraduate enrollment was about 35.

During the year the Department awarded 65 advanced degrees including 15 doctorates, 10 engineer's, and 40 master's degrees. In addition, 8 bachelor's degrees were awarded. This is estimated to be about 10 percent of the advanced degrees in nuclear engineering awarded nationally this year.

The sponsored research volume in the Department was about \$1.1 million, which compares to \$1.3 million last year. However, this year much of our fusion research was moved under the administrative control of the Plasma Fusion Center. The total research volume of the Department including our participation in the interdepartmental laboratories was about \$4.2 million and is up slightly from last year. Of this total, over \$700,000 is from non-government sources including the Electric Power Research Institute and a group of local northeastern utilities. Approximately one-third of this total support is in the area of fusion; a majority of the other two-thirds is in the areas of fission technology. Most of the US government support is through the Department of Energy, the National Science Foundation, and the Nuclear Regulatory Commission.

Though the funding of students is an ever-present problem, over 80 percent of our students are supported by either internal M.I.T. sources or by outside agencies. Approximately one-third are supported by research funds and another one-sixth receive support as teaching assistants. Many of the foreign students obtain support from their own governments. In addition, we continue to receive fellowship support from the General Electric Foundation, Northeast Utilities, and the Theos J. Thompson Memorial Fund.

The basic academic program was modified only slightly this year. Freshman seminars on fission reactors by Professor Michael Driscoll and also one by Professor David Lanning were very popular. A new freshman seminar in the fusion area was offered by Professor Peter Politzer and was very successful. Plans are now under way to offer more instruction in the area of plasma theory. The Engineering Internship Program, which offers undergraduates an opportunity to have a work experience as part of their educational program, completed its first year successfully under the direction of Professor John Meyer. Several more companies have joined the program and next year we expect to significantly increase the opportunities for students to participate in the Program.

Once again the Department offered its very popular Special Summer Session Program in nuclear power reactor safety under the direction of Professors Neil Todreas and Norman Rasmussen. Professor Gordon Brownell also offered a Program in nuclear medicine. The profits from these activities provide the Department with a very useful source of unrestricted funds for supporting academic projects beyond those covered in the budget.

RESEARCH

As noted above, the research volume in the Department has remained at a high level. In last year's report we noted the disturbing trend in this support: away from experimental work and toward more and more computer studies. Unfortunately, this trend still continues. Although these analytical studies are of value, we are gradually losing our ability to do first-quality experimental investigations. We continue to try all ways to slow this trend.

The research volume in the fusion technology area is still strong. Professors Politzer and Lawrence Lidsky and Dr. Bruce Montgomery continued their work on the Torsatron stellarator-type machine. This exciting new concept is drawing serious attention from funding sources and we are still hopeful that a machine of this type may eventually be constructed at M.I.T. Professor Mujid Kazimi continued his work on safety and risk analysis of fusion machines. Professor Thomas Dupree continued his work on the theory of nonlinear phenomena in plasmas. Professor Jeffrey Freidberg, who recently joined the faculty, initiated work in the behavior of plasmas based on magnetohydrodynamic theory. Professor Louis Scaturro was contributing importantly to the ALCATOR C project until his untimely death. Professor Kim Molvig, who recently joined the Department, worked on the theory of Tokomak machines. His work in energy confinement in Tokomaks has drawn considerable interest.

In the area of reactor physics, Professor Allan Henry continued his work on the development of improved calculational methods for analyzing time-dependent neutron behavior in a reactor. He and his students have developed a new code, QUANDRY, for this purpose, which has attracted interest in the nuclear community. The work is supported by the Electric Power Research Institute.

Research is being conducted in the areas of fluid flow and heat transfer by several faculty members. Professors Lanning and Meyer are improving calculational models for two-phase, two-fluid systems. Professors Todreas and Kazimi and Dr. William Hinkle continued their work on sodium boiling. Professor Michael Golay continued working on the Liquid Metal Fast Breeder Reactor (LMFBR) outlet plenum mixing problem and, with Professor Ralph Bennett, is developing atmospheric plume modeling that can be applied to cooling tower plumes as well as to other related problems. Professor Golay also continued his work in the area of cooling tower drift and is currently working on a comparison of different drift measuring techniques. In addition to his heat transfer work, Professor Lanning has been active in assessing ways to reduce the enrichment required in research reactor fuels with the goal of eliminating the use of fully enriched uranium wherever possible to reduce proliferation risks. Professors Rasmussen, Elias Gyftopoulos, and David Rose, jointly with Dr. Marvin Miller of the Energy Laboratory, have been working on various techniques for reducing the risk of proliferation in commercial nuclear fuel cycles. This work has been done for the US Department of Energy.

A broad spectrum of work has been carried out in the area of fission reactor safety. Professor Lanning has been developing possible approaches toward greater use of the computer in the reactor control process. Professor Rasmussen and Dr. Hinkle have completed the development of a method for assessing the risk reduction associated with possible changes in reactor design and operating procedures. Much of the research of Professors Lanning, Todreas, Kazimi, and Golay involves investigations leading to a better understanding of safety issues.

Professors Driscoll and Lanning have been doing analyses of the Fast Mixed Spectrum Reactor as a breeder reactor alternative. This concept reduces proliferation risk and provides better uranium ore utilization. However, it requires a substantial increase in fuel burnup performance before it will become practical.

Professors Meyer, Kenneth Russell, and Otto Harling are active in the area of structures and materials. Professor Meyer has projects on cladding and fuel behavior and also on the forces on core structures during loss of coolant accidents. Professor Harling is heading a new, three-year study on radiation effects on fusion reactor materials. Professor Russell also participates in this project. It will investigate, among other things, the effects of damage to the first wall as a result of helium formation.

Professor Gyftopoulos continued his work in the area of thermodynamics and is particularly addressing the question of ways in which to improve the energy efficiency of industrial processes. Professor Rose has been doing a considerable amount of work in the area of energy policy, which has formed the basis for his input to several National Academy of Sciences studies. He remained active in promoting more international cooperation in the area of fusion reactor development as an active consultant to the International Workshop on Tokamak reactors. He also has worked with Dr. Miller on world energy strategies.

Professor Driscoll continued his studies on fast reactor blankets and his project on possible methods for extracting uranium from seawater. He also has been analyzing the use of thorium as a nuclear fuel as an alternative to uranium. In addition, he has studied possible design changes for improving the utilization of uranium on light water reactors. Professors Sow-Hsin Chen and Sidney Yip have continued their investigations of neutron scattering phenomena. Professor Brownell and his co-workers have recently been funded to carry out basic studies on boron capture neutron therapy at the M.I.T. nuclear reactor. In addition, Professor Brownell continued his studies with cyclotron-produced isotopes and X-ray tomography at the Massachusetts General Hospital.

The growth in non-government support has been very encouraging. The program developed with eastern utilities has been growing and now provides nearly \$400,000 of support annually to the Department. In addition, the Electric Power Research Institute continues to be a strong supporter of our research efforts, at a level of nearly \$300,000 annually.

FACULTY

All members of the M.I.T. community and especially his colleagues in the Department of Nuclear Engineering were shocked and saddened by the sudden and untimely death of Professor Louis Scaturro. He will be missed. Professor Kent Hansen left the Department to become Associate Dean of Engineering. During the year, Dr. Freidberg joined the Department as a Professor and Dr. Molvig was appointed an assistant professor. Both are in the area of fusion reactor theory. Dr. Bennett was appointed an assistant professor in the area of heat transfer and fluid flow. Professor Russell of the Department of Materials Science and Engineering was given a joint appointment with the Department of Nuclear Engineering which recognizes the very close ties he has with our teaching and research program. Dr. Montgomery of the Francis Bitter National Magnet Laboratory was appointed a senior research engineer in Nuclear Engineering. He will continue as associate director of the Magnet Laboratory. Professor Yip took a sabbatical leave in Western Europe during the spring term.

Honors and Awards

Several of the Department faculty received honors or awards during the past year. Professor Rose received the James R. Killian, Jr. Faculty Achievement Award. Professor Brownell was elected a fellow of the American Nuclear Society. Professor Meyer received the Outstanding Teacher Award of the Student Chapter of the American Nuclear Society. Professor Rasmussen was elected to the National Academy of Sciences.

Activities Outside the Department

Nuclear Engineering faculty members continue to be active outside the Department in both M.I.T. non-departmental activities and in a wide variety of activities outside of M.I.T. for professional societies, government, and industry.

In the fall of 1978 Professor Lidsky stepped down as acting director of the Plasma Fusion Center to become an associate director of that Center. He currently is serving as a member of the Office of Fusion Energy Stellerator Steering Committee and will be editor of the *Journal of Fusion Energy*. Professor Rose has been active as chairman of the organizing committee of the World Council of Churches meeting on Faith, Science and the Future to be held at M.I.T. in July of 1979 and serves on the World Council of Churches advisory Committee on a Just, Participatory, and Sustainable Society. He continues to give numerous talks on energy and related problems in various public forums. Professor Golay is vice chairman/chairman-elect of the Environmental Sciences Division of the American Nuclear Society. He also serves on the Environmental Heat Transfer Committee of the American Society of Mechanical Engineers and is a member of the board of directors of the northeast section of the American Nuclear Society. Professor Kazimi served as a member of the International Tokamak Reactor Study Team on Safety and Environment, and is a member of the board of directors of the northeast section of the American Nuclear Society.

Professor Lanning continues his service on the Monticello Reactor Safety Audit Committee and on several design review boards for Stone & Webster Engineering Corporation. Professor Gyftopoulos continues his work in energy conservation as editor-in-chief of Project PROCEED, the goal of which is to develop monographs on energy conservation techniques. Professor Meyer served as a member of the executive committee of the mathematics and computer sciences division of the American Nuclear Society and as a member of the program committee of the April 1979 American Nuclear Society Topical meeting on computational methods in Nuclear Engineering.

Professor Driscoll continues as chairman of the Undergraduate Seminar Program at M.I.T. Professor Todreas serves as vice chairman of the technical group on thermal hydraulics of the American Nuclear Society and is chairman of the American Society of Mechanical Engineers K-3 Heat Transfer Committee. Professor Harling continues as director of the M.I.T. Nuclear Reactor Laboratory. Professor Rasmussen continues as a member of the American Nuclear Society Board

of Directors, and as chairman of the Scientific Review Committee of the Idaho National Engineering Laboratory. He has been appointed as a senior consultant to the Defense Science Board and chairman of the Idaho National Engineering Laboratory Fusion Safety Advisory Committee. He recently was appointed to the Utility Scientific Review Council for the Nuclear Safety Analysis Center of the Electric Power Research Institute. He continues as chairman of the M.I.T. Reactor Safeguards Committee on which Professors Harling, Lanning, and Driscoll also serve.

NORMAN C. RASMUSSEN

Department of Ocean Engineering

The Department completed its 85th year and continues to evolve to meet the demands of technology and world priorities. The national commitment to the exploration and development of ocean resources as well as the improvement of ocean transportation appears as strong as ever. The Department continues a role of leadership in the teaching and research programs in these areas.

Academic Highlights

The Department received confirmation of the accreditation of its bachelor of science programs by the Engineers' Council for Professional Development. This accreditation is of special concern to our undergraduates, many of whom find employment with the Federal government and whose degrees are recognized by that employer only if the programs are accredited.

The Department developed two new undergraduate subject offerings to be taught for the first time in the next academic year. These offerings are entitled Linear Systems and Random Processes in Ocean Engineering, and an introductory subject to the ocean environment called The Oceans.

The Department continues to modify and improve its graduate subject offerings. During the past year, the Department's offerings in structural design and analysis have been reorganized with the result that five new subjects have been developed to replace some of the current offerings. The new offerings include Structural Mechanics, Ship Structures, Ship Structural Design, Plastic Analysis of Structures, and Advanced Structural Topics. In addition, the following graduate subjects have undergone substantial revision: Computer Applications to Marine Problems, Mechanical Vibration, and Fundamentals of Underwater Sound Applications.

RESEARCH

The Department encountered some isolated difficulties in its research program. During the past year, it has been noted that sponsor interest in basic hydrodynamic research has diminished. In addition, funding of both basic and applied research in structural analysis and in design is lower than desired. The Department's research program, however, continues to represent a wide spectrum of ocean-related research.

The Department maintains several research facilities located on campus, and has at its disposal the small M.I.T. research ship R/V EDGERTON. Some of the highlights of the activities of the Department's facilities follow.

The *Ship Model Towing Tank* was used primarily for class demonstrations, student theses, and a minor amount of commercial testing during the past year with almost no research involvement. This has been primarily due to the absence of its director and primary researcher, Professor

Martin A. Abkowitz. Professor Robert J. Van Houten assumed the duties of director for the past academic year. It is expected that the research activities in the tank will increase in the next academic year with Professor Abkowitz's return.

The *Variable Pressure Water Tunnel* (Propeller Tunnel) continues to play an essential role in the Department's teaching and research activities. The laser doppler system for velocity measurement has proven to be a powerful research and teaching tool. As the current academic year closes, the tunnel is installing a minicomputer to enhance its ability to record and reduce data. Plans for further improvement both in the facilities and the capabilities of the tunnel are under way, and it is expected that the next academic year will see more changes. Sponsored research use of the tunnel over the past year has principally concentrated upon propellers with current emphasis being placed upon transient cavitation and its influence upon hull vibration. Advances have been made in techniques for time sequence photography of growing and collapsing cavities, and efforts are now being made to measure cavity volume fluctuation by reciprocity techniques.

The *Precision Wave Tank and Flume* has been active in the Department's academic program, but was not used during the past year on sponsored research primarily due to a dip in sponsor interest.

The *Marine Data Systems Laboratory* has been active in the Department's teaching program and sponsored research related to Arctic Ocean basin acoustics and a unique student project related to the development of instrumentation for study of the physiology and behavior of whales. Another project utilized the laboratory facility to study ventilation problems encountered in the hull of container ships.

The *Design Laboratory* continues to make major contributions to design education and ocean engineering and naval architecture. Many computer-based design programs developed via the Laboratory are sought by and made available to practicing naval architects and ocean engineers. The computational ability of the Design Laboratory was enhanced considerably this year by the addition of a Hewlett Packard 9845 calculator and its associated plotter. In addition, the Laboratory has acquired a Digital Equipment Company PDP 11/34 minicomputer with a high-speed multichannel digital-to-analog converter and a spectral analysis software package that has made it an important tool in research on dynamics of ocean structures. It is being utilized more generally in a variety of vibrations and acoustics problems.

FACULTY

The Department is pleased to report that Professor Henry S. Marcus was awarded permanent tenure effective next academic year.

Professor Judith T. Kildow returned from a two-year leave of absence at the University of California at San Diego and at Scripps Institute of Oceanography.

During this past academic year, Professors John W. Devanney III and Norman Jones resigned their positions. Professor Jones will be returning to England to accept a faculty position at the University of Liverpool. Professor Devanney is involved in a private venture.

Professor Wesley L. Harris is on extended leave of absence so that he may serve in a position at the National Aeronautics and Space Administration (NASA) Headquarters in Washington, DC.

Professor Philip Mandel has been granted leave of absence so that he may accept a position at the Naval Ship Research and Development Center (David Taylor Model Basin) in Carderock, Maryland.

Professor Chryssostomos Chryssostomidis spent the past year on sabbatical leave at Athens Polytechnic in Greece and the University of Newcastle, England.

Professor Abkowitz was also on sabbatical leave spending the first term in Singapore and the second term at the Technion-Israel Institute of Technology.

Professor Franklin F. Alvarez, Commander, US Navy, who has been with the Department since 1976, was replaced by Professor David Burke, US Navy. Professor Burke received his doctorate from the Institute in 1972.

Visiting professor Som D. Sharma of the University of Hamburg, Institut fur Schiffbau, remained with the Department through January of this year. His work on the application of game theory to collision avoidances was very stimulating.

Visiting Professor Kiyohide Terai (Kawasake Heavy Industries and Visiting Lecturer at the University of Tokyo, Nagoya University, and Tohoku University, Japan) has extended his stay into the next academic year and continues to assist Professor Koichi Masubuchi in his welding research.

Visiting Professor Dan Shneerson, Chairman, Department of Economics, University of Haifa, Israel, is conducting research with Professor Marcus for the Nigerian Port Authorities.

Other visitors included Dr. Abraham Tal, Head of the Department of Computer Sciences and Applied Mathematics, Ministry of Defense, Israel, who remained with us through August and assisted Professor Ira Dyer in acoustics research; and Dr. Katsuro Kijima from the Department of Naval Architecture at Kyushu University, Japan, who assisted Professor J. Nicholas Newman with research in ship hydrodynamics.

Professor Joao M. Gomes de Oliveira was awarded the General Electric Foundation Young Faculty Grant for the past academic year.

Public Service

Professor Jones was a member of the steering committee of a workshop conference held in Williamsburg, Virginia on the potential applications of aerospace technology in the marine transport industry.

Professor Marcus was appointed a member of the Boston Harbor Associates committee on harbor growth.

Professor Jerome H. Milgram is a member of the General Accounting Office panel studying Coast Guard response to oil spills for the Senate Appropriations Committee.

Professor Newman was a member of the Sea Grant review team, which visited the University of Michigan in March.

International Activities

Professor A. Douglas Carmichael was chairman of the Computer Aided Design Committee (TC3), International Cooperation on Marine Engineering Systems (ICMES).

Professor Ernst G. Frankel was an advisor to the Regional Government of Venice on port development and containment of lagoon flooding and also an advisor to IBRD on training of Philippine port management.

Professor Jones was the invited keynote speaker at a conference dealing with materials at high rates of strain in Oxford, England, in March.

Professor Kildow was a member of the board of the Law of the Sea Institute panel discussion at a meeting last October at The Hague, Netherlands.

Professor Patrick Leehey was guest professor at the Max Planck Institut fur Stromungsforschung, Gottingen, Federal Republic of Germany last July and August.

Professor Marcus presented a paper entitled "The Size of Future Energy Carriers" at a conference on supply and demand of water transport in Stockholm, Sweden, in June.

Professor Masubuchi is vice chairman of the Commission X (Residual Stresses, Stress Relieving, and Brittle Fracture) of the International Institute of Welding. He also was invited by the Government of Taiwan to present a series of lectures in Taiwan.

Professor Newman participated in the organization and presentation of the Weinbaum Memorial Lectures which were presented at the University of Hamburg, Institut fur Schiffbau.

Professor Ronald W. Yeung presented seminars and lectures at Tokyo University, Osaka University, Hiroshima University, and Kyushu University, Japan in May and June. He is also a member of the US-Japan Scientific Exchange Program on Ship Motions in Restricted Water. In addition, he will conduct seminars at Chiao-Tung University, Shanghai, and Hsin Hua University, Peking, Peoples Republic of China, July 1979.

HART NAUTICAL MUSEUM

The Museum, the Department, and the Institute have benefited from the Museum's being featured by several different groups. The highlight was the coverage on WBZ-TV's "Evening Magazine" program. In addition, Coffin and Richardson, Inc. of Boston reissued a calendar for 1979 featuring ship and yacht plans from the Museum files. This calendar originally had been used by the B.L. Makepeace Co. in 1978 and its popularity precipitated its reissue. A number of old yachting photographs have been furnished to a Rhode Island group for another 1979 calendar and more have been supplied for the 1980 version.

Plans and books concerning Viking ships were lent in August to the Museum of Fine Arts for use in developing suitable backgrounds for some of its display of early Irish art. Researchers from Time-Life Books and Boston's expanding Museum of Transportation found much of use in the files. A future issue of *WoodenBoat* magazine will carry an article about New Bedford yacht designer William H. Hand, Jr. that will be illustrated by plans from the Museum's collection.

Interest continues high in Hand and Herreshoff plans. Prints of Herreshoff plans have been sent to England, Belgium, France, Monaco, the Ile de France in the Indian Ocean, and Australia, as well as in answer to the normal inquiries received from yacht owners, model builders, writers of magazine articles, authors of books, and the like in this country. Other plans in more or less continual demand by model builders are those for clipper ships and fishing schooners.

Wooden boat builders, actual or prospective, have visited the Museum in growing numbers, one result of the explosion of interest in the field. A Wentworth Institute student was seeking a course in wooden boat and shipbuilding; another visitor was completing a nationwide survey of wooden boatbuilders for a research paper.

From the Pacific island of Yap, US trust territory, the Museum received a request for and supplied plans for some small schooners suitable for fishing under sail but with enough auxiliary power to return to port in calm weather. A diesel-propelled fishing boat designed by an Australian proved, in view of the island's economy, to be too expensive for the islanders to operate. It was thought that sail with a small auxiliary power plant would be more useful.

During the past academic year, Museum accessions by gift or purchase included:

- 1) One-half model of a Lawley-built "S" Class yacht made by and the gift of Roderick A. Matheson who until retirement operated the Department's shop. He also gave four booklets on the ship models in the Glasgow Museum.
- 2) Several reciprocating steam engine plans of the George Lawley & Son Corp. (circa 1900-1910) drawn by or under the direction of T.S. Poekel. He was a talented Danish designer who had worked for the Herreshoff Manufacturing Company, thus there were connections between the practices of the two years. These were a gift from Professor Evers Burtner who also gave the full model of the collier, USS JUPITER that had been on loan.

- 3) Many technical and research reports and other items pertaining to American yachting, 1962-1978, the gift of Walter C. Hadley, formerly of Jamestown, Rhode Island. He also gave some photostats of the arrangement plan of the 1920 battle cruiser HMS LION.
- 4) Four books -- two on American yachting, one on the USS MONITOR, and the Proceedings of the 9th Conference on Underwater Archaeology, 1978.
- 5) One 3/32" scale model of DD192, the WWI four-stack destroyer USS GRAHAM, a gouache painting of the vessel by Worden Wood, the ship's Battle Station Bill, and one of her boat's case aluminum numbers.
- 6) From alumnus Lloyd Bergeson, Class of 1938, an account of his single-handed 1978 passage to Norway in the yawl COCKATOO II. Some of the material for his article "Sail Power for the World's Cargo Ships," *Technology Review*, March/April 1979, came from the Museum's files.

As a pleasant contact with the past, Vida Howie of Edinburgh, Scotland, visited the Museum. She is the grandniece of Professor James R. Jack, second head of the Institute's Department of Naval Architecture and Marine Engineering and the first curator of the Museum. Ms. Howie came primarily to see and photograph the six models that Professor Jack had built for the Museum; she appreciated being able to talk with someone who had studied under her great uncle.

Philip H. Tobey of Hingham, and H. Kimball Faulkner of Brookline, each sent a monetary gift to the Museum. Mr. Faulkner wrote: "The intent of the enclosed is to express my appreciation for the assistance you gave me last fall. I had come in search of information about little Hand schooner and left with lots of other information."

IRA DYER

Center for Advanced Engineering Study

This year the Center was reorganized in a major way. Video Services was transferred to the Office of the Provost. Tutored Video Instruction (T.V.I.) was cancelled. The Seminars and Conferences Program was formalized. And the program to develop a school in Shiraz, Iran was cancelled.

In addition, the Advanced Study Program expanded in scope and became space-limited. The Self Study Program, based on videotapes, continued its spectacular growth (20 percent compounded on the average for the past four years, 44 percent growth last year); it now serves over 15,000 students per year and is the largest of its kind in the world.

The transfer of Video Services to the Office of the Provost was necessary for two reasons. Under C.A.E.S. management the developmental program in video, sponsored by the Alfred P. Sloan Foundation, had grown to 240 projects, all of them concerned with on-campus programs and in different departments of the Institute. At the same time the growth of the other C.A.E.S. programs required greater attention to off-campus populations. C.A.E.S. will continue to be the largest single user of Video Services but will no longer be required to serve the campus.

The T.V.I. program was cancelled because we could not afford to support the full-time person needed to persuade busy engineers to spend 15 hours a week on M.I.T. subjects in a program which does not lead to a degree. It is small consolation that very few schools have economically viable programs *with* a degree; none, including M.I.T., can find sufficient takers for "candid camera" in the classroom without that degree. Over 400 students were served in companies on the Route 128 complex and most reports indicate they found Tutored Video Instruction an excellent way to study.

It takes time for a program of conferences and seminars to get under way. This year our new program went "into the black" financially and with the startup costs behind us we expect next year to be a very good one.

Political events in Iran caused the cancellation of our program there. The new regime desires to avoid American influence. The texts and other teaching aids we developed are being offered for domestic sale.

THE CENTER'S PROGRAMS

With the removal of Video Services, the Center's activities fall into two broad classifications: 1) educational programs to serve professional engineers in a variety of ways, including the Advanced Study Program, the Self-Study Program, and the Conference, Seminar, and Short Course Program; 2) research and development to find new ways to serve, to produce "different strokes for different folks," including Project PROCEED and Project TRANSMIT.

Advanced Study Program

The Advanced Study Program is an on-campus program that enables engineers and scientists to work in depth in technological areas of their choice. The program serves technical managers who wish to understand developments that bear directly on their problems, men and women who seek competence in depth at technological frontiers, and those who desire to strengthen their technological base. This year there were 62 Fellows from 15 countries. The Advanced Study Program is directed by Dr. Paul Brown.

Fellows of the Program are affiliated with the Center for one or more terms. They may develop courses of study to meet their individual needs or may participate in specialized programs such as the Advanced Study Programs in Air Transportation or Education for Public Management. The entire offerings of M.I.T. undergraduate and graduate subjects, seminars, and colloquia are available, and participation in ongoing research work may be carried out and self-study programs with informal tutorial assistance arranged.

The Programs coincide with the normal academic terms and academic year. Special weekly seminars are planned and conducted during the fall and spring terms especially for Fellows of the Advanced Study Programs and the Education for Public Management Program. Each term, several special subjects of broad interdisciplinary interest are also offered within the Center for participants in the Programs.

Before the fall term begins, participants in the Advanced Study Program may attend Calculus Revisited, an optional six-week review which provides an opportunity for strengthening mathematical skills before entering the mainstream of activities of the Center. This review is an intensive development of the first two years of a modern approach to calculus.

Grades are recorded for all M.I.T. subjects taken for credit. A certificate is awarded following satisfactory completion of a Program. Fellows also may apply for admission to the M.I.T. Graduate School.

Self-Study Program

In fiscal year 1979, the Program's revenues reached \$650,000, up from \$450,000 last year. M.I.T. holds a major position in the world in video-based, high-technology continuing education.

The Self-Study Program now reaches more than 15,000 engineers, scientists, and technical managers worldwide. This is more than all other US engineering schools combined. We plan translations into German, Spanish, and Italian for several of the programs. We also are considering producing master tapes of some of the subjects on PAL and SECAM, video standards of Europe and other parts of the world.

Established subjects like Digital Signal Processing and Modern Control Theory continue to be our most popular. Our new course on Microprocessors also is proving to be very popular. And Electrochemistry and Corrosion, two courses now in production, are already generating substantial advance interest from the scientific and engineering communities.

More than 70 percent of our revenue is produced through direct mail. We now send two or three sets of brochures each month to selected mailing lists. The expansion of the distributor network is also proceeding successfully as we establish distributors in Latin America and Europe. Distributor growth in these areas will complement our established Far East and domestic distributor activity.

The Conference, Seminar, and Short Course Program

Conferences, seminars, and short courses are designed for engineers, scientists, and other professionals who wish to keep abreast of new developments in their respective fields. These short, intensive programs provide information on recent advances without requiring attendees to leave their jobs for extended periods of time.

The Seminar Office coordinates meetings which present recent technological developments and perspectives on timely scientific issues as well as new trends in the marketplace and their relationship to technological development. Programs are conducted by members of the M.I.T. faculty in addition to guest lecturers.

Seminars are open to professionals worldwide, and individual meetings are announced in a broad range of national and international technical journals.

Seminars given this year and planned for next year are: Computer Cryptography; New Perspectives on the Safety of Dams; Nuclear Power: Challenge to Journalists; Technology, Innovation & Industrial Development; New Direction in Welding Research & Development; and Decision Analysis and Climatological Data.

We also have held one European meeting, Communicating Technical Information, the result of a cooperative effort on the part of M.I.T. and Royal Netherlands Industries Fair in Utrecht. We plan eight more meetings to be held in Europe next year.

The director of this program is Lea Johnson who joined the Center in August 1978.

Project PROCEED

Project PROCEED (Program for Continuing Engineering Education) originated several years ago within a group of M.I.T. professors, led by Professor Lawrence B. Evans of the Department of Chemical Engineering. It originally was intended to be an innovative approach to continuing engineering education by providing modular instruction so that busy engineers would not have to take an entire subject just to learn the parts that interested them. The Project was funded by the National Science Foundation (NSF) in 1975. Dr. Myron Tribus, Director of C.A.E.S., joined Professor Evans as co-director of the Project the same year he came to M.I.T. Professor Karen C. Cohen is now the director and principal investigator of the Project.

As the problems of continuing education were studied, it was decided that the approach should not only be modular, but also problem-oriented, in contrast with the discipline-oriented approach used for most undergraduate and graduate study. A needs assessment in the summer of 1977 identified four nationally important and relevant areas which PROCEED should address: industrial energy conservation, protection of workers and users from toxic substances, alternative energy sources, and waste treatment management. We developed the first topic this year, the second is being developed, and the last two will be developed later.

Our first topic is Industrial Energy Conservation. Professor Elias Gyftopoulos of the Department of Nuclear Engineering is editor-in-chief of this series of modules and cases. A focused effort to find and develop problem-solving cases was made by teams of professors and graduate students in different parts of the country during the summers of 1977 and 1978. The information derived from these intensive efforts was used to determine the competencies required. These cases also are integral components of the system. We have field-tested the modules and the entire system during the last fiscal year.

Our second topic, which we are developing in a manner similar but not identical to that of Industrial Energy Conservation, is Protection of Workers and Users from Toxic Substances. To this end, we have enlisted the support of Professor Nicholas Ashford and several of his staff from the Center for Policy Alternatives.

We have built a constituency of users, developers, teachers, and brokers of continuing education throughout the country. We held a conference at C.A.E.S. on May 4 and 5, 1978 for university-based directors of continuing education from all parts of the country. They all agreed to field-test our materials and help us in the development of our system. We held a similar meeting for industrially based directors of continuing education in July 1978.

In addition to the modules and cases, we have developed an "adaptive reference system" which helps the user to define his or her problem and to find relevant educational materials. The adaptive reference system is based on an analysis of the problem structure, and therefore teaches "know-how" as well as knowledge.

This novel approach to continuing education has attracted a great deal of interest. Late this year we were invited by Congressman Rose to apply the PROCEED System to the House Information Services as a means of teaching new members of Congress how the budgetary process works. We are now planning this project. We also are conducting experiments funded by Control Data Corporation to introduce PROCEED modules onto the PLATO System.

We currently are facing the usual problems associated with renewal funding. NSF and several industrial interests are being pursued. The renewal funding for this project appears to be available at this time.

Project TRANSMIT

Project TRANSMIT is a research project, begun during the last fiscal year, to evaluate various modes of communication to determine which are pedagogically most effective. The modes are lecture, reprint, audio cassette, microfiche, and on-line access.

During the first six months we gathered data on all five modes. Survey forms and telephone interviews were used to determine what use purchasers made of information on reprints, cassettes, or microfiche or how they were influenced by attendance at lectures or on-line access. The American Institute of Chemical Engineering has cooperated by making their membership data base available.

Preliminary results suggest that on-line transmission is the least likely mode of successful communication and may not be considered in the final analysis. Final results will be submitted to the National Science Foundation, the project sponsor. Professor Cohen is the director and principal investigator of this project.

MYRON TRIBUS

Center for Policy Alternatives

The Center for Policy Alternatives is chartered to study and investigate substantive issues facing society, particularly those in which technology and engineering could play significant roles. The Center's basic purpose is to foster informed decision making for public and private policy by increasing our knowledge of the nature of the complex and interrelated problems of technological societies and by contributing to the practical understanding of effective policy formulation and evaluation. Among the Center's primary functions are the identification of major sociotechnical issues facing society, the assessment of the consequences of present policies and practices, and the development and appraisal of alternative actions for government, industry, labor, and education which will respond effectively to society's needs. In carrying out its

sponsored and ongoing research programs, the Center serves as a focal point for some of the policy-oriented activities of M.I.T. departments, centers, and laboratories, and seeks to stimulate faculty and students to participate in projects which have the greatest potential for social and economic utility.

Technology Policy and Innovation

One dimension of the Technology Policy and Innovation Program is concerned with the influence of national policies on innovation and technical change within various industries and national settings and with the formulation of alternative policies for the US and foreign environments. The second, and complementary research interest focuses on understanding the processes of innovation and technical change within the firm, and the private practices and public policies that influence these processes at the level of the firm.

One of the year's research highlights was the preparation of a series of papers under contract from the US Department of Commerce in connection with the Federal Interagency Domestic Policy Review on Industrial Innovation. The papers review and synthesize existing information and analyses on particular aspects of technological innovation in the US economy and were intended to provide a common frame of reference for those in government and industry involved in the review process. The eight papers will be published in September as *Technological Innovation for a Dynamic Economy* and are the basis for a national conference at M.I.T. in October for government and industry decision makers. Authors included: Dr. J. Herbert Hollomon, Director of the Center and Japan Steel Industry Professor of Engineering; Dr. Nicholas A. Ashford, Assistant Director of the Center and Associate Professor of Technology and Policy; Dr. Christopher T. Hill, Senior Research Associate; George R. Heaton, Dr. Curtiss Priest, and Dr. James M. Utterback, Research Associates; Dr. Paul Horwitz, part-time Research Fellow on leave from AVCO Everett Research Laboratories; Professor Edward M. Graham of the Sloan School of Management; Professor Clinton C. Bourdon of the Harvard Business School; and Professor Burton H. Klein of the California Institute of Technology.

Dr. Utterback continued his examination of the relationship between evolving product and process technology under a National Science Foundation (NSF) grant. This project seeks to develop a conceptual framework and a consistent set of hypotheses that account for the dynamics of firms' processes of innovation. The work draws upon the findings and results of a large number of descriptive studies and information that to date have provided diverse and fragmented views of the innovation process. The intent of the research is to integrate, synthesize, and extend existing knowledge into a framework that has utility for managerial and government decision makers.

Research continued on an 18-month study sponsored by the Ministry of Industry, Commerce and Tourism of the Government of Israel to examine government policies to encourage industrial innovation in the civilian Israeli economy. The overall program involves examination and analyses of the government's financial incentives for private firms and their influence on exports of technology-intensive products and processes, the changing role of universities and research and development institutes, and implications of the Israeli experience to other developing countries. The participation of the Interdisciplinary Center for Technological Analysis and Forecasting (ICTAF) at Tel Aviv University in data collection, documentation, and on-site analyses is a central aspect of this program which also provides for Israeli officials in residence at the Center for short periods throughout the program.

A related program was carried out during the year for the recently established Israel-US Binational Industrial Research and Development Foundation (BIRDF). The goal of BIRDF is to promote and support joint, non-defense industrial research and development activities by Israeli and US companies that lead to viable commercial products and processes. Participants in these programs included Dr. Hollomon; Dr. K. Nagaraja Rao, Senior Research Associate; Dr. Floyd R. Tuler, Research Fellow on leave from Hebrew University; Dr. Meir Weinstein, Research Fellow on leave from ICTAF; Brigitte Jessen and Rita Beuter, student interns from Konstanz University, and several graduate students.

Manpower Policy

Under the direction of Dr. Marvin A. Sirbu, Research Associate, a research group completed the extension and refinement of earlier econometric models used for forecasting the supply and demand for graduates in science and engineering in the US. The models relate demographic, enrollment, salary, market demand, and government support for education to the supply of young people opting for certain professions. Particular attention was given to the relative demand for scientists and engineers compared with other occupations, and to the development of models that encompassed the total stock of scientists and engineers and thus took into account attrition and inter-industry mobility. The two-year research program was funded by NSF and involved Professor Richard B. Freeman of Harvard University and several graduate students.

Dr. Sirbu also directed a study of high-technology manpower in Massachusetts with support from the Commonwealth's Department of Manpower Development. The program analyzed available data on the supply and demand for scientists and engineers in Massachusetts in comparison with national trends. An important aspect of this exploratory research effort was the findings on the extent to which high technology manpower is a national or a regional market.

Consumer Policy

The Consumer Policy Program is broadly concerned with government policies affecting consumer health and welfare and with consumer behavior patterns, particularly the economics of consumer choice, including elements of lifecycle costs, product life, and consumer protection. The NSF-funded warranties, service contracts, and alternatives project directed by Robert T. Lund, Senior Research Associate, was completed early in the fiscal year. The three-year program examined the warranty and service contract system for consumer appliances, including its legal context, the pattern of consumer behavior, and the economic and social consequences of various alternatives to the present system.

Mr. Lund continued his developmental efforts toward a major research program to appraise the potential of individualized lifecycle cost information as a means of influencing consumer purchase and use of durable products. A similar developmental effort was carried out for opportunities for conservation of energy and materials in the design, manufacture, use, servicing, and disposal of consumer products. These efforts and related consumer-oriented studies are continuing.

Industrial Productivity Policy

Industrial Productivity Policy activities are concerned with identifying new opportunities for technology in industry and with the relationships among productive processes, technology, job design, and social goals. In the fall, the Center completed a six-month research program focusing on the nature, effects, and management of industrial automation with support from General Motors Corporation. The program, which was directed by Mr. Lund, involved a number of graduate students, and identified a series of critical issues for further research.

As the fiscal year draws to a close, the Center's microprocessor applications project is nearing completion. Research consists of case studies of current applications of microprocessors in mechanical products and production process equipment with consideration of expected or actual impacts of the technology on innovation, flexibility in product design, and market and industry structure. Supported by the United Kingdom's Department of Industry, the program includes Mr. Lund, Dr. Sirbu, Dr. Utterback, and several graduate students.

With support from the US Department of Energy, a study was initiated to examine remanufacturing of durable products as an approach to resource conservation, waste reduction, and improved standard of living. The 18-month effort will define and describe remanufacturing as it applies in various market sectors, identify candidate products for remanufacturing, and delineate a plan for a demonstration project to better assess the prospect for durable goods remanufacturing in the US. The project is directed by Mr. Lund and involves Mr. Heaton, Dr. Tuler, Professor Joel P. Clark of the Department of Materials Science and Engineering, and graduate students.

Workplace and Environmental Regulation

Research concerned with workplace and environmental regulation continues to expand and broaden and generally involves identification of alternative strategies for regulation and the evaluation of regulatory impacts. The Center's efforts are concerned with the effects of regulation on worker and community health and safety and increasingly on the connection with the manufacturing process. The continuing development of analytical and methodological techniques for the complex technical, economic, political, and legal issues involved is an integral part of all the Center's efforts in this area.

The Center completed a two-year NSF-funded project examining the relationships between environmental/safety regulation and technological responses and innovation in selected production segments of the chemical and allied product industries. Final work involved Mr. Heaton, Dr. Ashford, Dr. Priest, and Research Associates Sally T. Owen and Dr. Dale Hattis.

Research activities for the Occupational Safety and Health Administration (OSHA) of the Department of Labor continued to be carried out under the direction of Dr. Ashford. A 20-month effort is in progress to explore generic issues and alternative policies available to OSHA for reducing occupational disease and injury. This multi-task effort involves an examination of legal and technical issues related to the removal of workers from hazardous conditions, studies of supplementary approaches to worker health and safety in addition to the standard approach, and analysis of mechanisms for improving both standard and non-standard approaches to the prevention of occupational injury and illness. One important aspect of this research is an examination of tort cases and an analysis of the effect of the tort system on the prevention and correction of occupational disease. Project participants included Ms. Owen, Dr. Hattis, Dr. Priest, and Research Associates Judith I. Katz and Dr. William Mendez.

A second OSHA-sponsored program is developing a series of issue papers concerning differences in determining feasibility in standard-setting and citation contexts; issues and strategies in pending litigation of lead and benzene standards; the role of cost-benefit analysis in determining feasibility; and methodologies for determining feasibility in judicial contexts. A third research effort is being carried out in collaboration with ICF, Inc. of Washington, DC, and focuses on developing procedures for assessing economic and health impacts of OSHA health standards. Important aspects of this work include relating hazards to health effects within more rigorous analytical frameworks and identifying costing techniques for innovative technological solutions to workplace health hazards. This latter activity began in early summer and involves Professor Roger K. Chisholm, Visiting Research Fellow on leave from Memphis State University, and Dr. Benjamin I. Ross, part-time Visiting Research Fellow on leave from The Analytical Sciences Corporation.

With support from the Environmental Protection Agency, Dr. Hattis continued his research on hypothesized relationships among noise, general stress responses, and chronic cardiovascular disease processes. A review of recent research findings and a three-day workshop for international authorities at M.I.T. in February provided the basis for current work on a theoretical framework to identify promising avenues for future clinical research. With support from the Department of Labor, a one-year program has been initiated under the direction of Dr. Priest to examine health and safety data collected as part of the national Quality of Employment Survey. The research utilizes a new industrial grouping system previously developed by the Center and will aid OSHA in developing health and safety standards, targeting compliance operations, and improving educational activities. At the request of the Office of Technology Assessment (OTA), Dr. Ashford and several staff members framed the major issues concerning carcinogens in the workplace, delineated research and development alternatives for these issues, and prioritized subjects for OTA to examine in greater detail.

Throughout the year, research progressed on an NSF-funded examination of the impact of government regulation on the process of technological innovation in the pharmaceutical industry through case studies of drug development in different therapeutic areas. Participants included Drs. Ashford and Hattis, several graduate students, and Dr. J. Worth Estes of Boston University's School of Medicine. In December, an eight-month program was initiated to explore the future of health care regulation with respect to health planning, hospital cost containment, and national health insurance. The study will consider the extent to which it is feasible to make predictions of regulatory events in the health care field. Funded by E.M. Warburg, Pincus and Company, the study involves Dr. Hollomon, Mr. Heaton, a graduate student, and Professor Harvey M. Sapolsky of the Department of Political Science.

As part of an Energy Laboratory and Center for Transportation Studies program funded by the Department of Energy, Mr. Heaton analyzed the legal constraints within which alternative emergency energy conservation plans must be developed. Work included consideration of the legal mechanisms through which these plans would be implemented, and examined relative environmental impacts of alternative plans. In April, the Center initiated a major research program to examine the technological changes which have occurred in foreign automobile firms in Germany, Sweden, and Japan as a response to US safety, pollution control, and fuel economy regulations. Funded by the Department of Transportation, the program will document the foreign response, analyze its similarities and differences to US companies' overall response, and consider the implications of these differences for US policy design. Collaborating with the Center will be the Science Policy Research Unit at Sussex University (United Kingdom) and Professor Taizo Yakushiji of the Institute for Policy Sciences at Saitama University, Japan.

Communications and Office Automation

Dr. Sirbu continued his research on the potential impacts of office automation on traditional employment patterns, the nature of office work and organizational structure, as well as the effects on industries producing office equipment. At year end, initiatives were being made to a consortium of private firms for a review and synthesis of existing studies of office procedures and the potential for office automation. In April, a six-month effort concerned with new technologies in telecommunications began under the direction of Professor Ithiel de Sola Pool of the Department of Political Science and Professor Jack Ruina of the Department of Electrical Engineering and Computer Science. Dr. Sirbu serves as project manager of this effort which will involve numerous faculty and staff over the coming months. Funded by ITT Corporation, the program will develop a four-day presentation surveying new technologies in telecommunications and their implications for service and investment planning by telecommunication companies and government agencies.

Educational Activities

The active participation of undergraduate and graduate students with Center staff in sponsored and developmental research projects is one dimension of the Center's role in the education and training of engineers and students in the School and the Institute. Center staff also contribute to the development of new degree programs, design and teach new subjects, and serve as advisors to students.

In the fiscal year 1979, five educational efforts were carried out with sponsored support. With funding from the Duke/Rand Public Policy Curricular Materials Development Program, Dr. Ashford, Dr. Mendez, and Ms. Owen developed an instructional case with teaching notes on regulating vinyl chloride in the workplace. The same program also supported the development of similar curricular materials about Federal Trade Commission rule making on depreciation allowances for calculating consumer refunds. This latter work was carried out by Mr. Lund and Dr. W. Michael Denney, now Professor at the University of Texas.

Early in the year, Dr. Rao and Alan F. White, Director of Executive Development Programs at the Sloan School, prepared a design for educational programs in the management of technology for senior to middle management professionals in Latin America. The work was funded by IBM Corporation. A Center team carried out initial work on the topic of protection of workers and users from toxic substances as part of the Center for Advanced Engineering Study's Program for Continuing Engineering Education (PROCEED). Funded by NSF, PROCEED is aimed at developing innovative approaches to continuing engineering education that have a problem-solving focus and relate primarily to engineers in the industry. Center participants in PROCEED activities included Dr. Ashford, Dr. Hill, Dr. Hattis, Dr. Mendez, and Ms. Owen.

Dr. Sirbu, Professor Thomas B. Sheridan of the Department of Mechanical Engineering, and Professor David Noble of the School of Humanities and Social Science, continued to teach the Proseminar in Technology and Policy, a core offering of the master's-level Technology and Policy Program. Dr. Sirbu and Professor Ruina jointly taught 6.074 Introduction to Telecommunications Systems. Mr. Lund, also Lecturer in the Department of Mechanical Engineering, and

Professor David P. Hoult of the Department of Mechanical Engineering taught 2.96J Management in Engineering, one of the newly designated School-wide electives in the School of Engineering. Mr. Lund also taught 2.863 Elements of Manufacturing during the first term. Dr. Ashford with Mr. Heaton taught 16.793 The Law/Technology Interface as part of the Institute's Law-Related Studies Program, and with Ms. Katz again presented 3.575/10.805J Technology, Law and the Working Environment. Dr. Ashford with Ms. Owen offered the Department of Civil Engineering's two-subject sequence on Environmental Law. Dr. Utterback taught 15.795 Seminar on Operations Management jointly with 2.95 Innovation and Industrial Development, with the participation of Professor Sheridan. Dr. Rao and Professor Richard D. Robinson of the Sloan School jointly taught 15.227 International Technology Transfer.

J. HERBERT HOLLOWAY

Center for Transportation Studies

The Center for Transportation Studies (C.T.S.) was established in 1973 to coordinate transportation activities at M.I.T. Prior to the formation of C.T.S., transportation at M.I.T. was segmented by mode (rail, highway, air, ocean, etc.), with major emphasis on vehicle design and the infrastructure facilities to support the vehicles (guideways, terminals, etc.). The formation of C.T.S. represents a broadening perspective of transportation at M.I.T.:

1) Provision of transportation services is not the final objective. Transportation is utilized to achieve other societal objectives, thus transportation problems cannot be addressed in isolation from the other concerns of society.

2) Transportation systems are affected by many considerations, such as energy, the environment, and the economy. Recent negative reaction to the interstate highway program is a good example of what can happen when these impacts are not properly considered.

3) Transportation problems are increasingly multimodal. A systematic approach is required to select between and interface the appropriate modal subsystems. Although the modes differ, a common frame of reference is possible to address basic transportation issues.

C.T.S. provides both the intermodal and interdisciplinary linkages for research and educational transportation activities at M.I.T. involving the Departments of Aeronautics and Astronautics, Architecture, Civil Engineering, Humanities, Economics, Electrical Engineering and Computer Science, Mechanical Engineering, Ocean Engineering, Political Science, Urban Studies and Planning, and the Sloan School of Management.

A steering committee consisting of 15 faculty members and chaired by Professor Joseph Sussman examines the overall policy direction of the Center. An executive committee has been established which meets monthly to discuss operational and implementation issues of the Center. Members of the executive committee include Professor Herbert Richardson, Mechanical Engineering; Professor Ralph Gakenheimer, Urban Studies and Planning; Professor Robert Simpson, Aeronautics and Astronautics; and Professor Marvin Manheim, Civil Engineering. Planning is under way to establish an outside advisory committee to oversee the various activities of the Center.

Transportation Master's Program

In October, the M.I.T. faculty and Corporation approved a new degree program, Master of Science in Transportation. Because of the importance of this new program, it will receive major attention in this annual report.

When C.T.S. was established five years ago, one of its primary missions was to provide a focus for M.I.T. educational activities in transportation. Although M.I.T. has a variety of transportation programs and options offered by the academic departments, the faculty involved in these specific departments recognized the need for a broader transportation program reflecting a multimodal and multidisciplinary perspective on transportation.

The new program is designed to reflect M.I.T.'s excellence in engineering and technology. This does not imply that the program is restricted to students with interests in transportation technology or engineering. Quite the contrary is the case. One of the primary motivations of the new program is to attract a broad cross section of students with interests in transportation, many of them having little or no previous background in engineering or technology. It does not imply, however, that the program will expose all students to an analytic and systematic perspective of transportation.

A new degree should reflect the intellectual foundations of fundamental methodology in the field. All students in a broad-based transportation program, regardless of their background and professional interest, should have a common framework to perceive transportation problems and their solutions. Students might use that framework in different ways with different emphasis, but the perspectives are similar. Thus, a set of core curriculum subjects is a fundamental component of the new program to provide the perspective, background, and disciplinary foundations to transportation.

The program has been developed to be rigorous and demanding. As such, the program's prerequisites and requirements are more extensive than in any existing M.I.T. departmental program in transportation.

The new program represents a natural evolution of our academic approach to transportation. During the past decade, faculty interested in transportation from more than 10 M.I.T. departments have worked closely together in a variety of educational activities. This is reflected by more than 10 joint faculty appointments and more than 15 joint subjects. A transportation academic community of people with different perspectives but common objectives has been achieved. This was reflected during a three-day academic retreat held this past summer. Twenty-eight M.I.T. faculty members with interest in transportation representing nine academic departments met to plan the new master's degree program. It was an exciting and productive meeting with many new ideas, approaches, and courses identified.

The new master's program is intended to complement rather than replace existing departmental programs in transportation. Students interested in a broad perspective on transportation would take the new program, whereas those with a more specific interest and the desire to work in a traditional departmental context would pursue an existing program.

An eight-member faculty committee, under the leadership of Professor Nigel Wilson of the Department of Civil Engineering, has been established to administer the new program. With membership from four engineering departments as well as Economics and Urban Studies and Planning, this committee has met monthly since its inception and has been the forum for all important decisions about the program.

Much of the early attention of the committee was devoted to the structuring of the core subject requirements for the degree. Consideration was given to options ranging from a core in which all subjects would be required, to a core in which two students might have no subject in common. After a good deal of debate, both within the committee and within the M.I.T. transportation community as a whole, a set of core requirements was adopted. Each student must take CTS 100 Basic Concepts in the Analysis of Transportation Systems, plus three out of the following five subjects: CTS 110 Transportation Economics, CTS 120 Transportation Institutional Analysis and Policy, CTS 130 Issues in Transportation Management, CTS 140 Transportation Performance and Technology, and CTS 150 Transportation Demand and Activity Analysis.

This core ensures that each student will have a basic familiarity with the application of analysis methods to transportation problems, but still provides substantial flexibility so that students with diverse interests can select highly relevant core subjects. Significant changes are required to teach the new core subjects, with each being a rigorous, in-depth introduction to the subject matter.

Beyond the core requirements, each student is required to take two additional subjects in a transportation program area, 11 of which have been defined to date, and must complete an acceptable thesis.

These degree requirements will be closely monitored by the committee over the first two years of the program to see if any changes may be appropriate after this start-up phase.

Substantial subject development effort is under way to implement the six core subjects for the coming academic year. Only two of these subjects had previously been taught in essentially the proposed format, and even for these, new faculty responsible have been identified and a budget allocation made for subject development. Faculty from four different departments will be directly involved in teaching the core subjects over the first two years.

In order to ensure that each core subject serves the interests of all the departments participating in the program, review groups consisting of both faculty and students have been established for each subject to advise the teaching faculty members on the material to be covered. Additionally, the faculty committee for the program will review the plans for each subject with those teaching it before it is presented. These reviews have already been held for the three fall-term subjects.

Beyond this current round of curriculum development, proposals are being solicited for subjects which will strengthen existing program areas. This second level of subjects will build on the core subjects as prerequisites and will provide more depth in areas now only superficially treated.

In order to highlight the new program, separate listings of the core subjects with their CTS numbers will be included in the *Courses and Degree Programs* catalogue under a new section entitled "Transportation Studies" in the subject descriptions chapter. This is the first time that transportation subjects have been listed outside their departments.

Under the auspices of the faculty committee, a five-member admissions committee has been established to oversee the admissions process. Publicity for the program was not given top priority this year. Posters announcing the program with mail-back cards have been sent to most US universities, with follow-up packages including information on the degree requirements, subjects offered, and current research projects. So far, well over 200 cards have been received indicating strong interest in the program. In addition, no effort was made to encourage those students who had applied for departmental transportation studies to enter the new program.

As a result of these actions, 12 applications were received for the new degree program. After review by the admissions committee, five of these were offered, and all subsequently accepted, admission. Since admission to M.I.T. at the graduate level is a departmental prerogative, the committee recommends to the appropriate department that the student be admitted through the department to study for the new degree. In this manner students have been admitted so far through Civil Engineering and Urban Studies and Planning.

In the coming year, it is anticipated that some students who were admitted to take departmental degrees will elect to switch to the new program and that in the first year, class size will be 10 to 15 master's students. In the fall a full scale admissions drive will be launched to increase the number of applications and the number of students admitted for September 1980. The program is planned to accommodate 30 to 50 students.

Transportation Summer Programs

To provide an opportunity for professionals now practicing in transportation or related fields to explore a multimodal, multidisciplinary perspective on transportation, and to acquire new techniques for application to their specific problems, C.T.S. is offering a coordinated set of Transportation Special Summer Programs. Some of these Programs are focused on a particular mode or topic area. Others are more general, designed to provide coverage of basic concepts and techniques. Participants in any individual Program are able to attend selected sessions of other Programs given the same week. Thus, attendees are able to tailor a broad multimodal perspective for their individual needs, as well as concentrate on topics in their own area of professional interest.

The Programs are designed for transportation managers, planners, analysts, and engineers in both industry and government, as well as university faculty interested in transportation.

Programs are offered in: Transportation Systems Management and Analysis, Air Transportation, Port Design and Development, Urban Transportation, Freight Transportation, Forecasting Transportation Demand, and Transportation in Developing Countries.

The Program in the first week generally concentrates on basic concepts and techniques. Those in the second week are in-depth treatments of the issues actually faced in the particular problem area addressed by the Program at the professional level, and assume prior knowledge at the level of the material covered in the first week.

During the summer of 1978, these Programs attracted over 130 students. The Programs will be presented again next summer.

Research Activities

The Center is involved in extremely broad research programs covering numerous aspects of transportation. The largest project is concerned with transportation energy contingency planning for the United States. This project under the sponsorship of the US Department of Energy is exploring a range of different approaches that could be utilized in the event of a serious shortage or interruption of gasoline supplies. The work is being done in response to a congressional mandate under the Emergency Policy and Conservation Act of 1975. An interdisciplinary team of approximately 30 professionals has been developed to examine and evaluate a number of different strategies. The project is considering the impacts and implementation issues associated with each of these strategies. It is a good example of how the Center blends together research and policy relevant areas of activity. The project is being pursued jointly with the Energy Laboratory.

Another major area of interest is transportation in developing countries. The Center currently has under way transportation research activities in Egypt, Nigeria, and Brazil. A new program on Transportation in Developing Countries will be offered for the first time this summer jointly with York and Toronto universities.

MIT Press Series in Transportation

A new series of transportation books has been inaugurated by the Center for Transportation Studies and the MIT Press. The first five books in this series were published this year. The titles are: *The Automobile and the Environment: An International Perspective* by Ralph Gakenheimer; *The Urban Transportation System: Politics and Policy Innovation* by Alan Altshuler; *Fundamentals of Transportation Systems Analysis* by Marvin Manheim; *Planning and Politics: The Metro Toronto Transportation Plan Review* by Jim Pill; and *Traffic Flow on Transportation Networks* by Gordon Newell.

Other Activities

The Center sponsors a weekly seminar series which brings experts in transportation to the campus. The 20 seminars sponsored this year attracted more than 50 people per week. An information center having major periodicals and books in the transportation field is also operated by C.T.S. In addition, M.I.T. research reports are distributed by the Center and a quarterly newsletter is published by C.T.S. summarizing major transportation activities at M.I.T.

DANIEL ROOS

Innovation Center

The Massachusetts Institute of Technology Innovation Center was funded originally by the National Science Foundation for the academic years 1973 through 1978. This past academic year represents the first year of the continuation of the Center with funding from other sources.

The Center carries on three major branches of activity: education, research programs, and product development. The educational activities are composed of three classroom subjects; namely, an undergraduate seminar in innovation, a graduate/undergraduate subject in invention, and a graduate/undergraduate subject in entrepreneurship. About 60 students attend these classes.

The research program has been sponsored by the National Bureau of Standards and the Department of Energy to develop a methodology for invention evaluation and for the development of ideas and human resources.

This past year, two product development projects were conducted by students under the supervision of the faculty and were supported by an industrial firm and a private venture group. One additional project was licensed out to a private venture group. Approximately seven faculty members and six students were involved in these activities over this last academic year.

The total funding level for the last academic year was about \$400,000.

A volume entitled *Proceedings of the Symposium on Innovation and Innovation Centers* was published in April 1979.

As a result of our experience over these last few years, we have concluded that in order for the Innovation Center to be viable, it must reach out to industry and to the innovative community for innovative ideas, skilled developers, and dedicated entrepreneurs.

The concept of an enterprise development laboratory, to be structured at arm's-length from M.I.T., was developed. In this format it could serve more effectively, like the relationship between a teaching hospital and a medical school. Extensive discussion has been conducted within M.I.T., as well as with the Office of Economic Development of the Community Service Administration, for generating a formal proposal for soliciting significant funding for this organization. A planning grant was set up to facilitate this function.

YAO TZU LI

School of Humanities and Social Science

There has been very little change in the overall pattern of student enrollments in the School of Humanities and Social Science during the last five years. The total number of graduate students has been virtually constant at about 290; the total number of undergraduate majors has fluctuated around 125. The distribution of concentrations within the Humanities, Arts, and Social Sciences Requirement is less well charted statistically, but seems not to have changed significantly. There has been more fluctuation in the choice of elective and distribution subjects, but much of this can be accounted for by changes in the size of the freshman class, and by changes in the faculty and the list of distribution subjects, rather than by shifts in student preferences. The enrollment statistics thus suggest that the last five years have been a period of substantially no change. It would, however, be very misleading to draw such a conclusion. For what has really been happening has been a consolidation and regrouping after the expansive and difficult years of the late 60s and early 70s. And there have also been new difficulties with which to contend.

In many ways the most disquieting feature of the last five years has been the difficulty of maintaining the quality of the Ph.D. programs. The demand for Ph.D. graduates in college and university teaching has declined (and a further decline seems almost certain). So has the amount of financial support for graduate education. In the competition among graduate programs around the country for the very best graduate students, the level of financial support available seems increasingly to determine student choice. Our new Doctors of Philosophy have done remarkably well in the job market, but most graduate students have felt the press of financial hardship in the course of their studies at M.I.T.

What considerations lead the very best students to apply to a particular graduate program in the first place? The reputation of the faculty and of the program is clearly the single most important factor. And the reputation of a program depends to a considerable degree on the perception that its faculty is strong in those areas of a discipline most in current demand. A strong economics department without several energy economists would, in the world of 1979, seem as much an anachronism as would a department with a bevy of energy economists 10 years ago. Planning for the future must therefore involve an element of judgement as to the way in which a discipline will evolve over a five or even 10-year period. Such planning is, however, extremely difficult to do unless there is some flexibility in the use of resources. Such flexibility is becoming increasingly uncommon, except in departments where a number of retirements are likely to take place in the near future.

The pressures for adaptation bear hardest on our newer graduate programs where there is difficulty in funding even existing research. The Department of Political Science, so strong in many international areas, has suffered as a result of the revulsion from international problems that has taken place in America since the Vietnam War. The level of research funding has been cut by the Federal government and foundations; the number of American (as distinct from foreign) students has shrunk. The Linguistics program, once heavily supported by the Federal government as a model of what such programs should be, has endured a steady reduction of Federal support. The Department of Psychology has outgrown its facilities and needs a new building if it is to maintain its existing research program. Yet all three programs must plan for the future and find resources for new developments while they strive to maintain the achievements of the past, and must do so with a faculty that is unlikely to change significantly over the next 10 years.

Future planning is greatly eased where there are new sources of funding in areas which are clearly likely to be of vital importance in the future. The Center for Cognitive Sciences is one important venture which has already helped to ease the transition to new patterns of research in parts of Linguistics, Philosophy, and Psychology. The Public Policy Program in the Department

of Political Science and the Language and Mind Program in the Department of Linguistics and Philosophy are good examples of new undergraduate programs capable in a more limited way of developing new resources and new interests. The Program in Science, Technology, and Society also has brought increased strength to a number of existing activities in Philosophy, Political Science, and Economics. But there are clearly not yet enough new ventures to sustain programs of the highest quality in all the areas where support is needed. There does, however, seem promise of foundation and government interest in such ventures of a sort that scarcely existed five years ago.

One desirable consequence of this interest is to encourage in all the departments of the School the sort of experimental boldness that has made such a large contribution to M.I.T.'s success. It is a new thing for most humanists to participate in such ventures. Philosophers at M.I.T. have never before raised substantial sources for an undergraduate program, and they rarely have done so elsewhere. The fast growth of the budget of the National Endowment for the Humanities suggests that other humanists should follow the example of the philosophers.

The Humanities were the subject of an important discussion during the year. A committee consisting of Professors Samuel Jay Keyser (chairman), Richard Cartwright, Kenneth Keniston, Pauline Maier, and Mary Potter was appointed by the Provost and myself to make recommendations as to the future organization of programs currently in the Department of Humanities. The committee reported late in the academic year, and its report had not been fully considered by the time of this writing. I should like, however, to offer my special thanks to the committee for the vigorous and effective way in which they pursued their work.

Outside the School a number of changes made by Professor Kenneth Wadleigh as Dean of the Graduate School have begun to have a very satisfactory effect on the work of two departments. Variations in tuition policy have made it possible to carry through a change in the whole pattern of financial arrangements for graduate students in Linguistics and Philosophy and Political Science, which make the M.I.T. programs in philosophy and political science better able to compete for the best applicants for admission with programs at other universities.

The end of the year brought a number of significant changes. The Program in Science, Technology, and Society became an autonomous program within the School and was separated administratively from the Dean's Office. In the coming year it will be preparing to move to new quarters. The Program has brought to the School a strength in crucial areas that are of vital importance for its future growth. The harmony with which the process of devolution has taken place is remarkable. Without Professor Donald Blackmer at the helm, such an easy transition would have been impossible.

At the end of the academic year Professor Bruce Mazlish returned to writing and teaching and ceased to be Head of the Department of Humanities after five strenuous years. Professor Cartwright was prevailed upon to become Acting Head and Professor Maier to become Acting Associate Head of the Department in Professor Mazlish's place. Professor Ithiel Pool, who had been Acting Head of the Political Science Department in place of Professor Alan Altshuler during the spring term, returned to teaching and research on Professor Altshuler's return. The lot of a department head is often a difficult one, and I am very grateful to all those who continue to serve or who have served as department heads in the School.

HAROLD J. HANHAM

TABLE I

Enrollment in Distribution Subjects: 1978-79

Field	# of Subjects	Year 1	Year 2	Year 3	Year 4 & 5	Graduate	Total M.I.T.	Wellesley	Harvard	GRAND TOTAL	%
History of Art and Architecture	7	37	60	60	69	17	243	4	0	247	5.1%
Humanities:	80	1,172	824	602	520	39	3,157	18	0	3,175	65.4%
American Studies	2	4	3	3	11	0	21	2	0	23	0.5%
Anthropology / Archaeology	4	60	38	33	28	0	159	0	0	159	3.3%
Creative Writing	6	140	98	48	42	3	331	2	0	333	6.9%
Foreign Languages	16	150	105	68	52	19	394	1	0	395	8.1%
History	13	203	129	124	91	2	549	2	0	551	11.3%
Literature A. (English)	13	231	145	113	100	5	594	4	0	598	12.3%
Literature B. (Foreign Language)	8	28	25	24	23	3	103	2	0	105	2.2%
Music	6	245	188	106	87	2	628	3	0	631	13.0%
Science, Technology, and Society	5	59	34	36	45	4	178	2	0	180	3.7%
Western Tradition	7	52	59	47	41	1	200	0	0	200	4.1%
Linguistics	1	31	37	36	40	2	146	0	0	146	3.0%
Philosophy	10	250	157	113	99	5	624	1	0	625	12.9%
Political Science	9	124	98	86	79	3	390	4	0	394	8.1%
Urban Studies	5	20	47	41	50	9	167	7	3	177	3.6%
Visual Arts and Design	2	25	45	17	7	0	94	0	0	94	1.9%
TOTAL	114	1,659	1,268	955	864	75	4,821	34	3	4,858	100.0%
%		34.1%	26.1%	19.7%	17.8%	1.5%	99.2%	0.7%	0.1%	100.0%	

Enrollment data are taken from the Registrar's fifth-week report.

TABLE II
Enrollment in Humanities, Arts, and Social Sciences Elective Subjects: 1978-1979

Field	# of Subjects	Year 1	Year 2	Year 3	Year 4 & 5	Graduate	Total M.I.T.	Wellesley	Harvard	GRAND TOTAL	%
Economics	24	203	420	393	331	31	1,378	6	2	1,386	23.3%
History of Art and Architecture	2	1	5	16	19	40	81	2	0	83	1.4%
Humanities:											
Anthropology/ Archaeology	13	6	11	23	20	2	62	5	0	67	1.1%
Foreign Languages and Literatures	40	143	158	83	106	163	653	10	0	663	11.1%
History	20	14	34	58	65	3	174	7	8	189	3.2%
Interdisciplinary	9	4	21	32	29	5	91	10	2	103	1.7%
Literature	36	64	158	217	253	9	701	23	3	727	12.2%
Music	26	36	111	108	127	1	383	6	1	390	6.6%
Science, Technology, and Society	8	8	11	16	27	5	67	2	3	72	1.2%
Writing	19	43	68	96	138	26	371	4	1	376	6.3%
	<u>171</u>	<u>318</u>	<u>572</u>	<u>633</u>	<u>765</u>	<u>214</u>	<u>2,502</u>	<u>67</u>	<u>18</u>	<u>2,587</u>	<u>43.4%</u>
Philosophy and Linguistics	17	11	64	79	97	23	274	2	10	286	4.8%
Political Science	33	7	151	192	148	9	507	65	7	579	9.7%
Psychology	9	39	122	130	115	5	411	15	1	427	7.2%
Urban Studies	14	3	32	54	46	7	142	21	2	165	2.8%
Visual Arts	31	16	78	83	103	50	330	24	12	366	6.2%
Subjects in Other Schools	8	4	21	31	13	2	71	0	0	71	1.2%
<u>TOTAL</u>	<u>309</u>	<u>602</u>	<u>1,465</u>	<u>1,611</u>	<u>1,637</u>	<u>381</u>	<u>5,696</u>	<u>202</u>	<u>52</u>	<u>5,950</u>	<u>100.0%</u>
%		10.1%	24.6%	27.1%	27.5%	6.4%	95.7%	3.4%	0.9%	100.0%	

The figures include all subjects listed in *Courses and Degree Programs* as routinely eligible toward the Institute Requirement. Other subjects approved by petition have not been counted. The data are taken from the Registrar's fifth-week report.

TABLE III
Fields of Concentration Selected

Under the Humanities, Arts, and Social Sciences Requirement

<u>FIELD</u>	<u>YEAR</u>				<u>TOTAL</u>
	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	
American Studies	7	1	0	0	8
Ancient and Medieval Studies	1	0	0	0	1
Anthropology/Archaeology	12	4	0	0	16
Drama	3	4	0	0	7
Economics	271	164	33	0	468
Foreign Languages and Literatures	64	42	35	6	147
History	54	28	4	0	86
History of Art and Architecture	14	6	1	0	21
Labor in Industrial Society	2	1	0	0	3
Linguistics	6	3	0	0	9
Literature	93	61	14	1	169
Music	98	33	14	2	147
Philosophy	67	26	4	0	97
Political Science	103	71	14	0	188
Psychology	143	40	8	1	192
Russian Studies	3	1	0	0	4
Science, Technology, and Society*	21	10	1	2	34
Urban Studies	18	9	1	0	28
Visual Arts and Design	39	14	2	0	55
Western Tradition	5	1	0	0	6
Writing	89	31	5	1	126
Special	<u>23</u>	<u>1</u>	<u>3</u>	<u>0</u>	<u>27</u>
TOTAL	1,136	551	139	13	1,839

* Figures include former Technology Studies concentrators.

TABLE IV

Undergraduate Majors in the School of Humanities and Social Science *

Year	Economics	Humanities	Philosophy	Political Science	TOTAL
1967-68	81	148	--	76	305
1968-69	84	195	--	79	358
1969-70	68	200	--	85	353
1970-71	60	162	--	59	281
1971-72	63	124	13	38	238
1972-73	64	92	15	39	210
1973-74	55	67	10	30	162
1974-75	63	48	1	14	126
1975-76	67	41	3	24	135
1976-77	67	31	7	25	130
1977-78	52	34	7	21	114
1978-79	48	38	5	30	121

TABLE V

Graduate Students in the School of Humanities and Social Science **

Year	Economics	Linguistics	Philosophy	Political Science	Psychology	TOTAL
1967-68	114	31	27	80	27	279
1968-69	118	38	23	87	27	293
1969-70	117	41	31	82	41	312
1970-71	103	34	36	78	23	274
1971-72	104	40	29	70	29	272
1972-73	109	34	24	82	23	272
1973-74	114	33	21	96	25	289
1974-75	114	35	18	95	25	287
1975-76	120	33	16	89	27	285
1976-77	114	32	14	91	29	280
1977-78	123	--	45***	102	24	294
1978-79	121	--	48***	96	28	293

* As registered in the second term of academic year 1967-68 to 1978-79 (omitting Freshmen and Undesignated Sophomores). Data taken from the Registrar's fifth-week report.

** As registered in the second term of academic year 1967-68 to 1978-79 (including special graduate students). Data taken from the Registrar's fifth-week report.

*** Includes students in linguistics.

Program in Science, Technology, and Society

S.T.S. was formed in 1977, after several years of preparatory work, as the developmental phase of a prospective College of Science, Technology, and Society. Several major landmarks in the development of the College have been noted in previous reports: the appointment of three distinguished scholars (Professors Kenneth Keniston from Yale, Leo Marx from Amherst, and Gerald Holton on a visiting basis from Harvard) to form the original nucleus of the new institution; the merger of this core group and the faculty members assembled earlier under the aegis of the Technology Studies Program; the receipt of grants totaling \$2.5 million from the Sloan, Mellon, and Hewlett foundations as start-up funds for the College; and the appointment of several new faculty, most notably Drs. Loren R. Graham from Columbia and Merritt Roe Smith from Ohio State.

These accomplishments allowed us to begin the year with a faculty roster of nearly 20 people, although delayed arrivals, research leaves, and part-time affiliations left us with the equivalent of about a dozen full-time participants. The year's major accomplishment, intangible but critical for the future, was the gradual formation of a consensus about the Program's purposes and the emergence of a sense of community among a heterogeneous company of scholars.

There were several other notable developments during the year. First, we are delighted that two distinguished senior colleagues will be added to our roster next year. Dr. Thomas S. Kuhn, the widely known philosopher and historian of science and author of *The Structure of Scientific Revolutions*, is coming to M.I.T. from Princeton in the fall; although he will be affiliated primarily with the Department of Linguistics and Philosophy, he will hold a part-time appointment in the Program, teaching an undergraduate subject and participating in other aspects of the Program. Dr. Carl Kaysen, David W. Skinner Professor of Political Economy, who has been on leave as director of the Sloan Commission on Government and Higher Education, has agreed to join the Program when he returns to M.I.T. for the second term of the coming year.

A second major development was the receipt of a grant of \$930,000 from the Max C. Fleischmann Foundation for the renovation of space at 70 Memorial Drive, the former National Research Corporation building, into which the Program will move early next summer. This building, which will be shared with the Sloan School and linked by a bridge over Wadsworth Street to the Sloan Building, will house the faculty, staff, and others associated with the Program and provide facilities for lectures, seminars, research projects, and other Program activities. We will be sorry to abandon our comfortable, centrally located quarters in historic Building 20 -- which has an aura all its own, however dubious the aesthetics -- but we look forward to the flexibility that the new space will provide.

The third special contribution to the Program's future was the receipt, toward the end of the year, of a grant of \$500,000 from the Exxon Foundation in support of a Fellows Program for the prospective College. The grant will allow us to bring to M.I.T. four or five postdoctoral or senior fellows each year for five years (beginning in 1980-81). Fellows will be selected through a carefully supervised national competition based on such criteria as the following: a record of outstanding performance in a particular field of science, engineering, social science, or the humanities; evidence of a strong commitment to teaching and research in a field involving the interaction of science or engineering with the humanities or social sciences; and a proposed program of study and research requiring substantial work in a field outside the candidate's original area of competence. The regular presence of a stimulating group of postdoctoral and senior fellows cannot help but enrich the life of the Program, and of the Institute as a whole. We believe that the fellowship opportunity will also make a contribution toward meeting the national need for more scholars, of the highest possible quality, dedicated to work on the interaction of science, technology, and society.

Educational Programs

Our educational concerns this year have centered primarily on the undergraduate curriculum. The Program received authorization from the Committee on Educational Policy to list its subject offerings in a separate section of the *Courses and Degree Programs* catalogue rather than under the aegis of the Department of Humanities. Curriculum planning has progressed, with virtually every member of the Program developing one or more new subjects. The curriculum for the 1979-80 academic year will include more than 40 subjects, both introductory and advanced, organized around five general areas of inquiry: the history of science; the history of technology; contemporary problems in science and technology; science, technology, and the organization of industrial society; and cultural dimensions of science and technology. The coming year will thus provide our first real opportunity to interest undergraduates, especially engineering and science majors, in developing broader intellectual and cultural perspectives on their chosen fields.

We also have begun to work on ways of integrating an S.T.S. perspective more fully into the mainstream of science and engineering education. The objective here is to enable students to achieve a double competence: competence in a particular field of science or engineering and competence in some relevant dimension of the social or cultural context within which science and technology function. This is an ambitious goal, implying the need either for a rigorous interdisciplinary major or for some kind of coordinated double major.

As a first concrete step in this direction, the Department of Humanities, with the particular assistance of faculty from S.T.S., will offer a new version of the Humanities and Science and Humanities and Engineering majors in Course XXI for students interested in the social and cultural dimensions of science and technology. This option of the Course XXI major will center on a core requirement of three components: a two-semester reading seminar to study key texts concerning the relations of technology and science to important social and cultural issues; two subjects from a selected list dealing with historical and cultural dimensions of science and technology; and a senior thesis. The remainder of the program will comprise a coherent combination of 10 electives, at least four of which must be drawn from science or engineering, and at least four from the humanities.

An interdisciplinary team is also planning an experimental program of dual majors to be undertaken in collaboration with departments in Engineering. The experiment is part of a larger exploration by the School of Engineering into the usefulness of dual majors as a way of broadening the training of engineers beyond the boundaries of their particular fields. Two half-time members of the Program faculty, Professors Leon Trilling of the Department of Aeronautics and Astronautics and Michael Meyer of the Department of Civil Engineering, have made particular contributions to development of the dual major possibility.

The Program also has been developing a variety of arrangements for graduate students who wish to pursue questions relating to interactions of science, technology, and society. We now offer graduate-level subjects jointly with several M.I.T. departments, but do not yet have a formal graduate program. Graduate students are participating in research and reading seminars and becoming involved in faculty research projects. With departmental permission, they will be able to structure a special concentration or minor field in S.T.S. as part of their degree program. For example, such arrangements are being made with students in the Department of Political Science specializing in science and technology policy and the comparative study of advanced industrial societies. Financial assistance has been offered to several of these students. Further curriculum planning at the graduate level has high priority.

Workshops and Lecture Series

The Program shared in the sponsorship of a number of workshops and lecture series during the year. An Environmental Studies Colloquium was organized in collaboration with the Department of Urban Studies and Planning. Led by Professors Lawrence Susskind and Lawrence Bacow of that Department, the colloquium brought together faculty and graduate students from a number of fields to discuss ways in which M.I.T. students might be better prepared to deal with environmental issues.

A faculty seminar on the social and cultural impact of the computer was sponsored jointly by the Program and the Laboratory for Computer Science under the leadership of a steering committee consisting of Professors Sherry Turkle from S.T.S., Jeffrey Meldman of the Sloan School, and Michael Hammer and Joseph Weizenbaum of the Department of Electrical Engineering and Computer Science. Following several small group sessions during the fall semester, two public symposia with outside speakers were held in the spring, one on "Computers and the Workplace," the other on "Computers and Education."

A lecture series on "Technology and Work" was sponsored jointly with the Technology and Culture seminar. This series, for which Professor David Noble of S.T.S. and the Reverend Scott Paradise, Episcopal Chaplain at M.I.T., deserve much credit, proved to be a particular success. The series attracted a substantial audience to most of the lectures and a smaller, intensely committed group to the informal suppers and discussions that went on well into the evenings following each lecture. During the spring, the Program also offered a seminar series on "Social Change and the Life Sciences," organized by Dr. Peter Buck; these talks explored historical or social dimensions of 19th- and 20th-century biology and medicine.

RESEARCH

Research in progress or recently completed falls under three broad headings: 1) the social study of science, 2) technology and the organization of industrial societies, and 3) cultural systems in industrial societies. Here I will touch on this year's highlights.

Social Study of Science

An impressive amount of work has been proceeding on various topics in the history of science. Dr. Buck's book *American Science and Modern China* will be published by the Cambridge University Press next winter. Professor Graham has had an extremely productive year of research leave, writing a number of articles and nearly completing a book under contract with Alfred A. Knopf entitled *Between Science and Values: Expansionism and Restrictionism in Modern Science*. Professor Holton's book, *The Scientific Imagination: Case Studies*, published last year by the Cambridge University Press, has been uniformly well received; it was selected by *Choice* magazine as one of the outstanding academic books of 1978 and is being translated into several languages. Professor Holton was in great demand as a conference participant during this Centenary Year of Albert Einstein's birth, playing a particularly large role in the Jerusalem Conference organized by the Israel Academy of Sciences and Humanities; Professor Graham also delivered a paper at that meeting.

Two other contributions to the understanding of 20th-century American science deserve mention. First, Professor Kenneth Manning has completed several chapters of his full-scale biography of the biologist E.E. Just, which explores what it meant to be a black and a scientist in early 20th-century America. Second, the Harvard University Press has accepted for publication next year the book on which Professor Charles Weiner and Alice Kimball Smith have been at work for some time entitled *Robert Oppenheimer: Letters and Recollections*.

Work is also going forward on controversial present-day issues of public policy in which scientific and technical matters play a central part. Professor Weiner has continued his research on the recombinant DNA controversy, publishing several articles and continuing to develop archival and oral history materials relating to that and other issues. Professor Joel Yellin has spent the year at the Kennedy School of Government doing research on a book on risk and the judicial system which will explore ways in which scientific uncertainty and changing scientific knowledge are and should be treated in environmental issues. Professor Yellin also has continued his collaboration with two members of the Department of Economics, writing papers jointly with Professor Paul Samuelson on population biology and with Professor Paul Joskow on nuclear siting.

Technology and the Organization of Industrial Society

Research is being conducted on both historical and contemporary questions under this heading as well. The study written by Professor Louis Bucciarelli in collaboration with Nancy Dworsky on Sophie Germain and her contributions to early 19th-century developments in elasticity has been accepted for publication by the Reidel Press. Professor Noble has continued his National Science Foundation funded study of the design and deployment of numerically controlled machine tools; this research forms part of a larger investigation of the development of new technologies and their effects in the workplace. Professor Smith, on research leave this year, made good progress on a book tentatively titled "Mechanizing America," a thematic survey of the interactions of American technology and culture in the 19th century; he is simultaneously pursuing his work on the role of the military in industrial development and on the history of early American industrial communities.

Two promising investigations into aspects of contemporary industrial societies have been launched this year. Professors Keniston and Leon Trilling have begun work on a collaborative research project to compare the selection, training, and career patterns of professionals with "elite" engineering educational backgrounds in France and the United States. Professor Keniston was awarded a Guggenheim Fellowship for the coming year to enable him to pursue his part of this study on a full-time basis. A second study, still in the planning stage, is a collaborative venture led by Professors Charles Sabel of S.T.S., Suzanne Berger of Political Science and Michael Piore of Economics. Organized as a series of coordinated studies of the technical and social problems of particular industries, the project seeks to analyze the constraints and areas of choice inherent in the technologies of advanced industrial societies. Professor Sabel completed several related articles this year as well as a book to be published by the Cambridge University Press under the title "Struggle in the Factories: Industrial Conflict and the Society of the Labor Market."

Cultural Systems in Industrial Societies

This part of our research program is seeking to clarify the role of historically transmitted belief systems and ideologies in shaping the interactions of science and technology with the rest of contemporary life. Our premise is that the social significance of scientific and technological innovations derives largely from the interpretive frameworks -- religious, political, philosophical, literary, and aesthetic -- which people use to comprehend those changes. One of the vital mediating functions which cultural systems perform in industrial societies is thus to impart meaning to developments in science and technology.

This general perspective forms the basis of the book which Professor Marx is currently writing on the place of "pastoralism" in contemporary American culture. Pastoral ideals express a desire, in the face of the growing power and complexity of organized society, to recover a simpler way of life, closer to "nature." His study examines how this mode of thought, whose roots are in antiquity, has continued to make itself felt not only in literature and art, but also in current social and quasi-political movements like environmentalism, the cult of voluntary simplicity, the migration to the suburbs, and the politics of disengagement favored by the radical counterculture which developed during the Vietnam era.

Two other projects deal with the use of scientific and technological systems as symbolic structures which give meaning to human experience. Professor Turkle's current research examines social and psychological factors which influence how people relate to computers. An ethnographic investigation of computational cultures and subcultures, this study explores how computers become carriers for different personal styles and social ideologies. Professor Turkle's previous book, *Psychoanalytic Politics: Freud's French Revolution*, was published by Basic Books last fall and has been widely, and favorably, reviewed. A French edition will appear next year.

Professor Langdon Winner has continued his research on the linkages of technology, philosophy, and political theory. His current study deals with the social, moral, and political dimensions of technological design. It aims to show how categories and modes of judgment found in political theory can be employed in selecting design criteria for contemporary technological systems. In broad terms, the study is concerned with the role that technologies of various kinds play in giving cultural shape to people's experiences of order, power, authority, and freedom.

STAFF CHANGES

I am pleased to report two administrative appointments made during the spring. Dr. Peter Buck, who has been associated with the Program for the past two years, has been named Assistant Director on a half-time basis; he will also continue as lecturer, teaching subjects in the history and social study of science and contributing to curriculum development. Martha Taylor has been appointed full-time Assistant to the Director, with wide-ranging responsibilities which include providing staff support to several Program committees, overseeing preparation of publications, supervising the secretarial staff, and coordinating the move to our new quarters.

DONALD L.M. BLACKMER

Department of Economics

Departmental activity this year was remarkable for its continuity and similarity to other years. While many modest changes and improvements were implemented, only a few require special mention.

Undergraduate Program

The number of bachelor's degrees awarded this year in economics is a little lower than the average for the decade. Undergraduate enrollments in economics have fallen somewhat from their sharp peak in the academic year 1974-75, but remain substantially higher than in the first half of the decade. It is also significant that the proportion of total credit hours taught to non-majors has risen from 80 percent five years ago to over 90 percent in the last term.

Graduate Program

The Ph.D. program had somewhat fewer applicants this year than the decade average. The entering class will be about the same size as before and will contain 10 National Science Foundation (NSF) Fellows who will represent 30 percent of the class and over half of the first-year NSFs awarded nationally. Two recent Ph.D.s won prizes for their dissertations: Charles Revier received the award for the 1978 Outstanding Doctoral Dissertation in government finance and taxation by the National Tax Association and Tax Institute of America; and Gary Burtless won the 1979 Wassily Leontief Prize for best thesis awarded by the Eastern Economics Association.

RESEARCH

Faculty research produced some 60 articles, 40 chapters in books, three monographs, five books edited, two books published, and one classic revised. The range of interest is substantial: from microtheory through energy, housing, food, labor, transportation, health, to macrotheory and inflation and stabilization policies, through international economic problems, economic development, migration, and central planning. The original volumes published were by Jagdish Bhagwati, *Anatomy and Consequences of Exchange Control Regimes*, Lance J. Taylor, *Macro Models for Developing Countries*, and Paul A. Samuelson's eighth edition of his seminal volume *Foundations of Economic Analysis*. An unusually large number of volumes were edited by the faculty this year: Peter A. Diamond, *Uncertainty in Economics*; Rudiger Dornbusch, *International Economic Policy*; Stanley Fischer, *Rational Expectations and Economic Policy*; Daniel L. McFadden, *Production Economics* (in two volumes, a substantial portion of which was contributed by the editor); and William C. Wheaton, *Interregional Mobility and Regional Growth*.

FACULTY

A number of faculty changes have taken place. A major senior appointment brought Daniel L. McFadden of the University of California at Berkeley to M.I.T. His distinction as an applied economist was recognized by the American Economic Association when they awarded him the J.B. Clark Medal in 1975. His major interest in the study of engineering economic systems of various types, such as transportation, energy, and telecommunications, will provide leadership in furthering linkages with the engineering disciplines.

Dr. Jerry A. Hausman was promoted to professor and Dr. William C. Wheaton to associate professor with tenure. Robert F. Engle, a former faculty member, was a visiting professor from the University of California at San Diego in the fall term. Professors Morris A. Adelman and Evsey D. Domar were on sabbatical leave in the fall and spring terms, respectively.

Three junior appointments have been made for next year: Drs. Robert C. Litterman from the University of Minnesota and Lawrence H. Summers from Harvard University as assistant professors, and Joseph V.R. Farrell from Oxford University as an instructor.

Professor Peter Temin was voted the outstanding teacher of the year by the Graduate Economics Association. Professor Michael J. Piore completed his two-year term as Associate Chairman of the Faculty. Professor Robert M. Solow is serving this year as president of the American Economic Association, Professor Franklin M. Fisher is president of the Econometric Society, and Professor Franco Modigliani is vice president of the International Economic Association. Professor Dornbusch was elected a fellow of the Econometric Society and a Guggenheim Fellow. Several major lectures were given by the faculty: Professor Bhagwati, the V.K. Ramaswami Memorial Lecture at Delhi University; Professor F.M. Fisher, the David Kinley Lecture at the University of Illinois; Professor McFadden, the Irving Fisher-Henry Schultz Lecture to the Econometric Society. Professor Adelman received an award for his contribution to mineral economics from the American Institute of Mining, Metallurgical and Petroleum Engineers.

With sorrow I report the death of Donald S. Tucker, Professor Emeritus for many, many years. He was one of the last bridges between the "old" and "new" departments. He retired in 1950, not long after I first came to M.I.T. Even now I can recall the willingness, even eagerness, with which Don would volunteer for extra teaching while we, the junior faculty, begrudged even the normal load. Don's infectious good humor helped establish a departmental temper that made a uniquely congenial environment for junior faculty. He was a memorable teacher and a warm friend.

E. CARY BROWN

Department of Humanities

With this report, I conclude five years as Head of the Department of Humanities. Instead, therefore, of surveying only this year's activities, I wish to give my overview of the activities of the past half decade. I can take no better guide than the man most responsible for my originally coming to M.I.T.: Dean John E. Burchard. In his farewell report, he spoke of how his earlier reports all looked forward, and then said, "Now the time has come when it is another who should be looking forward; I may be pardoned the vanity of looking backward.... It would be absurd and Tartuffian for me to pretend that I do not look ... back on the years ... with more than a little satisfaction. We have had some failures and many successes, and we *are* bigger and better than we were. There is perhaps nothing that we might somehow not have done better; and there is little we might not have done worse. I think the weight is on the better." I write in the same spirit.

The major challenge over the five years has been to foster an atmosphere of increased intellectual concern and to hold the Department to the highest standards of scholarship, while preserving its traditional dedication to teaching. This is necessarily a delicate balance. Another challenge was to develop further a sense of Department affiliation and loyalty -- a requisite sense of belonging -- while encouraging the maximum ambitions for sectional and disciplinary identification and even autonomy. Again, this has made for a special sort of tension, with unusual pulls and pushes.

In contrast to the pedagogic and intellectual side, the governance of the disparate elements of the Department, which in 1974 included an Anthropology/Archaeology Program, a History Section, a Literature Section, and a Music Section, plus other endeavors, has been a perennial problem. Professor Harold J. Hanham, my predecessor, as acting Head of the Department (and Dean of the School of Humanities and Social Science), continually pointed out the need for what he called a group of "wise old men" (and women), to offer counsel and support to the Head. In place of that group has stood the Policy Committee. That Committee has had fine individuals on it; but its composition has been uncertain and its provenance vague. Because the Committee's membership has frequently changed from year to year, it has been difficult to establish continuity of policy; and the Committee has necessarily existed in an uneasy relation with the Head, and vice-versa, with both parties unsure as to whether only advice was involved, or consent as well. Happily, all parties concerned took a Burkean view of the matter and argued not over the legal right but rather over the pragmatically desirable. For five years, against all odds, a basic harmony reigned.

Still, like Dr. Holmes' One Horse Shay, the wonder is that the Policy Committee did not fall apart. As a structure of governance, it left much to be desired. So did the Departmental Personnel Review Committee, where problems of continuity were compounded by the fact that, often, members of the Committee were themselves non-tenured and, indeed, subject to promotion review. Again, miraculously, the Committee managed to function reasonably well, serving as a basically impartial and informed review group and a safeguard of both the individual's and the Department's interests.

The administrative problems of the Department were felicitously compounded in July 1976, when the Foreign Languages and Literatures Section, newly separated from joint departmentship with Linguistics, joined the Department of Humanities. I hasten to add that, along with the problems involved in taking on yet another discipline and roughly 30 new people, came additional intellectual stimulation and pedagogic range. At about the same time, the Writing Program moved out of its experimental stage, took a new, expanded lease on life, and became firmly enmeshed as a regular part of the Department. Again, whatever the administrative strain -- and what else are administrative officers for but to cope with such strain? -- the Writing Program, too, added another note of intellectual excitement and engagement to the Department.

Let us look more closely for a moment at the component parts of the Department. The Anthropology/Archaeology Program underwent a five-year review in 1977-78 by a committee composed of Professors Ernestine Friedl, Dell Humes, and David Riesman. The committee admired the Program's professionalism and its homogeneity of aim; it worried about the Program's ability to reach large numbers of M.I.T. students and to give adequate attention to modern industrial society, viewed from an anthropological perspective. These, then, would seem to be Anthropology/Archaeology's main tasks. A possible joint appointment with the Program in Science, Technology, and Society (S.T.S.), of an anthropologist studying modern societies, holds promise of addressing the last of these issues. Note should also be taken of one of the Anthropology/Archaeology Program's great successes: the formation of an Inter-University Consortium for a Center for Materials Research in Archaeology and Ethnology, under the able direction of Professor Heather Lechtman.

The Foreign Languages and Literatures Section has grown in both numbers and quality. Under the acting directorship of Associate Dean Donald Blackmer -- where he got the time to do it is one of the modern mysteries -- the implementation of a decision to end the language/literature schism in Foreign Languages and Literatures was begun, and a new director, Professor Margery Resnick, was appointed. Under her vigorous leadership, the synthesizing process continued apace. The teaching of Foreign Languages and Literatures at M.I.T. is now marked by high morale, a sense of dedicated professionalism, and a high order of pedagogy. The hard question for future administration will be: has the section expanded too fast and too far, or has it simply grown to its legitimate boundaries? A specific facet of this question concerns the competing claims of the Foreign Languages and Literatures Section and the Literature Section on the teaching of what is variously called literature in translation, world literature, or comparative literature.

The Literature Section faced a different problem. An integral part of the Department since its inception, its problem has been to establish a situation in which its senior members could provide leadership for the younger members, hold to clear and commendable standards for promotion and tenure, make outstanding new appointments, and remodel its curriculum in a convincing way. I am glad to report that under the principled leadership of Professor Alvin Kibel, Chairman of the section until this year, when he will be succeeded by Professor Irene Tayler, these goals have largely been reached. There is a new cohesion and intellectual rigor in the section, much helped by the recent new appointments, that bodes well for the future. With Foreign Languages and Literatures, Literature faces a common problem, however; the two sections must come to agreement on the teaching of world literature. The Literature Section must also define more clearly its relation to the Writing Program.

The History Section has also been a long-time core element of the Department. After a weakening trend in numbers of faculty and students, it is on the rebound. Strong, new appointments have been made in American history, and a thoughtful curriculum worked out. A similar effort can be expected in European history. The Section badly needs new, young appointments, and it is sadly deficient in the areas outside European and United States history, especially Asian and Latin-American history. It has shown unexpected strength in the fields of ancient and medieval/Renaissance history, and is now offering an exciting concentration in this area. Once the seat of work in the history of science and technology, the section has yielded these fields to the S.T.S. program; the History Section, however, has established friendly relations with fellow historians there, and joint appointments have been made and will and should be made in the future. For five years, Professor Thomas H.D. Mahoney has provided a needed stability to the section; his successor, Professor Pauline Maier, will have the task of adding further intellectual excitement to the solid foundation he leaves behind him.

Music has had great success with the students and in making a recognizable contribution to the Institute as a whole. Its faculty has registered strong professional achievements. Somewhat diffused in its aims -- performance and theory, classical and experimental -- it has required a certain amount of finesse from its successive chairmen, Professors John Buttrick and Stephen Erdely. Its major challenge in the future may well focus on whether or not it ought to offer a graduate degree.

The Writing Program began as an experimental unit, asserting autonomy from the Literature Section, whence it sprang. This "history" has hung over the Program until now. After a few unsettling years, the Program was reorganized, and under Acting Director David Breakstone

and then Professor Robert Rathbone, carved out a clear mandate for itself: to teach a spectrum of writing modes, from creative through expository, technological and scientific, with a staff made up of practicing writers who meet the highest professional standards. The appointment of Professor Emma Rothschild in 1978 as Director of the Writing Program emphasized anew the Program's intent to reach out to the whole of the Institute. A residual problem is the Writing Program's relations to the Literature Section, remarked upon earlier in this report from a different perspective. At present, there is only one tenured member in the Writing Program; clearly, more are needed.

Drama, while not properly a section, deserves separate mention. It can be thought of as being where Music was 10 to 15 years ago. It needs adequate space, additional resources, and strong administrative support. Professor Joseph Everingham, over the years, has done wonders with what he has had, and is now ably aided by Professor Robert Scanlan.

The Course XXI major has gradually been increasing in numbers again. The new joint majors, XXI-A, Option Two, and XXI-B, 1, Option Two, offered with the cooperation of the S.T.S. Program, promise to be an exciting resumption of the long-term effort of the Department to mount a truly interdisciplinary science/technology/humanities offering, along with its single Humanities discipline majors.

Such is the state, individually, of the parts of the Department. For the Department itself, some general statements remain to be made. With the support of the Chancellor, Dr. Paul Gray, the budget base overall was rationalized in fiscal 1977. Budget problems still remain, but they are now soluble in a settled framework. As with other departments in the Institute, Humanities makes its full-time appointments through a nationwide, affirmative action search, carried out with great expenditures of time and care. I am pleased to note that in my five-year term, the first appointments of tenured women have been made in History and in Literature, and the first awards of tenure to women already on the faculty have been made in Anthropology/Archaeology, Foreign Languages and Literatures, and the Writing Program; more are expected. Moreover, a black member of the Music Section also has been awarded tenure, and black members of the History and Literature sections grace our ranks. It is a record of which we can be proud, though humility reminds us that it is merely a record, to be built on and tested.

There are items that deserve discussion, but I shall simply list them here: the Wellesley Exchange and the Council for the Arts, both in terms of their relation to the Department; the Western Tradition, as successor to the core curriculum; the Humanities, Arts, and Social Sciences distribution requirement and its effect on the Humanities disciplines; the newly instituted mentorship program for younger faculty; and the various workshops, such as those in Literature and History.

There are names to be mentioned, and thanks to be offered. I would like to express the Department's gratitude to those who served it so well for many years and have retired during the last five years: Lecturer Primus Bon, Professors E. Neal Hartley, Robert Rathbone, and Theodore Wood; and Professor Joseph Everingham, who is retired to one-quarter time, should be included.

We have had a number of distinguished visiting professors. One notes among others -- it is always hazardous to list some and not others, but the risk is necessary -- Professors Samuel Allen (Black Literature), Felicia Bonaparte (Literature), Henry Steele Commager (History), John Hersey and Lillian Hellman (Writing), and Andor Kovach (Music). We have had a host of distinguished guest lecturers, including E.I. Doctorow, Geoffrey Hartmann, Justin Kaplan, Bernard Malamud, and Steven Marcus.

On another note, the Department could not have functioned as smoothly as it has without the talents and dedication of its superb Administrative Officers: Ruth Dubois, until her retirement in 1976, and Marjorie Lucker, from 1976 on. I must add my deep personal thanks to them, and to Ann Rourke, who headed the office staff and served as my personal secretary. The Department's debt to the Friends of Humanities, and especially to I. Austin Kelly III, is enormous. Both their moral and financial support were of critical importance at a number of junctures. They provided the Head with a flexibility, in the form of discretionary funds, that allowed for vital support of the scholarship of individuals and of innovative efforts of

the Department at large. On behalf of my colleagues, as well as myself, I would like also to thank the Visiting Committee of the Department, and its various members and chairman, for their constant concern and helpful counsel over the years.

In my very first report, 1974-75, I wrote: "It is plain that the structure of the Department and its ways of administering its affairs is a continuing problem." Those words are still true. Coincident with my retirement as Head, it seemed wise to consider a reorganization of the Department. Though the Department had become a relatively harmonious body, imbued with much pedagogic energy and new-found intellectual commitment, the very success of its parts argued for giving them increased autonomy. Discussions that began in early spring 1979 have culminated in a Committee for the Reorganization of the Humanities (Professors Richard Cartwright, Kenneth Keniston, Pauline Maier, Molly Potter, and Jay Keyser as Chairman), which on April 30, 1979 submitted its recommendations to the Provost and Dean of the School. Somewhat unexpectedly, the discussions aroused various anxieties and even dissension -- as one of the members of School Council remarked dryly, "We opened Pandora's box" -- but I am confident that the issues can be resolved, and structures worked out that will better facilitate the work of the Humanities disciplines. It is, however, with a reasonable amount of *Schadenfreude* that I leave such resolutions to Professor Richard Cartwright, Acting Head for 1979-80 (assisted by Professor Pauline Maier as Acting Associate Head), who will, in my view, bring the necessary calm impartiality so vital to a smooth transitional period. At the end of next year, therefore, there is a high probability that the Department of Humanities, as we have known it, will cease to be.

I close on a personal note. I had not expected to derive the satisfactions I did over my five years as Head of the Department. While seeking to maintain my own scholarly work -- if nothing else, such activity avoids the "Do as I say, not as I do" syndrome -- I experienced an extraordinary reward from spending most of my time trying to enhance the work of my colleagues (even if that often meant simply listening to them for long stretches of time). I discovered that in helping them enlarge their pedagogic and intellectual spheres, I expanded my own as well. For giving me the opportunity to work with them in this way, I wish to record a debt of gratitude to the Provost and the Dean, and especially my colleagues in the Humanities. I end, in the spirit with which I began this report, with the conviction that the weight in the Department has been "on the better." I count it a privilege to have served as its Head.

BRUCE MAZLISH

ANTHROPOLOGY/ARCHAEOLOGY PROGRAM

The 1978-79 academic year represents the completion of a cycle in which each member of the Program has had the opportunity to spend at least one year away from the Institute to carry out field research or other scholarly activities. This continuing contact with the primary field of study results in an ongoing contribution to the teaching effort and forms the basis for evolving and deepening research interests. Further, the Program has learned how to coordinate and plan leaves, and hire temporary replacements without serious discontinuity in our subject offerings.

As a result of the last five years' experience, and in accordance with the recommendations of an outside committee of three distinguished social scientists which reviewed the Program in 1977, we have been devoting our energies this year toward revising our curriculum. The revision is being timed to meet the deadline for inclusion in next year's catalogue. We also are planning a Program laboratory that will enable us to introduce a lab component into many subjects, both cultural and archaeological.

Professor Martin Diskin served as Head of the Anthropology/Archaeology Program this year and will continue in that capacity next year. His major research effort is the elaboration of his Mexican field material. He exhibited a series of photographs entitled "Mayordomía in Oaxaca" in the Tozzer Library at Harvard from September 1978 through January 1979. His photographs,

with accompanying text, are now being considered for publication. His village demographic analysis continues and the first findings are expected this summer. He was principal discussant at a symposium on "Mexican Food Systems" at the annual meeting of the American Anthropological Association in Los Angeles, November 1978. He also served as faculty member of the Oaxaca Seminar, a one-semester program of study and fieldwork in Mexico which commenced in California and continued in Oaxaca, where Professor Diskin helped organize student field projects.

After spending a year with the San Blas Cuna of Panama, Professor James Howe completed his leave in the fall semester, working on his field materials. In the spring he resumed his teaching. He published a commentary, "Ninety-two Mythical Populations: A Reply to Divale et al," in *American Anthropology*, and two articles, "The Effects of Writing on the Cuna Political System," in *Ethnology* and "How the Cuna Keep Their Chiefs in Line," in *Man*.

Professor Howe is finishing his book on the village politics of San Blas Cuna. After that he will work on a more specialized monograph on Cuna decision making, a book on fox hunting, and a study of New England town meetings. While on leave, he was a consultant for the US Agency for International Development on the situation and development prospects of indigenous populations in Paraguay. The report of this trip has been submitted to USAID. He is an outside member of a doctoral dissertation committee in the Anthropology Department of the University of Arizona. He also served as a resource person for the committee on the restructuring of the M.I.T. Department of Humanities.

Professor Jean Jackson, in association with a colleague from Wellesley, Professor Sally Merry, taught a joint M.I.T.-Wellesley course, Colonialism, Nationalism and Development: The Impact of the State on Traditional Societies. Her review of the book, *Carib-Speaking Indians: Culture, Society and Language*, edited by Basso, appeared in *American Ethnologist* in November 1978. She also wrote an article entitled "Colombia: Instant Underdevelopment for Indigenous Tribes" in the *Anthropology Resource Center Newsletter*, December 1978.

She is finishing revisions of her book, *The Bará: Individual and Group Identity in Tukanoans of the Northwest Amazon*. She is also completing two entries for the *Dictionary of American Indians*. She and Professor Merry are preparing a paper summarizing the conclusions of the M.I.T.-Wellesley joint seminar. Professor Jackson also served last year on the Committee on Curricula.

Professor Heather Lechtman continued to devote significant time as Director of the Center for Materials Research in Archaeology and Ethnology. During this year, the Center received additional support from the National Science Foundation and the Samuel H. Kress Foundation of New York.

Professor Lechtman's research continues in the study of ancient Andean technology, particularly in bronze metallurgy and the study of ore smelting practices. She also is working on Minoan and Mycenaean elite metallurgy. She published a paper entitled "Temas de Metalurgía Andina" in *Tecnología Andina*, edited by R. Ravines. She serves as a Miembro Consultor, Centro de Estudios Andinos, Cuzco, Peru, as well as on the Committee on Regional Conservation Centers of the American Institute of Conservation. She is vice president of the Institute of Andean Research, New York, and is a member of the Public Broadcasting Associates Advisory Group on a television series on anthropology and archaeology. She is also a member of the M.I.T. Committee on the Visual Arts.

Professor Arthur Steinberg maintained a full teaching schedule during the past year and continued his research on the metallurgy of Cyprus and the study of Ubaid and related ceramics of early Mesopotamia. He was a member of a Ph.D. thesis committee at Pennsylvania State University.

Professor Wilma Wetterstrom was on leave of absence during 1978-79. Much of this time she spent abroad. In August and September of 1978 she conducted archaeological fieldwork in Upper Egypt, launching a new research program that will occupy her for the coming years. This work, focusing on the archaeological plant remains of Predynastic sites, is concerned with the development of agriculture and the evolution of the diet in Egypt. It promises to be the first large, systematic paleoethnobotanical research in Egypt in recent times. During the field season Professor Wetterstrom, working with a group from Washington State University,

collected archaeological plant remains from a series of Predynastic sites near Luxor. In the winter she returned to Egypt to work at the Cairo University Herbarium and to collect materials for a modern reference collection.

Since the Old World is a new geographic region for Professor Wetterstrom, she spent part of the winter consulting with specialists in order to acquire the necessary expertise and skills. She spent five weeks at the Biologisch-Archaeologisch Instituut in Gronigen, Holland, working with Professor W. van Zeist, one of Europe's most eminent paleoethnobotanists. She also worked with Dr. Maria Hopf (Römisch-Germanisch Zentral Museum, Mainz, Germany), another distinguished European paleoethnobotanist, and with Dr. Daniel Zohary (Hebrew University, Jerusalem), a botanist specializing in the genetics of wheat and barley. As a result of this work, Professor Wetterstrom is now one of the few scholars in the US qualified to study plant remains from the Old World.

In the summer of 1978 Professor Wetterstrom wrote a paper entitled "Cognitive Systems, Food Patterns, and Paleoethnobotany" which appeared in spring 1979 in *The Nature and Statutes of Ethnobotany*, edited by Richard I. Ford. Her paper, "Plant Remains from Mesilla and El Paso Phase Sites of the Hueco Bolson, A Preliminary Report," was published in summer 1978 in *Settlement Patterns of the Western Hueco Bolson Publications in Anthropology*, by Michael E. Whalen.

MARTIN DISKIN

FOREIGN LANGUAGES AND LITERATURES SECTION

During the past year the faculty and staff in the Foreign Languages and Literatures Section have worked extensively in four major areas: the elaboration of a new undergraduate curriculum in foreign languages and literatures; the definition and strengthening, in collaboration with the Writing Program, of our sequence in English as a Foreign Language, which serves the Institute at large; full participation in Institute activities; and the establishment of a leadership role in our field through scholarly activities and sponsorship of programs which have drawn the attention of our community.

Curriculum Development

A number of curricular changes have taken place in our program. The expertise of our new faculty members made it possible for us to propose major programs in Russian, French, German, and Spanish this year. In addition to a literary track, we have developed various area studies programs.

As a related venture in the upgrading of our foreign literature and civilization program, several faculty members, under the direction of Professor Robert Jones, studied the M.I.T. library collection in each language. With the support of Jay Lucker, Director of the Libraries, and the staff of the Humanities Library, a significant number of books from the bibliographies we compiled will be purchased. These acquisitions will improve the collection so that it will meet the needs of students in our program.

A full complement of Spanish language and literature courses was developed over the past year. To correspond to the demand for advanced subjects in Hispanic civilization and literature, the Section completed a recruiting effort which will bring Dr. Elizabeth Garrels, currently chairperson of Spanish at Amherst College, to M.I.T. as assistant professor of Spanish. Also appointed in Spanish is Gladys Varona Lacey, who is completing her Ph.D. at the University of Pittsburgh and will be joining us as instructor. As an analogue to the academic program in Spanish, there was a noticeable increase in extracurricular activities in Spanish at the Institute. Students and faculty worked with Robert Sherwood, Associate Dean of Student Affairs, on plans for a Spanish house which will be available for students this coming September. The Hispanic Cultural Committee sponsored several speakers during the course of the year, and a play in Spanish was included in the Dramashop's revue night.

During the fall, the Section developed a coherent sequence of subjects in foreign literature in translation. We have devised a modular system in this sequence which will encourage students with a reading knowledge of a specific language to study the works in the original. These courses on foreign literature in translation will make available literary works which, in most instances, have never before been taught at the Institute.

With the support of the Dean of the School of Humanities and Social Science, remodeling of our language laboratory was completed this fall. All groups have been pleased with the new cassette system which allows for greater flexibility and a wider range of services than our former reel-to-reel system. As a result, there has been increased use of the laboratory not only by our students, but by faculty and staff throughout the Institute who want to learn a language on their own, or who want to acquire greater fluency in a language they already know. The recording room in which individual instructors create their own materials for classes has been improved and is actively used. As part of the renovation of teaching facilities, audio equipment was installed in four classrooms. To help us exploit the full capabilities of the technologies we now possess, we held a search for Director of the Language Laboratory. Ruth Trometer, currently an assistant director of the Harvard Language Laboratory, was named director of our laboratory and will be joining us this coming year.

The Wellesley Exchange has continued to enhance the variety of subjects offered at both institutions. This year, in French, Professor Jones of M.I.T. offered a course at Wellesley, and Professor George Stambolian of Wellesley taught a course at M.I.T. A full complement of Chinese subjects was taught by Wellesley faculty members at M.I.T. A Wellesley course on Arts and Letters of Mexico was given at M.I.T. this fall. The participation of Wellesley faculty members in the Foreign Languages and Literatures Section luncheon seminars on language pedagogy provided opportunities for intellectual discourse on our shared disciplines. The Section worked closely with Joel Orlen of the Provost's Office on two colloquia: one held at Wellesley with Professor Jay Keyser of M.I.T. (Department of Linguistics and Philosophy) and Professor Michel Grimaud of Wellesley College (French Department) and the other at M.I.T. with Professor Jones and Professor John Knudsen of Wellesley (History Department).

Our course offerings were enriched by the 19 activities offered by the Section during I.A.P. These activities included a three-week trip to Paris led by Professor Kathryn Crecelius and a trip to the Soviet Union led by Professor Julia Alissandratos.

Significant curricular changes have taken place in our program in English as a Foreign Language. The new Institute-wide testing program allowed us to collect data on each incoming graduate student and forward it to advisors before the semester began, thus allowing them to advise foreign graduate students more effectively. Analysis of the data generated norms for use by graduate admissions officers at the Institute. As a result of the exam, our staff held a series of meetings with representatives of graduate programs of various departments to help them understand the implications of the level of competence in English demonstrated by their foreign graduate students. In several departments our testing program was held in conjunction with a testing program for native speakers of English developed by faculty in the Writing Program. This collaboration has allowed members of both sections to develop an innovative educational program which includes workshop seminars for graduate students, classes geared to the specific needs of students in science and engineering, and special I.A.P. subjects. We have developed a sequence of nine subjects in English as a Foreign Language which meet the special requirements of M.I.T. students.

Faculty and Staff Activities at the Institute

The faculty and staff of Foreign Languages and Literatures served the Department and the Institute in a variety of ways. Professor Catherine Chvany chaired the Department's Special Topics Committee and Professor James Harris chaired the Department Personnel Committee. Members of the Section worked closely with the Writing Program; Professor Isabelle de Courtivron served on three faculty search committees for the Program, and Professor Margery Resnick on four. Professor Resnick is also a member of the Writing Program's advisory committee.

In the Institute at large, Senior Lecturer Claire Kramersch serves on the Humanities, Arts, and Social Sciences Requirement Committee, Professor Chvany on the I.A.P. Committee, Professor Jones on the Committee on Foreign Scholarships, and Lecturer Ilse Evans as Chair of the West Campus Working Group of the Institute Committee on Campus Dining. Instructor Margret Guillemín taught in the Experimental Study Group (E.S.G.) this year. Professor Resnick is Housemaster of McCormick Hall, and serves on the Search Committee for the Dean for Student Affairs, on the Ad Hoc Committee on Women's Admissions, as Chair of the Hispanic Cultural Committee, and as member-elect of the Committee on Educational Policy. Ten individuals from the Section are freshmen advisors, and five members of the Section worked on admissions. Professors de Courtivron and Edward Turk, as well as Ms. Kramersch, gave a number of lectures during the year to various groups at M.I.T.

Community Activities

Members of the Foreign Languages and Literatures Section have worked to establish productive relationships with the public school system in Massachusetts. Ms. Kramersch organized a German exchange with local high schools in which M.I.T. students visited high school German classes and then reciprocated by hosting classes at the Institute. In addition, Ms. Kramersch was awarded a grant which allowed her to conduct a "total immersion" project in German at M.I.T. this June. This project brought high school students and teachers from the state to an intensive German program housed in McCormick Hall. Ms. Evans conducted a workshop on the teaching of intermediate German which drew participants from the entire Boston area to M.I.T. Professor Chvany served as a judge in the State Olympiada of high school Russian. Professor Resnick organized a program of children's theatre in Spanish at M.I.T. which brought more than 800 elementary school children and teachers to the Institute.

In addition to activities involving the public schools, the Section sponsored a series of cultural events which attracted faculty at other universities and the greater Boston community. The French group's sponsorship of the Comédie Française at M.I.T. provided an opportunity for our students and the community to savor excellent French theatre. Under the leadership of Professor Turk the French group, in cooperation with the French Embassy, arranged for a Contemporary Film Festival at M.I.T. consisting of an exclusive showing of high quality works by French filmmakers not yet released for general distribution in the United States. In conjunction with the festival, the screenwriter and director Marie-Génévieve Ripeau came to campus; her week-long stay at McCormick Hall gave a number of students the opportunity to discuss her experiences with her. Another film festival, which was organized by Ms. Kramersch with the support of the Goethe Institute, was equally successful and brought to the Boston area works by German filmmakers which had never before been available in this country. As a member of the steering committee of the Mayor's Committee for Hispanic Theatre in Boston, Professor Resnick was able to arrange for several plays from Latin America to be given in Spanish at M.I.T. this fall. This theatrical activity was extended into the spring term when, with the support of the Spanish Embassy, several avant-garde Spanish plays of the post-Franco era were presented here. In addition, colloquia delivered by Professor Angel Rama, one of the leading literary critics of Latin America, and Professor Lucía Sala, a Uruguayan economist currently in exile in Mexico, attracted Hispanicists to the Institute. In Russian, lectures on a variety of literary and social themes by Professors Donald Fanger, Yuri Striedter, and Maurice Friedberg enriched the year for our students and colleagues.

Several members of the Section were elected to leadership roles in scholarly organizations this year. Professor Chvany is vice president of the American Association of Teachers of Slavic and Eastern European Languages and treasurer of the Massachusetts and Northern New England Chapter of AATSEEL. She is also on the Board of Directors of the American Council of Teachers of Russian. Professor Krystyna Pomorska serves on the National Endowment for the Humanities Committee to evaluate translation projects. Professor Martin Dyck was elected to the Delegate Assembly of the Modern Language Association. Ms. Kramersch is vice president and president-elect of the American Association of Teachers of German. Professor Resnick has been elected to the Board of Directors of the International Institute of Spain and has been named chair of the International Bibliographical Project of the Women's Studies Division of the Modern Language Association.

Scholarly Activities

A number of individuals in the Foreign Languages and Literatures Section were invited to deliver papers at national and international meetings during the year. Papers were given by Professor Alissandratos at the American Association for the Advancement of Slavic Studies, The Greater Boston Byzantine Fellowship, and the Pushkin Symposium; Instructor Patricia Chaput at the Bryn Mawr Symposium on Russian Syntax; Professor Chvany at the International Congress of Slavists, the American Association for the Advancement of Slavic Studies, and the American Association of Teachers of Slavic and Eastern European Languages; Professor de Courtivron at the Modern Languages Association, the National Conference on French Literature at the University of South Carolina, and the First National Women's Studies Conference; Professor Crecelius at the National Meeting of the Society for Women Engineers; Professor Dyck at the FILLM International Congress, the National History of Science Society, the Modern Language Association, and the Northeast Modern Language Association; Ms. Evans at the Methodology Workshop; Professor Frederick Hodgson at the North American Society for the Study of Seventeenth Century French Literature; Ms. Kramsch at the Massachusetts Foreign Language Association; Instructor Abelle Mason at the Massachusetts Association of Teachers of Other Languages; Professor Pomorska at the Pushkin Symposium; Professor Resnick at the Modern Language Association and the First National Women's Studies Conference; Professor Jay Rosellini at the American Association of Teachers of German and the Modern Language Association; Professor Turk at the North American Society for Seventeenth Century French Literature, the Third Annual Colloquium on Modern Literature, and the Northeast Modern Language Association. All of these talks gave visibility to the presence of a professional group of scholars in the field of foreign languages and literatures at M.I.T.

In addition, the faculty and staff of the Foreign Languages and Literatures Section were invited to speak at universities in this country and abroad. Professor James Harris delivered a two-week lecture series at the Universidad Central de Venezuela; Professor Pomorska lectured at the University of Tel Aviv; and Professor Resnick spoke at the National University of Mexico and the Instituto Allende in Mexico. In this country, talks were given by Professor Chvany at the University of Washington; Professor de Courtivron at Brown University; Ms. Kramsch at Tufts University, Boston College, and the Goethe Institute; and Professor Resnick at Colorado College, Williams College, and Yale University.

During this year members of the Section published widely in the fields of literature, linguistics, and language pedagogy. Literary studies which appeared included four books by members of the Section: Professor Pomorska's *Papers from the Symposium on the Structure of the Narrative Text*, a new edition of her *Readings in Russian Poetics*, and *Dialogues*, as well as Professor Turk's *Baroque Fiction-Making: A Study of Gomberville's "Polexandre."* In addition to book reviews and essays accepted for future publication, numerous articles by members of the Section appeared during the year. In the field of literature, the following articles underscore the variety of literary studies pursued by members of the Section: Professor Dyck's "Lessing and Mathematics" and "Schiller's Urballade"; Professor Crecelius' "Feminist Magazines: The View from Europe"; Professor de Courtivron's "Le Repos du Guerrier: Rochefort's Warrior Reconsidered," "The Sand Image: Weak Men and Fatal Women," "Rethinking Differences: an Interview with Helene Cixous," and "Violette Leduc's *L'Affamee*: the Courage to Displease"; Professor Frederick Hodgson's "Descartes"; Professor Jones' "Giraudoux: Electra et la Tragedie," and "Samuel Beckett: A Biography"; Professor Pomorska's "Bakhtin's Universe"; Professor Resnick's "El Mundo Poetico de Antonio Machado" and "Women Writers of Latin America"; Professor Turk's "Scarron's *Dom Japhet d'Armenie*: Metaphor, Burlesque and the Nature of Comic Language," "Nature and Women: Jean Renoir's *Une Partie de Campagne*," "Comedy and Psychoanalysis: The Verbal Component," and "Films and Dreams: Truffaut's *La Nuit Americaine*."

The linguists in our Section were equally active. The publication of Professor Chvany's "Denotative and Connotative Meaning of the Preterite and Perfect in Bulgarian and English" and "Adjusting and Justifying the A-over-A Principle," along with Professor Harris' "Some Observations on Substantive Principles in Natural Generative Phonology," "A Rejoinder to Vocalic Variations in Spanish Verbs," "Tendencias Actuales en Fonologia Generativa y Problemas Tradicionales en Fonologia Espanola," "Voiced Versus + Voice in Spanish Obstruents," and "Palatal Alternatives in Spanish" mark the continued scholarship of those whose primary field is linguistics.

In the field of language pedagogy, the several published articles included: Ms. Kramsch's "Word Watching: Learning Vocabulary Becomes a Hobby" and "Getting the Ball Rolling: A Functional Approach to Teaching Language Skills;" Professor Chvany's "For Independent Reading;" and Ms. Evans' "Bridging the Gap between Pattern Drills and Communication Exercises."

MARGERY RESNICK

HISTORY SECTION

In recognition of the developing interest in social history, and in the belief that the field appears destined to have a most significant impact on the study of American politics, the Section sponsored a series of informal history workshops to discuss aspects of these issues. Four distinguished lecturers spoke on their own work which, in each case, centered on the intersection of social and political history. Following their prepared remarks, the guest lecturers engaged in discussion with the audience. Invitations were extended to faculty and graduate students of Boston-area universities, and the response was encouraging.

Professor Gordon Wood of the Department of History, Brown University, inaugurated the series in February with a talk on "Ideas and Reality in Historical Explanation." He was followed in March by Lawrence Goodwyn, Associate Professor of History and Director of the Oral History Program, Duke University, whose topic was "Writing the History of Protest." Next came David Rothman, Professor of History, Columbia University, who spoke in April on "Reforming the Asylum: Public Policy Toward the Deviant, 1900-1940." The concluding speaker was J. Anthony Lukas, Pulitzer Prize winning correspondent for the *New York Times*, who examined "Past and Present in the Lives of Three Boston Families: the Busing Crisis in Perspective."

Another activity of the Section was a review of our course offerings. It resulted in a new system of subject groupings together with a renumbering of various courses. This, it is hoped, will prove useful to students in planning the courses which they will elect in our discipline.

As is customary, the Section members participated in a variety of activities connected with Institute life. Committees on which individuals served varied widely and included: the Abramowitz Lecture Committee; the Keyser Committee on the Restructuring of the Department of Humanities; the Kelly Fund; and the Pre-Law Advisory Council.

Another exercise in which several took part was the direction of undergraduate theses in Course XXI.

Professional honors and activities were numerous during the past year. Heading the list was the award of the Guggenheim Fellowship to Professor Cyril Stanley Smith. Professor Smith was also awarded an Honorary Doctor of Science by the University of Massachusetts at Boston. Professor Thomas H.D. Mahoney was chosen to be a project evaluator for the National Science Foundation, and Professor Pauline Maier served on the editorial board of *Reviews in American History* and was elected to the executive board of the Organization of American Historians. Professor Bruce Mazlish was asked to become chairman of a task force on "Ethical and Social Responsibilities in Political Psychology" by the International Society for Political Psychology. Professor Robert I. Rotberg was a panelist on the "Impact of CO₂ on the Environment" at the American Association for the Advancement of Science and chaired the nominating committee of the American Historical Association. Cyril Stanley Smith was the Wulff Lecturer at M.I.T.

Section members were invited to speak on their specialties or to give expert testimony at a number of other institutions of higher learning and government agencies or committees. *Inter alia*, these included: the University of California at Santa Cruz; the University of Colorado; the Congressional Committee on Banks and Corporations; the Department of State; Drew University; the Fogg Museum (Harvard University); the New School for Social Research;

the University of Massachusetts at Amherst; the University of Rochester; the Smithsonian Institution museums; the University of Southern California; and Central Washington University.

Staff publications, excluding the usual long list of book reviews, numbered the following: Robert E. MacMaster, "No Peace Without War: War and Peace as Cultural Criticism," *American Contributions to the VIIIth International Congress of Slavists*, September 1978; Pauline Maier, "Class, Law and Revolutionary Violence," *Reviews in American History*, March 1979; Bruce Mazlish, "Psychoanalytic Theory and History: Groups and Events," *The Annual of Psychoanalysis*, 1978; Harald A.T. Reiche, "The Language of Archaic Astronomy: a Clue to the Atlantis Mystery?" in Brecher and Morrison *The Origins of Science: the Astronomy of the Ancients*; Robert I. Rotberg (ed.), *The Mixing of Peoples* and "The New Namibia," *The Washington Quarterly*, Autumn 1978; and Cyril Stnaley Smith, "Structural Hierarchy in Science, Art and History," in J. Wechsler, ed., *On Aesthetics in Science*, and (with M. Kranzberg) "Materials in History and Society" in *Materials Science and Engineering* 1979.

The only member of the Section on leave this year was Professor David Ralston, who once again spent the year at the Naval War College, Newport, Rhode Island, where he taught military history.

The academic year just closed marks the completion of the terms of Professor Mazlish, a most valued colleague in the History Section, as Head of the Department of Humanities, and Professor Mahoney as Chairman of the History Section. Professor Maier has been appointed as Professor Mahoney's successor as Chairman of the Section. It is with great pleasure that I report that both Professor Mazlish and I will continue as active teaching members of the Section following the coming academic year.

THOMAS H.D. MAHONEY

LITERATURE SECTION

This year the Literature Section continued to advertise by the outside activities of its faculty the presence of a vigorous program of humanistic studies at the Institute. Most notably, Professor Barry Spacks' new book of poems, *Imagining a Unicorn*, was nominated for a Pulitzer Prize. Professor Albert Gurney's novel, *Entertaining Strangers*, was reprinted in paperback by Avon in this country and by Pelican books in England. In addition, Professor Gurney's television adaptation of John Cheever's "O Youth and Beauty" has been scheduled for fall production on public television and Professor Gurney has been appointed theatrical editor for *Decade*, a prestigious new monthly magazine. Professor Peter Donaldson's edited translation of the pre-Elizabethan Italian text, *A Description of England, 1556*, was published by the Royal Historical Society in its Camden Miscellany Series and Professor Donaldson has been elected a member of the Society itself -- one of the few non-Britons to receive this honor. Professor David Thorburn was one of four speakers, along with Bruno Bettelheim, Wayne Booth, and E.D. Hirsch, Jr., at a special congress on "The Literature Curriculum Under Fire" called at the University of Chicago by the Illinois Department of Education; along with S.M. Lipset, Kenneth Boulding, and Julian Bond, he is to be guest panelist at the annual Broadcaster's Television Conference this year. His edition of critical studies of John Updike's work will appear this fall. Professor Felicia Bonaparte, a visiting associate professor, published her book *The Triptych and the Cross* this winter with the New York University Press; Simon and Schuster has accepted her biography of Elizabeth Gaskell for publication in one year's time.

Professor Irene Tayler has been appointed editorial consultant for Oxford University Press's edition of Blake's illustrations for Young's *Night Thoughts*; she continues on the supervisory board of the English Institute, whose annual conference is the most prestigious of all those held in literary studies. An essay of hers on Blake has been selected for inclusion in the Norton Critical edition of Blake's work. Professor Stephen Tapscott was nominated for a junior staff fellowship at the Breadloaf Writer's Conference for summer 1979, and was awarded the prize for best essay of 1978 by *American Literature*. A new volume of his poetry,

Letter to an Immigrant, is scheduled for publication in spring 1980. Professor Alvin Kibel was appointed consultant to the National Endowment for the Humanities.

The M.I.T. Literature Workshop, which currently numbers 65 active members drawn from institutions of higher learning in the Boston-Cambridge area, continued through its third year of existence. Five meetings were held, at each of which a major scholar in the field of literary studies conducted a discussion of work-in-progress precirculated to the membership. There is no doubt that the Workshop fills a long-felt need for some kind of intellectual community in the area among scholars otherwise separated by their institutional affiliations, and plans are presently under way to approach public agencies and private foundations to seek funds for expanding its program.

A major achievement of the Section this year has been the institution of a three-tiered curriculum in literary studies, capping a four-year effort at curriculum revision. The three tiers of subjects are: 1) Introductory, focusing on major literary texts grouped in broad historical and generic sequences; 2) Intermediate, exploring literary forms and their relation to themes in greater depth; and 3) Seminars, restricted to students who have taken at least two previous subjects in literature. To an extent unusual in an undergraduate program, the curriculum lays emphasis on interdisciplinary approaches to literary texts and on theoretical, generic, and thematic subjects that range widely across geographical, linguistic, and historical boundaries. A feature of the new curriculum is the identification of subjects in the *Courses and Degree Programs* catalogue in a relatively permanent way by general categories and descriptions, to be supplemented each year by a special publication indicating in more detail how each instructor proposes adapting the general purpose of the subject to his or her particular scholarly or pedagogical interest. In this way, the curriculum will keep its overall shape in the catalogue from year to year, enabling the student to plan a career of literary studies for two or three years in advance.

ALVIN C. KIBEL

MUSIC SECTION

Enrollment in musical studies was high during the 1978-79 academic year; 1,338 students took academic courses and 510 participated in performing organizations. As in the previous year, the enrollment in theory and history was higher than in Introduction to Music, a Humanities Distribution subject, indicating a trend toward more concentrated musical studies. Next to Introduction to Music, the Elements of Music, a subject which teaches skills in musical literacy and perception, was the second most popular individual subject.

The Music Office organized 56 public performances and visiting lectures. Included among these were concerts of the diverse M.I.T. performing organizations (the Chamber Music Society, the Chorallaries, Choral Society, Concert and Jazz bands, Early Music Society, Gospel Choir, Logarithms, and Symphony Orchestra), the Thursday Noon Hour Concerts, and the Faculty and Guest Artist Series. Total estimated attendance at these concerts was between 25,000 and 30,000. A highlight of the Guest Artist Series was the Kontarsky piano duo, with the American premier of Stockhausen's *Mantra*; equally successful was the Beethoven String Quartet cycle presented by the Concord String Quartet.

The lecture series titled "Music and the Related Fields," sponsored through the Friends of Humanities fund, brought distinguished speakers to the campus from the US and abroad. The purpose of these lectures was to focus on the interdisciplinary nature of music as a form of communication.

The M.I.T. Symphony Orchestra, under the leadership of Professor David M. Epstein, continued its recording schedule with Korngold's *Schauspiel Overture* and Henry Brant's *Spatial Concerto*. The latter was also videotaped for future airing on public television. The M.I.T. Choral Society gave outstanding performances of Antonin Dvorak's rarely heard ballad-oratorio *Spectre's Bride* and Beethoven's *Missa Solemnis*.

Reporting on the activities of individual faculty members, Professor Epstein's book titled *Beyond Orpheus: Studies in Musical Structure* was published by the M.I.T. Press. He was invited to be a guest conductor by the American and Haifa symphony orchestras, and continued as Music Director of the Worcester Orchestra.

Professor Timothy Aarset published articles in the *Journal of the American Recorder Society*, gave a lecture on Renaissance choral practice at the National Conference of Choral Conductors, and made a recording of Desply's *Missa Fortuna Desperata* on the Desmar/Advent label. He also performed in or directed numerous concerts in the Boston area, including the Castle Hill Renaissance Dance and Music Week, and continued as Artist-in-Residence at Brandeis University.

Professor John Buttrick participated in the International Musician's Seminar in Cornwall, England, and gave recital tours in Switzerland, Germany, and Greece, as well as New England.

Professor John Harbison had two works premiered: His "Flower-Fed Buffaloes," commissioned by the New York State Bar Association, was presented at Sanders Theater by the Fromm Music Foundation, and his one-act opera *Full Moon in March*, based on a play by W.B. Yeats, was performed by the Musica Viva. Both premiers received high appraisal by Boston and New York critics. Another of Professor Harbison's operas, *A Winter's Tale*, based on the Shakespeare play, will be premiered in August by the Western Opera Theater, a division of the San Francisco Opera, in the War Memorial Auditorium of that city.

Professor Marcus Thompson gave recital tours throughout the US and won the distinction of being elected a board member of the newly formed organization, Chamber Music America.

Professor Barry Vercoe last summer introduced a successful seminar on computer and electronic music, concluding with a public concert of the works composed during the course. Currently he is engaged in organizing a similar project for this summer.

This writer has seen the publication of his monograph "Traditional and Individual Traits in the Songs of Three Hungarian-Americans" in *Selected Reports in Ethnomusicology*, the University of California Press, and has completed an assignment for the Harvard Encyclopedia of Ethnic Studies on "Ethnic Music in the US." The Erdely Duo has given concerts at several universities in New England and is continuing its recording schedule of violin-piano sonatas for Educo Records of California. Professor Erdely was also invited to participate on the panel of the National Endowment for the Arts in Washington, DC.

Among the lecturers, Edward Cohen's composition *Stone and Earth* was published by Mobart Publishing Company, New York, and received its premier with the M.I.T. Symphony Orchestra last fall. Dr. Mary Lewis read papers at the national meeting of the American Musicological Society and is invited to be an active participant in the Conference of Medieval and Renaissance Music at Kings College, Cambridge, England, this summer. John Oliver has continued as director of vocal music at the Berkshire Music Center at Tanglewood and conductor of the John Oliver Chorale and Tanglewood Festival Chorus; he also made his second record, *Twentieth-Century American Choral Music*, with the Tanglewood Festival Chorus, published by Deutsche Grammophon. Claudia Von Canon's book *Noon Clock* was published by Houghton Mifflin Company, and an article by her on Johann Strauss appeared in the *Journal of the Nineteenth Century*, published by the University of California.

STEPHEN ERDELY

THE WRITING PROGRAM

In 1978-79 the Writing Program established new relationships throughout the Institute and worked on building a curriculum which reflects the growing recognition that writing is an increasingly important part of the professional life of technically trained people. The Program continued to develop its three main areas of undergraduate teaching -- creative

writing, essay writing, and science and technical writing. It also began new programs of graduate teaching in engineering writing and business writing.

Several new people have joined the Writing Program. Emma Rothschild became Director of the Program, and Dr. Lee Warren was appointed lecturer in expository writing. Fanny Howe and other writers were part-time lecturers in creative writing, and Stephen Ault was a part-time lecturer in business writing. We have acquired an enormously generous Writing Program Advisory Committee, composed of Professor Anthony French of Physics, Jay Lucker Director of the Libraries, and Professor Margery Resnick of Foreign Languages and Literatures; Professor Elzbieta Chodakowska will become a member of this Committee in 1979-80.

Professor Robert Rathbone, former Acting Director of the Program, will be retiring this summer after 30 years of service to the Institute. We will miss him, but hope that the expansion of the program he founded in technical writing will continue to please him.

A number of books and articles by members of the Program appeared during the year and several others are in press. Professor James Paradis' book *T.H. Huxley: Man's Place in Nature* was published by the University of Nebraska Press. Professor Chodakowska's book *Rosa Luxemburg: Letters to Leo Jogiches* will be published this year by the MIT Press. Professor Rothschild is coauthor of *Science and Technology in the New Socio-Economic Context*, to be published by the Organization for Economic Cooperation and Development (OECD). Professor Rae Goodell contributed essays and reviews to *The Sciences*, *Interdisciplinary Science Reviews*, *Psychology Today*, and the *Washington Post*. Professor Thomas Postlewait's essay on Beckett's drama came out in *Twentieth Century Literature*. Lecturer Robin Becker's poems appeared in several publications, including the *Nantucket Review* and the *Real Paper*.

The research activities of Program members are diverse. Professor Chodakowska is traveling to Poland to continue research on a biography of Rosa Luxemburg and is revising her novel *Quicksand*. Professor Paradis is preparing an edition of T.H. Huxley's letters. Professor Goodell is beginning work on a new book about public understanding of science. Professor Postlewait is working on a book on modern drama. Lecturer Barbara Hartmann has completed a monograph on Hawthorne. Professor Patsy Cumming, who will be a research associate in 1979-80, has been on leave completing a new volume of poems. Professor Rothschild is revising a book about food exports and social change; she is also principal investigator in a research project, supported by the United Nations, to study disarmament and scientific and technical work.

Several members of the Program gave readings and talks. Professors Paradis and Postlewait presented papers at the Modern Language Association Conference, and Professor Paradis also spoke at the College Conference on Composition and Communication. Professor Goodell delivered papers and participated in panels at meetings of the Society for Social Studies of Science and the Word Guild, as well as at the University of California, Harvard University, and the National Science Foundation. Lecturer Becker read her poems at Wesleyan University, Lake Forest College, and elsewhere. Lecturer John Kirsch presented a paper to the International Technical Communication Conference in Washington, DC. Professor Rothschild presented papers at the International Seminar on Metropolitan Areas in Sao Paulo, Brazil, the Midwestern Conference on Food and Social Policy in Sioux City, Iowa, and at Wellesley College; she also participated in conferences in Karlsruhe, Paris, and Stockholm, as well as in meetings at the Council on Foreign Relations, the United States Senate, and other organizations in the United States.

Professor Paradis presented a series of seminars at the Brookhaven National Laboratory. Lecturer Ken Skier was a consultant to the Harvard Business School and to the New Jersey Department of Environmental Protection. Professor Rathbone presented seminars on technical communication in the Netherlands, Wales, and elsewhere. Lecturer Warren participated in an administrative skills seminar at Wellesley College. Professor Rothschild was invited to Sweden by the National Swedish Board for Technical Development, and was on leave for part of the second semester as a consultant to the Science Policy Division of OECD in Paris. During Professor Rothschild's absence Professor Resnick served as Acting Director of the Program.

The Program's undergraduate curriculum broadened in 1978-79, with increased emphasis on writing about subjects of social and technological concern. New subjects were introduced in

Essay Writing and in the the Scientific Essay. The Science Writing program continues to develop under Professor Goodell's leadership, and will be linked to the new program in Science Communication undertaken by Course XXV. Lecturer Kirsch and Professor Rathbone taught more than 1,000 undergraduates in the Cooperative Teaching Program with the School of Engineering.

The Writing Program also instituted a new program to teach writing to graduate students in the Department of Mechanical Engineering. This program, led by Professor Paradis, will be repeated next year, and versions will be offered by the Departments of Aeronautics and Astronautics and Ocean Engineering, and by the Technology and Policy Program. The School of Engineering and the Writing Program will also cooperate next year in a major expansion of this Engineering Writing Program to involve all engineering departments.

The other large new project of graduate instruction was the Business Communications Program initiated by the Sloan School and the Writing Program. Lecturer Ault and Professor Rothschild, with Professor Lester Thurow, initiated this program, which will provide instruction in communication to all S.M. students at Sloan. A new Writing Program faculty member will be appointed to the business program in 1979-80.

The Writing Program established new connections with many other groups at the Institute in 1978-79. It worked closely in its graduate teaching with members of the English for Foreign Students program in the Foreign Languages and Literatures Section. It also worked with faculty of the Program in Science, Technology, and Society. Members of that Program, as well as of the Foreign Languages and Literatures Section, will teach writing subjects next year. Writing Program staff members are also discussing future writing projects with faculty in the Departments of Physics, Chemistry, and Earth and Planetary Sciences in the School of Science.

The Writing Program continues, finally, to offer a wide variety of more general Institute activities. Susan Sontag, John McPhee, Elizabeth Hardwick, Stephen Jay Gould, and John Williams were among the speakers in the reading series organized by the Program. Lecturer Skier directed a Text Editor Center, in which Lecturer David Breakstone also participated. Professor Paradis and others presented several Institute seminars in technical communication. Members of the Program gave talks at the Institute about their own work, and Lecturer Becker gave poetry readings in a fraternity house and in the Department of Humanities. These activities seem certain to increase in 1979-80; it is through such projects, as well as through the undergraduate and graduate curriculum, that the Program hopes to establish the importance and excellence of writing at M.I.T.

EMMA ROTHSCHILD

CAMBRIDGE HUMANITIES SEMINAR

The Cambridge Humanities Seminar continues as a collaborative effort of universities in the Boston-Cambridge area to enrich and diversify their curriculum offerings in the humanities, while providing faculty participants with an opportunity for learning under peer-criticism. The Seminar meets biweekly, exploring an interdisciplinary topic through a series of pre-circulated papers written especially for Seminar discussion and ancillary readings of not more than 75 pages.

The topic chosen at the end of last year for this year's discussion was "Interpretation and Explanation in History, Science, and Literary or Artistic Studies," and began with a paper outlining Dilthey's classic presentation of interpretation and explanation as *alternative* modes of understanding. During the course of the year, the seminar explored the ways in which this alternation could harden into *opposition* (between, say, scientific explanation and literary exegesis) or dissolve into *identity* (as in certain forms of sociological inquiry). As part of this inquiry, the Seminar was forced to consider such issues as: 1) the relation between the different kinds of materials upon which interpretation, as distinct from explanation,

is practiced -- e.g., the relation between primitive societies and literary documents, both considered as "texts;" 2) the role of narrative, as distinct from exposition, in explanation; 3) the relation between adducing *reasons* in interpretation and adducing *causes* in explanation, and the extent to which participation in a given social institution would lead one to characterize a particular action either as reason-based or as the causal product of antecedent events. Although we have made significant progress this term, we believe that we have a subject that we are far from exhausting and are now prepared to engage it in greater depth next year.

This year marked the first year of full participation in the Seminar by five institutions -- M.I.T., Wellesley, Boston College, Boston University, and Brandeis. Following the lines of this year's discussions, we have made arrangements to include in next year's membership two new members -- a philosopher whose subject is the history of interpretative practices (from Brandeis) and an historian of science (from Boston College). We can further report an extension of our grant from the National Endowment for the Humanities for the purpose of publishing a typescript journal of the yearly proceedings of the Seminar, to be distributed to 500 institutions of higher learning throughout the country.

Four new subjects were generated out of this year's Seminar meetings. These will be listed in the catalogues of participating institutions and open to students on the basis of cross-registration. The subjects are: 1) "On Quality in Art," an exploration of attempts from Vasari to Gombrich at formalizing critical judgments of works of visual art; 2) "Literature and History in Europe after the Industrial Revolution," which explores two major historical events in modern times, the industrial revolution in England, and the Revolution of 1848 in France through a study of novels and historical materials; 3) "American Television: A Cultural History;" 4) "Style and Substance," a study of the relation between stylistic procedures and choice of subject matter in Western painting since the 13th century.

ALVIN C. KIBEL

COURSE XXI

The 1978-79 year brought some important changes for Course XXI, all of them good.

Numbers and Quality

For the second year running, the population of Humanities majors in all XXI programs registered a gain of better than 15 percent, moving to a total of 60, the highest figure since 1973-74. An additional 70 students -- mostly freshmen and sophomores -- have come in to discuss their active interest in Humanities majoring.

Revision of the Joint Major

After five years of planning, discussion, and consultation, there was positive action on a modified version of the scheme (proposed by Professors Louis Bucciarelli and Travis Merritt) for strengthening the joint degree programs, XXI-A and XXI-B,1. The new form of this major, to be called Option Two, differs from the original joint program in requiring a four-term core of studies which expressly addresses the relation between the humanities and science/engineering, and, by allowing the student greater flexibility in combining subjects from different fields, to form a coherent program.

Option Two will be administered by the Course XXI Office and the Department of Humanities with special assistance from faculty in the Program in Science, Technology, and Society (S.T.S.). Such matters as designation of academic subjects for the program's core offering and approval of students' individual programs will be handled by a supervisory committee

consisting of the Directors of Course XXI ex officio and two faculty members each from the Department of Humanities and S.T.S. For 1979-80 the members of this committee are: Professors Bucciarelli (XXI), Merritt (XXI), Peter Buck (S.T.S.), Martin Diskin (Humanities), James Paradis (Humanities), and Dean Donald L.M. Blackmer (S.T.S.). The full-year Reading Seminar in Humanities, Science, and Technology, which serves as the program's curricular center, will be led in 1979-80 by Professors Buck and Richard M. Douglas (Humanities).

Although Option Two was not approved by the Committee on Curricula (C.O.C.) and its availability made known to the Institute community until very late in the year, there has been a gratifying show of interest among undergraduates. It is anticipated that about a dozen will enter the major and participate in the Reading Seminar next fall.

The old form of the joint major will be retained, for the time being, as Option One of XXI-A and XXI-B,1, with the following modification: The Humanities Senior Seminar, formerly required of all joint majors, is replaced by a seventh elective subject in the humanities component of each student's program.

Degree Programs in Foreign Languages and Literatures

Also approved by the C.O.C. for 1979-80 is the addition, under the headings XXI-A, XXI-B,1, and XXI-B,2, of major programs in Foreign Languages and Literatures (French, German, Russian, and Spanish). The addition of these programs to the array of fields covered by XXI makes it possible to clarify a long overdue working distinction between the Literature major, whose central substance is literature originally written in English or read in English translation, and the Foreign Literature major, where all or most of the material is encountered in the original foreign language.

Since the announcement of these programs for next year, there has been a lively display of interest in them among students taking foreign language subjects.

Changes in Degree Requirements for Particular Fields

Literature. Starting in 1979-80, the senior thesis will no longer be a standard requirement for all Literature majors. Students who wish to undertake a thesis project will need approval from the Literature Curriculum Committee and the Course XXI Office. There are other minor changes, but details need not be given here.

Writing and Literature. Students in the joint (XXI-A and XXI-B,1) programs may substitute for the three-subject Literature component either three subjects from another humanistic field (such as music, visual arts, philosophy) or four subjects from history, anthropology, or a field of social science.

Requirements for the full (XXI-B,2) major remain, for the time, unchanged.

Social and Informational Events

Various series of luncheon meetings and presentations by individual faculty members, organized by the sections and also department-wide, were to differing degrees successful in effecting broader contact between students and faculty and in giving students a closer sense of identification with their disciplines. Attendance at these functions was, however, highly inconsistent. Better publicity would have helped.

The Department Open House in April was moved this year from the Hayden Courtyard in Building 14 to the Bush Room, 10-150. The change improved the event considerably, as we worked to make it a bit less of a party and more of a serious opportunity for students to gain information and acquaintance with faculty.

Department of Linguistics and Philosophy

The Commencement Day Breakfast, to which Department faculty, graduating seniors, and their guests were invited, was once again well-attended and appreciated.

Course XXI Degrees and Honors in 1979

Two undergraduates received the Course XXI degree in February 1979, and 12 received the degree in June. Of the total of 14, 12 were in the B,2 program (four in History, three in Literature, three in Music, one in Anthropology/Archaeology, and one in Writing), one was in XXI-A (Writing), and one was in XXI-B,1 (Music). Michael Gold, Mark Lehrer, and Walter Witryol were elected to Phi Beta Kappa. Leigh Slaughter won the Compton Award. The winners of the I. Austin Kelly III Prize Competition were Marjorie A. Beale, Class of 1982, and David T. Gallagher, Class of 1979.

Department of Linguistics and Philosophy

The Department began a major effort this year in curriculum innovation at the undergraduate level. Aided by the receipt of an important grant from the National Endowment for the Humanities for the next three years, Department faculty in linguistics and in philosophy, joined by members of the psychology faculty, have begun work toward the creation, integration, and development of a unified program in Language and Mind. The program will deal with the problem of how human knowledge is represented mentally, based upon recent research results in the three major disciplines. The end product will include a unified curriculum, including teaching materials and textbooks. The enterprise is under the direction of Professor Ned Block of the philosophy faculty.

In February 1979, the Center for Cognitive Science was established at M.I.T. Members of the Department are very closely associated with the Center (see the report of the Center elsewhere in this volume). Among the collaborative enterprises which were begun is the preparation of a curriculum guide in cognitive science which lists all subjects taught at the Institute relevant to this new branch of inquiry. The preparation of this guide is under the direction of the philosophy chairman, Professor Sylvain Bromberger. Very close interaction between the Department and the Center is expected over the next decade.

Two lecture series constituted an important part of the year's activities. Sponsored in part by a grant from the Franklin J. Matchette Foundation, the Department presented three lectures on human knowledge which were delivered by Professors Jeremy Bernstein of the Stevens Institute of Technology, Gerald Holton of Harvard University and M.I.T., and Harry Frankfurt of Yale University. The Department colloquium series included lectures by Professor Richard Patterson of Columbia University, Andreas Eshete of the University of Pennsylvania, and Calvin Normore of Princeton University.

As in previous years, the Department sponsored two separate lecture programs during I.A.P. One was entitled "What is Linguistics?" and consisted of a series of six lectures on a variety of topics, including linguistics and literature, the computer, reading, education, psychotherapy, and medicine. The second series was entitled "What is Philosophy?" and consisted of a series of eight lectures dealing with the philosophy of language and of psychology, with metaphysics, aesthetics, logic, political and moral philosophy, and theory of knowledge.

RESEARCH

Linguistics

Research in linguistics has continued along the same general lines as in previous years. As is to be expected considering the composition of the group, narrowly linguistic problems continue to predominate the work of the group with special attention being paid to broader cognitive and psychological implications of the results.

These implications are quite obvious in the work on syntax and semantics conducted by Professors Joan Bresnan, Noam Chomsky, and Kenneth Hale, where fundamental propositions of the field -- especially the central role of transformations -- have been subjected to searching criticism, and radically new departures have been explored. These new developments have also made possible new language processing models. Work on a particular implementation of one such model is now being carried out by Professor Bresnan in conjunction with Dr. Ronald Kaplan of the Xerox Palo Alto Research Center, who spent the fall of 1978 at M.I.T. as a fellow in cognitive science.

In areas outside of syntax and semantics, the major effort has been in four separate subjects. Professors Hale, Morris Halle, and Paul Kiparsky have been investigating the suprasegmental organization of the phonological string. It appears that a single organizational principle underlies such superficially disparate phenomena as syllable structure, stress assignment, and vowel and consonant harmony. An important contribution to these efforts is constituted by the dissertation on the phonology of Arabic and Hebrew completed in the spring of 1979 by John J. McCarthy III. During the academic year Professor Kiparsky completed a monograph on analogic changes in language and on the light that these changes shed on the proper formulation of linguistic theory. The presence as visiting scientists of Drs. Edwin Williams and Margaret Allen, who have done pioneering work in the area of morphology, has created great interest in this topic on the part of faculty and students. Two doctoral dissertations dealing with problems in this important area are now under way, and additional work is being planned by several members of the group.

Professors S. Jay Keyser and Wayne O'Neil are engaged in a phonological history of English, beginning with the earliest Old English documents and working through Middle English to early modern English of the late 17th century.

Philosophy

A wide variety of research topics has been explored by the philosophy faculty. Professor George Boolos has continued his research into the application of modal logic to proof theory. One project is the development of a semantics for the modal logic whose theorems represent the forms of sentences of formal theories that are always true, and he uses this semantics to show that the modal sentences that always represent truths always represent theorems, when the characteristic notion of modal logic is interpreted to mean 'provable and true.'

During her first year with the Department, Professor Judith DeCew worked on several papers, including one arguing that an interesting concept of conditional obligation cannot be expressed in standard versions of deontic logic augmented with counterfactual conditionals. Another new member of the Department, Professor Edwin McCann, worked on several articles, among them one contrasting Locke's and Kant's criticisms of the Cartesian notion of the self.

Professor Paul Horwich continued research on various topics in philosophy of science, in particular, the applicability of Bayesian methods in giving a unified rationale for various aspects of scientific methodology.

Professor Jerry Fodor has been preparing for publication a collection of essays on the philosophical foundations of cognitive psychology and also writing some of the essays that will appear in the volume. Professor Block has continued research in current theories of mind, including a project on conceptual change in children and scientists with some members of the Department of Psychology.

PERSONNEL

The Department, jointly with the Program in Science, Technology, and Society, has appointed Professor Thomas S. Kuhn as Professor of Philosophy and History of Science. Professor Kuhn has gained an international reputation through his writings on the history of science and through his views on the philosophical issues related to that history. He will teach at both the undergraduate and graduate levels. The presence of Professor Kuhn is expected to bring together

Department of Political Science

the Department's educational programs with those of several other Institute departments, and the faculty look forward to increased interdepartmental cooperation as a result of Professor Kuhn's association.

Professor Chomsky, while on sabbatical leave, spent the spring term at the Scuola Normale Superiore in Pisa, Italy, where he conducted a special seminar on grammatical theory. Also on sabbatical leave, Professor Judith Thomson continued work toward the completion of her book on rights.

Professor Richard Cartwright has accepted an appointment as Acting Head of the Department of Humanities for the academic year 1979-80.

The Department enjoyed the presence of a large number of visiting scholars from both the United States and abroad. They include the following Professors: Joseph Graham, from the State University of New York at Binghamton; Ray Jackendoff, Brandeis University; Per-Kristian Halvorsen, University of Oslo; Howard Lasnik, University of Connecticut at Storrs; Michael Lipton, Northeastern University; Graham McKay, The Australian National University; Rajendra Singh, University of Montreal; and Knut Taraldsen, University of Oslo. Professor Jackendoff delivered a series of three lectures entitled "Semantics and Cognition" in March 1979. These lectures were cosponsored with the Division for Study and Research in Education.

Awards

Professor Halle, the 1978-79 recipient of the James R. Killian, Jr. Faculty Achievement Award, delivered the two Killian lectures during the spring term under the title "Sound, Meter and Mind."

SAMUEL JAY KEYSER

Department of Political Science

For the Political Science Department, the most significant events of 1978-79 were some constructive administrative measures taken to adapt our graduate program to function better in a period of drastically changed and more difficult financing. The Graduate School has adopted a realistic tuition policy for students working on theses in absentia. The Office of the Dean of Humanities and Social Science made it possible for us to expand our fellowship offerings. And the Department adopted a regularized system for faculty leaves of absence. Other important developments were the resignation of Professor Wayne Cornelius and the appointments of Professor Emma Jackson, Instructor Donald Morrison, and Lecturer Steven Meyer. A serious unresolved problem is the misapplication by the US Department of Health, Education and Welfare of the review requirements for research on human subjects.

Undergraduate Program

The Public Policy Program, directed by Professor Deborah Stone and financed by a grant from the Sloan Foundation which terminates in 1979-80, continues to be a great success. The internship program made over 80 placements, a 20 percent increase over last year.

The Department's Independent Activities Period program included a well-attended series of lectures on Politics, Policy, and Crisis of Democracy.

Graduate Program

Last year's annual report noted that in a five-year period tuition and student living costs had risen by 40 percent, while financial aid had declined by 11 percent. A consequence we then reported was that of the top 10 students we had admitted only two came. This year, though, the problem of graduate student support is still our biggest one.

The Department is using funds saved from the income of its chair funds for graduate student support, and the Office of the Dean of Humanities and Social Science enabled us to grant additional fellowships, bringing funds available for incoming graduate students up 60 percent over last year. As a result, seven of the top 13 students admitted have accepted our offer.

Applications and placements both continue to reflect the high reputation of our Department and confirm our conviction that, despite financial pressures, we should try to maintain our graduate program at roughly present levels. Seven students from our graduate program took academic jobs during the past year. Others took jobs in government, think tanks, or private sector organizations. There is a growing trend which we encourage toward placements outside of universities. This reflects both a decline in recruitment of young faculty by universities, but also a growing recognition in the private sector that they have a need for well-trained political scientists.

Political research requires many of both our graduate students and faculty to be away in the field at any given time. What the laboratory is to some disciplines and the library to others, the field is for a political scientist. During the past year, Professor Myron Weiner was on leave in Israel for a term, Professor Lincoln Bloomfield in Geneva for a term, Professor Alan Altshuler in France for a term, Professor Ted Greenwood in Washington, DC in the Office of Science and Technology, Professor George Rathjens four days a week in Washington in the Arms Control and Disarmament Agency, and Professor Michael Lipsky in the Legal Services Institute in Jamaica Plain. Among our graduate students one was studying Chicano politics in the Southwest, another state science policy in Rhode Island, another in Japan studying local government there, another in Brazil studying opposition in a repressive state, and two in Germany studying arms control. This is as it should be. Our program benefits from the field experience of both students and faculty. But there are some problems.

In the past one problem was an inappropriate tuition system. We appreciate the action of the Graduate School in adopting a new set of rules which for the first time creates a recognized category of graduate students in absentia, with a modest and appropriate tuition fee.

A problem associated with the extensive activity of our faculty in the field is the occasional disruption of course offerings. A student may find that a course on which he was counting is not offered in a particular year. To meet this problem the Department this spring adopted a set of guidelines for leaves. It establishes a norm of being in residence at least eight out of 12 semesters, and requires each subfield within the Department to plan leave and course patterns two years in advance.

Leaves granted for the coming year include those to Professor Suzanne Berger in France under a Guggenheim Fellowship, Professor Bloomfield with the National Security Council for a year, Professor Lucian Pye for one term in Asia, and Professors Rathjens and Lipsky continuing their leaves begun this past year.

The Department, in the 13 years since we granted our first Ph.D., has developed a remarkably successful alumni cadre, including the head of the Social Science Division of RAND, the head of the International Studies Program of the Brookings Institution, professors at Harvard University, Yale University, the University of California at Berkeley, Santa Barbara, and San Diego, Columbia University, the University of Chicago, Northwestern University, Carnegie-Mellon University, California Institute of Technology, and many others. Other alumni are found in the Congress, in high office in the National Security Council, the Office of Management and Budget, the Congressional Budget Office, the Department of State, the Department of Defense, and the United Nations Secretariat. The Department recognizes that the time has come to organize that resource. We are now issuing an alumni bulletin to strengthen our ties with these alumni.

One of our alumni, Clark Abt, President of Abt Associates, has established an annual award of \$1,000 for the best paper by one of our students analyzing a domestic policy issue. A selection committee, including Professors Stone and Walter Dean Burnham, and David Mundel, an alumnus who is an Assistant Director of the Congressional Budget Office, is selecting the winning paper.

FACULTY

Publications

Books were published during the past year by seven members of the faculty including: Alan Altshuler (with James Womack and John Pucher), *The Urban Transportation System: Politics and Policy Innovation*; Nazli Choucri (co-editor and author), *Forecasting in International Relations*; Edwin Diamond, *Good News, Bad News*; Lloyd Etheredge, *A World of Men: Private Sources of American Foreign Policy*; Lucian Pye, editor and co-author (with Sidney Verba), *The Citizen and Politics*; Robert Rotberg, *Black Heart: Gore-Browne and the Politics of Multiracial Zambia*, and editor, *The Mixing of Peoples: Problems of Identity and Ethnicity* (with chapters by Myron Weiner, Daniel Lerner, and Ithiel Pool); and Myron Weiner, *Sons of the Soil: Migration and Ethnic Conflict in India*, and *India at the Polls: The Parliamentary Elections of 1977*.

Public Service

Professor Greenwood has just returned from full-time leave as a senior staff member of the US Office of Science and Technology Policy (OSTP) in the Executive Office of the President, and Professor Eugene Skolnikoff served as a senior consultant to the director of OSTP. Professor William Kaufmann was a consultant to the Secretary of Defense. Professors Weiner and William Griffith were consultants to the National Security Council. Professor Rathjens is working on the Soviet-American negotiations on arms control.

M.I.T. Activities

One of the significant developments of the past year has been the growth of interaction with other departments at the Institute. Dean Donald Blackmer has been working as Director of the Program in Science, Technology, and Society. Professor Skolnikoff is Director of the Center for International Studies. Professor Sapolsky is Deputy Director of the University Health Policy Consortium, and serves on the Whitaker College Council and the Administrative Board of the Medical Department. Professor Altshuler is active in the Center for Transportation Studies and is on its Steering Committee, as well as on the Faculty Executive Committee of the Joint Center for Urban Studies. Professor Pool has been directing an interdisciplinary Research Program on Communications Policy, which operates under five of M.I.T.'s interdepartmental laboratories and centers. Professor Berger has developed a new program in the comparative study of advanced industrial societies together with Professor Michael Piore of the Department of Economics and Professor Charles Sabel of the Program in Science, Technology, and Society. Four courses in the Department are jointly taught with faculty from the Department of Urban Studies and Planning, including the basic course in our Public Policy Program.

Professor Choucri has played an important role in the Technology Adaptation Program, both on its Executive Committee and in conducting research in Egypt. Her study, conducted with Professor Richard Eckaus of the Department of Economics, is on the economic roles of migrants from Egypt. Professor Pool is doing a study of rural communications in the same program. These research projects (supported by the US Agency for International Development) are conducted jointly with faculty members of the University of Cairo.

PERSONNEL

Two members of the Department were promoted during 1978-79: Professors Etheredge and Martha Weinberg to associate professor.

Professor Wayne Cornelius resigned from the Department to accept a chair at the University of California at San Diego, where he will also head a new institute on Mexican-American relations. M.I.T. has always had many students from Latin America who return in some cases

to important positions of leadership. Our Department also has a substantial number of students doing dissertations on Latin American subjects. For next year we are planning to make a temporary appointment; the Department is convinced of the need to maintain its work in this area.

During the past year the Department conducted several searches for open positions. Some were successful, some not. Dr. Emma Jackson of the faculty of the University of Indiana has been appointed assistant professor; her field is urban problems. For a new post for work on arms control, funded primarily by a Ford Foundation grant in the area, we have appointed Dr. Steven Meyer as lecturer in the Department as well as research associate in the Center for International Studies. Dr. Meyer did his dissertation on nuclear proliferation at the University of Michigan and is currently a postdoctoral fellow at Harvard University. For the position stressing research methods which was left vacant this past year by Douglas Hibbs' departure, we have appointed one of our present graduate students, Donald Morrison, as instructor. We were unable to find a candidate who met our requirements for a slot in the field of Science and Public Policy.

THE PROBLEM OF HUMAN SUBJECTS

The US Department of Health, Education and Welfare (HEW) requires that universities to which it makes grants establish review committees to assure that no untoward risks to human subjects will be incurred in research that it funds. The requirements for review, however, have been extended to the point where they are a major threat to social scientists. In the first place, the view was taken by HEW that it would not make grants to universities that did not apply the same review process to all research using human subjects, whether or not funded by HEW. In the second place any human interactions, even including conversational interviews, were construed as use of human subjects.

M.I.T.'s counsel has advised the Institute that there is no legal basis for HEW to extend its rules to research not funded by it. The second extension, that requiring prior review of speech (as in interviews), is clearly a prior restraint, violating the First Amendment.

There is, therefore, no obligation on M.I.T. or on students or faculty in most ordinary social research situations to submit to the review process. Members of our Department, when conducting unfunded research, rarely feel obliged to submit projects to the review committee, and in most cases as a matter of conscience would not do so.

However, projects that go through the Office of Sponsored Programs may be routinely sent to the Committee. Since the research is almost always harmless, the reasonable and liberal minded members of the committee approve it instantaneously, and so the temptation is for faculty or graduate students to acquiesce at the referral. Anything else may put their project at risk. Some members of the Department, however, refuse to process such proposals through the Committee, including the Acting Head, Professor Pool, who refuses to sign the forms, causing problems for his Department members.

There have been two particular cases. One project, funded by the Markle Foundation, involved interviews with television executives on program exports. A second study required talking to government officials about radio spectrum allocation. In both cases Professor Pool insisted that the project not be subjected to Committee review, and in both cases the Provost recognized the Constitutional force of his position, and agreed. These precedents, however, have not been codified into Institute rules; the issues, therefore, re-arise every time. The Department of Political Science considers it essential that Institute procedures be revised promptly to eliminate prior review of interview research that is not part of the decision process of the funding agency.

ITHIEL DE SOLA POOL

Department of Psychology

Over the past 12 months, the Department has continued on course with few major changes. Some of the highlights of the year's ventures are summarized in the following.

Graduate Program

At present, 26 students are being trained in our graduate program, 16 of them concentrating in the brain science aspects of the program. Two members of our graduate student group earned their Ph.D.s during the past year, bringing the number of graduates from our Department since its inception to 64.

We are happy to report that our pool of applicants (76) for admission to the graduate training program is up almost 50 percent compared to that of the previous year. As a partial consequence and because of the extraordinary quality of many of these applicants, we have admitted 11 students, which constitutes the largest entering class in over 10 years. Among these 11, no fewer than three will come with National Science Foundation predoctoral fellowships awarded to them on the basis of merit prior to our acceptance, and three more will come with pre-awarded fellowships from other sources. These statistics attest to the continued attraction and the viability of our training program.

RESEARCH

As in previous years, our research efforts continue to be well received, as attested by grant awards. In addition to the high level of extra-Institute support from grants to individuals, we have block grant support to the Department from the Eye Institute of the National Institutes of Health and the Spencer Foundation of Chicago. Recently, we have profited by a Sloan Foundation grant awarded to the Institute's Center for Cognitive Studies which includes several of our faculty and staff. A recent summary of research volume shows that despite only very limited increases of faculty (partial appointments) we have increased our support by an average of 22 percent per year over the last four years (currently at approximately \$2 million per annum).

The significance of this figure must be assessed against the background of relatively small increases in Federal support for research and increasing competition for that support. We are proud of this record and recognize that our basic strength stems from it. So do some of our problems. In attempting to maintain the momentum of research, we are increasingly constrained by space limitations imposed on us by the size and location of our present facilities. We currently occupy Building E10 and part of the first floor of adjacent E20, an additional part of which the administration has generously agreed to refurbish. New space for research in adjacent buildings is either scarce or non-existent at this time, in part because of the demolition required for the new Health Services and Whitaker College building construction. Moreover, the special problem of maintaining animals puts further limitations on spaces which may be used. Recognizing our needs, the administration quite recently has offered us space on the sixth floor of the Whitaker College quarters which, when available, could relieve our overcrowding.

In the absence of space constraints, we could maintain our growth rate in research volume. With a few new young faculty and research staff -- desirable on other accounts -- we could easily increase this volume.

TEACHING

Our introductory course 9.00 (Introduction to Behavioral and Brain Science), in a return to the single-instructor format which formerly was run with such renown by Luke Teuber, was taken over with considerable success by Professor Stephan Chorover. We anticipate that a good part of the Institute's undergraduate population will remain interested in this offering. Professor Chorover also added a welcome freshman seminar to our list of courses.

Other new teaching ventures include a course by Professor David Marr on Current Topics in Computer Vision Research, jointly taught with Dr. Shimon Ullman and others from the Artificial Intelligence Laboratory; Nature, Nurture and the Individual Brain, a course taught by Professors Peter Schiller and Gerald Schneider and joined, for specific lectures, by Professor Norman Geschwind.

The number of Undergraduate Research Opportunities Program (UROP) students over the past year has remained pretty much the same as in previous years. We had three students enrolled in 9 U.R. Undergraduate Research during the fall term and count four students during the current term.

Psychology continues to attract undergraduates to its field as a topic for concentration within the Humanities at M.I.T.: 143 seniors have completed their concentration in psychology, while another 49 undergraduates are still registered as "in progress."

PERSONNEL

Postdoctoral Researchers and Visitors

In addition to graduate students, we attract many more postdoctoral candidates than we can admit. Fifteen postdoctoral fellows are currently associated with our departmental laboratories. Eight of this group have come from six different foreign countries. It is well known that such young and eager postdoctoral scientists make up one of the most active cadres of researchers in academic laboratories. Our inability to house more of these postdoctoral researchers is a source of frustration.

To the postdoctoral trainees we should add the professional visitors who come to us for periods ranging up to a year and more. Some come as visiting professors either on leave or sabbatical. Others, particularly our foreign colleagues, come for a period of renewed training in disciplines in which we excel relative to our foreign counterparts. These visitors frequently add a new dimension to the Department and are greatly valued for their contributions. Space constraints again restrict our opportunities to both give and receive from such visits.

New Appointments and Promotions

The academic year 1978-79 saw the arrival of two new faculty members. Associate Professor Daniel Osherson, from the University of Pennsylvania, carries a joint appointment between our department and the Division for Study and Research in Education, and will lend support to the cognitive-developmental part of our program. Professor Geschwind, James Jackson Putnam Professor of Neurology at the Harvard Medical School, joined both the Department of Psychology and Whitaker College on a part-time basis while maintaining his association with his home department at Harvard Medical School. We welcome his efforts on behalf of our offerings in neuro-psychology.

We are pleased to be able to report the promotion of Professor Merrill Garrett to full professor. Dr. Suzanne Corkin, previously our only lecturer, moved to the position of principal research scientist, within the newly established hierarchy of research appointments. We expect to make at least one more of these appointments in the future.

Service and Honors

In addition to their regular research and teaching activities, 13 of our faculty and staff served on more than 20 advisory councils and committees for either Federal or private support of our science. Nine of these faculty members served on 17 editorial boards of professional journals. Our faculty and staff delivered more than 100 addresses and invited lectures to outside organizations, many of these abroad.

Highlights among these occasions were Professor Walle Nauta's Grass Visiting Lectureship at the University of Newfoundland and his Distinguished Scientist Lecture Series at Tulane University; Professor Emilio Bizzi's First Alden Spencer Award from Columbia University; Dr. Marr's Computers and Thought Award for 1979; Professor Richard Held's Glenn A. Fry Award from the American Optometric Foundation; and Professor Geschwind's honors as Honorary Fellow of the Royal Belgian Academy of Medicine and Honorary Member of the Brazilian Academy of Neurology, among others.

As in previous years, we continue to enjoy close collaboration with many other Institute endeavors. Prominent among these are the Center for Cognitive Science; the Department of Linguistics and Philosophy; the Division of Health Sciences and Technology in the Whitaker College; the Division for Study and Research in Education; the Artificial Intelligence Laboratory; the Man-Vehicle Laboratory of the Department of Aeronautics and Astronautics; the Clinical Research Center; the Laboratory for Neuroendocrine Regulation; and the Technology and Human Rehabilitation Engineering Center.

To a considerable extent our personnel serve an Institute-wide function in many endeavors in which the behavior of humans and the functioning of the brain are the foci of scientific and technological interest.

RICHARD HELD

Sloan School of Management

The Sloan School historically has been engaged in three major activities: 1) research, largely sponsored, in virtually every field of management taught at Sloan; 2) the education of undergraduates but to a larger extent of Master's candidates and business executives all seeking to become first-rate management professionals; and 3) the education of doctoral candidates who become the educators of the next generation of management professionals and the researchers of tomorrow.

Through the quality education of management professionals we see the maximum opportunity for impact on the quality and practice of management in this country and in others. The Master's programs and the executive development programs are the principal vehicles whereby this central purpose is furthered, but we believe that it is possible to accomplish this successfully only in the presence of the other two major activities of the School -- serious research and the training of Ph.D. candidates. These latter activities are critical in helping to attract and retain outstanding faculty and staff.

The Sloan School now possesses in substantial degree the appropriate mix of faculty skills and attitudes to prepare professionals in ways that are especially effective. The consensus of the Sloan faculty is to retain our high quality and to build uniqueness which can trade on our small size and faculty strength in research.

The following sections report on the Sloan School's programs in teaching and research during the past year and on the broad array of related professional activities in which the School's faculty and staff have engaged during the past year. Those activities continue to reflect the exceptionally high national and international rankings of the School's programs and its reputation for breadth and quality in research.

Over the years, however, a number of other management schools have essentially been able to build new or build upon older established Master's programs which are of high quality. The Sloan School's uniqueness in the future can be re-established by capitalizing on our size and strengths. We can move education toward more student involvement in research and professional experience. We can build student skills as well as knowledge through practice and through some strengthening of the students' writing and speaking abilities. We can build these student skills through more exposure to practicing managers. We can build -- on the basis of knowledge which is now strong -- more confidence and effectiveness in practice and thereby try to combine the strengths of both knowledge and practice in our graduates.

In order to do this, we will need to make several modest changes which taken together can provide the basis for continuing evolution of strong programs and exciting research activities. We will need to increase research relative to teaching. We will need to build more efficient teaching facilities. We will need to add support staff to facilitate some of the projects in which our faculty and students will engage and the professional contacts these will require. We will need to increase the School's visibility through improved alumni and corporate relations. And we will need to increase the School's cash flow to finance all of the above.

Toward this end the School has developed a plan during the past year which has as its objective building of uniqueness in the School's major programs, the strengthening of research in the School, and the enhancement of visibility and impact of the School's programs and research. The requirements will include some more faculty, some more students, particularly in the senior executive and Master's programs, better facilities, more money, better connections, and stronger support organization for all of these teaching and research activities.

There is no question that the activities of the past have provided us with an extraordinarily sound basis for such extension onto a level of opportunity for continued and extraordinary success in the next decade. It is vital that we carry forward these plans since the problems of management in private and public organizations continue as a matter of major concern in all countries of the world. The School's strengths are a major resource in helping the practicing professional manager deal more effectively with these enormously complex challenges of our era.

TEACHING PROGRAMS

Undergraduate Program

The level of undergraduate enrollment in Course XV, including students who are pursuing double bachelor's degrees with other departments, remained high this year. This enrollment, taken together with the increasing number of M.I.T. students from other departments who are electing Sloan School subjects, reflects a growing recognition of the need for managerial skills in diverse professional careers.

Since the details of the curricula of our four undergraduate program options had not been reviewed for some years, a review was begun this past year. Some minor modifications were effected during the year and the implementation of more substantial changes should complete the program review and revision during the next year.

A major and welcome development was the formation of a student-faculty advisory committee. The committee has put on its agenda (among other issues) the matter of improvement in the generation of undergraduate placement opportunities and in the general visibility of Course XV inside and outside the Institute.

Senior Lecturer Stanley M. Jacks continued to chair the program with the assistance of Professor Jeffrey A. Meldman, who will become chairman of the program advisory committee next year. Esther Merrill continued to serve as program coordinator. Mr. Jacks, Professor Meldman, and Ms. Merrill also served as undergraduate advisors, together with Professors Thomas J. Allen, Arnold I. Barnett, Stephen C. Graves, and Gilbert W. Low. Professor Hoo-min Toong served as the Sloan School's coordinator in the Institute's Undergraduate Research Opportunities Program.

Master's Programs

The Master's programs in the Sloan School which the School has begun to reshape and revise during the past two years have given evidence of the effect of such past added attention. All of the typical measures used to describe such programs show continued improvements. Our applications were up over 20 percent from the preceding year to a high of 1,454. The number of applications from women increased by 24 percent to a total of 315, or 22 percent of all those received. As a result of some efforts on the School's part, we experienced an increase of 38 percent in the number of minority applicants. From the 77 minority applicants we accepted 28, and of these, 16 have indicated that they will be enrolling in September. This increase is very gratifying in light of the continuing difficulty experienced by other schools in their minority recruitment.

There have been similar improvements in the very high demand for Sloan School graduates experienced by our Placement Office, and the evaluation of the substantive content of the School's program by our own students and by outside evaluators continues to remain high.

However, it is important to recognize that we are benefiting from a nationwide swing to management education. All business schools are experiencing an unprecedented demand from applicants and from recruiters. The nation's demographics project decreasing numbers of younger people. The large increase in numbers of business schools and, more importantly, the actions of our principal competitors, suggest that we cannot stand still if we wish to remain among the leaders in graduate management education.

The Sloan faculty have recognized this, and the Master's Programs Committee is engaged in a further re-examination of what we teach and how we teach it. We should examine ourselves and make changes while we are in a position of strength. Although this renewed effort is just under way, there are some tentative conclusions drawn from our early considerations:

- 1) Learning from the informal is important. Adequate physical facilities are essential to allow the faculty and students to learn out of the classroom as well as in it. Initial steps were taken earlier in the year to plan the improvement of some of our currently inadequate facilities. Continuation of the corrective action should begin to have some noticeable impact on the Master's programs by the fall of 1980.
- 2) Learning by doing should be expanded. The committee feels that it is also important for the Master's students to be involved in using some of the tools, techniques, and theories they learn in the classroom. More research projects going on in the School on which the Master's students could work would be one excellent way of implementing this. The School's level of research has been increasing over the last few years, and we expect this emphasis to continue.
- 3) Development of new material for the next decade is needed. The faculty are continually involved in modifying the content of our subjects. The Master's Programs Committee feels that there is a need to invest even more effort in this activity, however, to permit us to update the content of some of our subjects to serve more adequately the decade ahead.

With these changes, which have been under way this year and which will continue through next year, we should be able to continue to provide outstanding and effective Master's programs in competition with the leading management schools of the country.

The following data highlight some of the major characteristics of the classes of 1979 and 1980, broken down by our two-year program (the Sloan Master's Program) and the Accelerated Master's Program (the AMP).

<u>Characteristic</u>	<u>AMP</u>		<u>SMP</u>	
	<u>1979</u>	<u>1980</u>	<u>1979</u>	<u>1980</u>
Sex: Female/Male	9/31	10/34	28/86	19/78
Age: Median /Range	29/22-38	27/22-36	24/19-48	25/21-37
Percent with Full-Time Work Experience	100%	100%	70%	71%
From: Countries/States	4/9	9/15	20/22	13/18
Mean Undergraduate Grade Point Average*	4.2	4.2	4.2	4.2
Median Admission Test Score**	635	618	600	616

Preliminary placement information on 1979 graduating Master's candidates indicates a continued strong demand this year and reflects Sloan's continuing predominance in the market for Master's programs graduates. The mean starting salary in 1979 for Master's candidates will increase 20 percent from \$23,800 in 1978 to an estimated \$28,700. Over a period of three years the mean starting salary for Sloan Master's students has increased 43 percent.

* On 5.0 scale (excluding some foreign students).

** National average is approximately 460.

Activity in the Sloan Placement Office has expanded to help match jobs and candidates: on-campus recruiting grew by 15 percent; subscription to the Sloan Resume Book by 13 percent; and interviewing of first-year students for summer jobs increased 61 percent in terms of number of interviews and 138 percent in terms of the number of organizations recruiting.

A number of changes in staffing, facilities, and services offered helped improve the quality as well as the extent of the placement services. The office moved to a larger space which provided much needed room for increased client (student and recruiter) use. Paula Budlong Cronin (Class of 1977) joined the staff as Associate Director of Placement. The combination of Ms. Cronin, working full time on placement, and Pamela Walker Turner, Director, working half time on placement, provided the professional capacity necessary to improve and add to our placement services.

The Placement Office also has extended its career counseling activities, computerized its data base, and has developed new listings of Sloan alumni by industry, region, and company -- all as part of an effort to improve access for graduating students and alumni to placement contacts.

During the year, the number of organizations recruiting on campus increased about 15 percent from 140 organizations in 1977-78 to 162 organizations reserving recruiting dates in 1978-79. The ratio of organizations recruiting on campus to students interviewing is about 1.0, with 145 students this year actively seeking employment. During 1978-79 the Sloan Placement Office arranged 290 interview schedules for 2,907 individual interviews.

To some extent the small size of the graduating class constrains the quality of the placement process. Despite the strong demand for Sloan graduates, some students are limited in their exploration of individual areas of interest. Similarly, despite the existence of qualified candidates at Sloan, some organizations cannot justify campus visits to interview these students.

In an effort to make the current placement process as effective as possible, efforts have been made to complement on-campus recruiting with opportunities generated through correspondence and the preparation and distribution of a Sloan Resume Book. In 1977-78 the Placement Office received over 500 job descriptions by correspondence (about the same as last year). Subscription to the Sloan Resume Book increased this year about 13 percent, from 174 organizations ordering 191 books in 1977-78 to 196 organizations ordering 215 books in 1978-79.

Associate Dean Michael S. Scott Morton has continued to serve as chairman of the Master's Programs Committee and to give leadership to the Committee's efforts at strengthening our Master's programs. Ms. Turner continued to serve as Manager of the Accelerated Master's Program in addition to fulfilling her duties as Director of Recruitment and Placement and working with Dean Scott Morton on the Sloan Master's Program. As noted, Ms. Cronin, a 1977 graduate of the program, joined the Placement Office as Associate Director. Miriam Sherburne served once again as Program Director and was assisted in these tasks by Harriet Barnett, Master's Programs Coordinator.

The Ph.D. Program

The Sloan School's doctoral program seeks to prepare men and women for academic and related types of careers requiring advanced research and analytical capabilities. Emphasis is placed on students' acquiring a solid grasp of relevant social science disciplines as a foundation for pursuing scholarly research on important issues in applied and functional areas of management. The program plays a special role in the intellectual life of the School in that doctoral students are a vital resource for the faculty's research commitments and activities. The growth of enrollment in collegiate management schools here and abroad has created a very strong demand for Ph.D.s to staff the faculties of these institutions, and the Sloan School's doctoral program enjoys an excellent international reputation as evidenced by several recent studies.

In the 1978-79 academic year, 17 Ph.D.s were granted in Management; 14 members of this group immediately took up positions in academic institutions. The major fields of these graduates were distributed as follows: Applied Economics, 2; Finance, 3; International Management, 2; Management Information Systems, 2; Management Science/Operations Management, 1; Management of Technological Innovation, 1; Marketing, 2; Organization Studies, 2; and Systems Dynamics, 2.

The program experienced another successful year in attracting a highly qualified group of new students. A total of 162 applications were received from people desiring to begin doctoral studies

in the fall of 1979. The number of applicants has been running at approximately 160 per year for the past three years, down somewhat from the level of 200 experienced in the early 1970s. Historically, the Doctoral Program Committee has aimed for an incoming class of roughly 20 students and admission standards are accordingly selective. Admission was offered to 35 of the 162 applicants and 18 of the 35 admitted formally entered the program in September, including 4 women and 8 foreign citizens. This favorable yield was particularly gratifying in light of the keen competition that exists among major management schools for prospective doctoral students with strong scholastic backgrounds.

The Doctoral Program Committee, chaired by Professor Alvin J. Silk, undertook a careful review of the program's formal requirements and procedures during the past year. Some modifications in previous policies were recommended and approved by the faculty, but the overall design continues to be guided by the philosophy that professional excellence is best encouraged through the creation of rigorous individualized courses of study within a flexible program structure. Progress was also made in increasing the level of funding available for financial aid to doctoral students. Compared with other leading management schools, the Sloan School's program has less fellowship aid available to offer students and relies more on teaching and research assistantships as sources of support. While such involvement has certain educational advantages, this arrangement places a heavy burden on students in the early stages of their programs when they are faced with demanding subject loads and examination schedules. The effect is frequently to extend the time taken to complete requirements for the degree, the median figure in recent years being four years. To deal with these circumstances, the School has committed additional funds to the program allowing more attractive offers of financial aid to be made and thereby strengthening the program's position in competing with other leading business schools for outstanding doctoral prospects. Dean Peter P. Gil has been active in developing further sources of support. These efforts in combination with the Sloan School's growing level of sponsored research bode well for assuring the program's continuing success.

Alfred P. Sloan Fellows Program

On June 4, 1979, 54 Alfred P. Sloan Fellows were awarded the degree of Master of Science in Management. The class of 1979 reflected a broad diversity of backgrounds and interests, and again was drawn from organizations from the United States and abroad. A comparison of the class of 1978-79 with previous classes follows:

	<u>1973-74</u>	<u>1974-75</u>	<u>1975-76</u>	<u>1976-77</u>	<u>1977-78</u>	<u>1978-79</u>
Industry						
US	26	29	21	25	26	31
Foreign	13	5	11	11	14	8
Government						
US	7	11	11	8	8	5
Foreign	2	1	1	1	1	2
Other						
World Bank	0	0	0	1	0	0
Municipal Management	0	1	1	1	0	0
Medical Management	1	0	6	6	2	6
Church Management	1	1	0	0	0	0
University Management (US)	<u>0</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>0</u>	<u>2</u>
	50	51	53	54	55	54

The demand for the program continues to be strong and the quality of nominations is extremely high. On June 15, 1979, the Class of 1980 arrived; it is the largest (56) in the history of the program.

During 1978-79, a new Alfred P. Sloan Fellows Professor, Edgar H. Schein, was named. Over the years, Professor Schein has made a number of important contributions to the program. He teaches the Sloan Fellows the fall term subject in Organizational Psychology, serves on the Program Committee, and is the thesis advisor for a number of Sloan Fellows each year.

Also during 1978-79, Professor Eli Shapiro became the new Faculty Chairman for the Sloan Fellows Committee. Professor Shapiro will work closely with the new Director of the Sloan Fellows Program, Alan F. White. Mr. White is an alumnus of the program (Class of 1971).

The program continues to be widely respected as one of the best executive education programs in the world.

Health Management Executive Development Program

The fourth year of operations was completed by the Health Management Executive Development Program as an integral part of the Alfred P. Sloan Fellows Program. The number of Fellows from the medical field was six: Robert M. Amick, Chief of Staff, Veterans Administration Hospital, Boston; Judith H. Carey, Senior Research Associate, Boston University Health Policy Institute, Boston; Martin H. Flax, Professor and Chairman, Department of Pathology, Tufts University School of Medicine, Boston; David R. Kaloupek, Vice President for Planning and Development, Cooper Medical Center, Camden, New Jersey; Stanley J. Pappelbaum, President, Pediatric Cardiology Medical Group, Inc., San Diego, California; and J. Thomas Parmeter, Director of Curriculum Implementation and Associate Professor of Medical Education, College of Human Medicine, Michigan State University, East Lansing, Michigan. The interest of such professionals in the Sloan Fellows Program continues to grow. The program is co-directed by Professor Edward B. Roberts and Mr. White.

M.I.T. Program for Senior Executives

1979 marked the 23rd year of the M.I.T. Program for Senior Executives. There are now over 1,000 alumni who occupy positions of leadership in many companies and organizations around the world. Demand for the 30 places in the program continues to be very strong; for the past few years this demand appears to have been unaffected by the economic slowdown. Approximately one-fourth of the participants in each of the two nine-week programs offered came from abroad.

Professor Eli Shapiro served as chairman of the program's faculty committee, and Mr. White continued as the Program Director.

Greater Boston Executive Program (G.B.E.P.)

The 22nd session of the Greater Boston Executive Program was held from January 19 to May 4, 1979. Once again the attempt to limit the number of participants to 15 was unsuccessful due to the quality and quantity of those who were nominated. There were 19 participants and their evaluation of the program upon completion indicated the most enthusiastic endorsement of the program to date.

Given the increasing amount of concern about M.I.T.'s contribution to high-technology based companies, a new and different approach will be taken to recruit more participants with technological background and responsibilities. Professions such as medicine and law are already represented in the program.

The alumni reunion on May 1 brought out the largest number of returning alumni in the program's history. Participants met with Professors William F. Bottiglia and Henry D. Jacoby (for a short session before dinner) and participated in an informal discussion after dinner with former Governor Michael Dukakis. James Gabbert is now providing very effective coordination of the program.

Summer Programs

Sloan School faculty and staff participated in 12 of the regular Special Summer Session Programs offered by M.I.T. Ten of these were on subjects covered in summer sessions of previous years and followed the same formats, although materials presented invariably incorporated the latest developments in the particular fields.

The 10 repeats were -- Corporate and Economic Policy: The Systems Dynamic Approach (Professor Jay W. Forrester); Mini-Micro Computer Systems: A Close Look at Minicomputers/Microcomputers and Their Applications to Real World Problems (Professor Toong); Management of Research, Development and Technology-Based Innovation (Professor Roberts); Management Control Systems (Lecturer J. Morrison McInnes); Strategic Planning Systems (Professor Peter Lorange); Modern Concepts in Financial Management and Strategy, and, Models for Financial Management and Long-Range Financial Planning (Professors Stewart C. Myers and Richard Cohn); Computer-Based Information Systems Technology -- Database Systems, Telecommunications, and Performance Evaluation (Professors John J. Donovan and Stuart E. Madnick); The Dynamics of Health Service Systems: Strategic Planning for Complex Health Organizations (Professor Roberts); and New Horizons in the Management of Change and Organizational Development (Professor Schein and Richard Beckhard).

Professor Robert M. Alloway offered a new three-day session on Project Design for EDP Applications. This program was designed for managers of systems development departments and project managers. The purpose of the Program was to cover recent advances in project design, build an in-depth understanding of useful managerial techniques, and discuss the implications for improved practice in participants' firms.

Professor Jeremy F. Shapiro of the Sloan School and Professor Richard C. Larson of the Department of Electrical Engineering and Computer Science, Co-Directors of the Operations Research Center, presented a two-week program on Recent Advances in Public Sector Operations Research. Professor Shapiro directed the first week which was devoted to Energy and Transportation. Professor Larson handled the second week which dealt with Urban Systems, Health, and Criminal Justice. Professor Thomas L. Magnanti also participated in the lectures.

In addition, the Center for Information Systems Research (C.I.S.R.) held its third annual seminar, Current Issues in Information Systems: A Managerial Perspective. Lectures were presented by Senior Lecturer John F. Rockart, Director of the Center; Professors Alloway, Donovan, Madnick, Meldman, Toong, Peter Chen, Michael D. Zisman, and Associate Dean Scott Morton.

The Marketing Group of the School, under the direction of Professor Gary L. Lilien, conducted a three-day symposium, Industrial Marketing: State of the Art and Outlook for the Future. Assisting Professor Lilien were Professors Barnett, John D.C. Little, Glen L. Urban, Manohar Kalwani, Alvin J. Silk, and Eric A. von Hippel.

Professor J.D. Nyhart, holding dual appointments in the Sloan School and the Department of Ocean Engineering, again joined Professor R.R. Baxter of Harvard Law School in directing the fifth eight-day seminar on Legal and Policy Aspects of Ocean Resources Management. As in the past, this seminar was held under the joint auspices of M.I.T. and Harvard Law School.

Industrial Liaison Symposia and Seminars

Sloan School faculty again participated in two seminars and one symposium sponsored by the M.I.T. Industrial Liaison Program. In October, Professor Lorange conducted a morning seminar in Minneapolis entitled Strategic Planning Systems -- Recent Advances. In December Professor Jeremy Shapiro went to New York City to conduct an afternoon seminar on Strategic Planning Models.

The Systems Dynamics Group of the School held an all-day symposium in Kresge Auditorium in March entitled The System Dynamics National Model. Professor Forrester chaired the session; other speakers were Professors Low, Peter N. Senge, Nathaniel J. Mass, and Alan K. Graham.

As has been true in past years, these summer and liaison programs, although designed to give specific post-experience training to professional managers, have continued to serve as the basis for substantial improvement in the quality and teaching of the School's larger residential and degree programs by serving as "proving ground" for curriculum innovation and redesign.

RESEARCH

The research interests of the School's faculty, staff, and students are extensive. The volume of sponsored research support at the Sloan School is substantially larger than at most of the major management schools in the country. These research interests are also diverse and changing.

This section summarizes the major research efforts and accomplishments of the School. This work is both disciplinary and multidisciplinary in character and the groupings below are necessarily arbitrary and may not always reflect the cross-disciplinary and cross-functional mix entailed in both the design and execution of the research described.

Human Factors in Management

The faculty in the organization studies area and in the employment and industrial relations area take as their primary research focus the human issues involved in the management of an organization or in the relation of organizations to one another and to the economic, social, political, and environmental contexts within which they function. The social and behavioral sciences of psychology, sociology, economics, and so on are the disciplinary bases upon which much of the research here builds.

Organization Studies. Several members of the faculty are continuing to focus on the problems of adult socialization, career development, and the interaction of work, self, and family issues throughout the lifecycle of men and women in different occupations. While work so far has tended to focus on people in technically based careers, on managers, and on some urban workers, plans are developing for a broader, comparative longitudinal approach to a wider range of occupations. The goals are 1) to better understand how such interactions at different life stages lead to patterns of productivity, creativity, job satisfaction, and accommodation among different life concerns; 2) to improve the activities of human resources planning and career development within organizations; and 3) to help individuals to plan more productive and satisfying lives.

Professor John E. Van Maanen is continuing his research on the characteristics of different kinds of work settings in different occupations and how these settings produce certain patterns of socialization of new recruits into the occupation, leading ultimately to a general theory of occupational socialization. Professor Van Maanen has carried out further participant observer studies on workers in a variety of organizations and has coedited a book of readings on police work. He and Professor Schein have published a paper which develops a more formal theory of organizational socialization, and have collaborated in the fourth revision of the book *Essays in Interpersonal Dynamics*.

Professor Lotte Bailyn is continuing her study of accommodation patterns in educated adults, especially in dual career families, and has contributed a chapter to the current book *Working Couples* edited by Robert and Rhona Rapoport. Professors Bailyn and Schein have finished a major report of their alumni survey of the M.I.T. Classes of 1951, 1955, and 1959 which analyzes career patterns and the nature of work involvement in this technically trained group of people now at mid-life. Professor Bailyn finished a paper on patterns and determinants of work involvement in technically based careers and is now conducting follow-up research of some of the alumni to determine further adaptation patterns.

Professor Ralph Katz is continuing his analysis of the determinants of job satisfaction, especially as a function of career variables such as job longevity. This seminal research shows that people who have been in the same job for long periods of time are much less responsive to job enrichment, getting more of their satisfaction from contextual and organizational rewards. Professor Katz has extended this work to an examination of productivity and commitment both in individuals and

groups as a function of job longevity, and is in the second major year of a project on research and development groups.

Professor Schein is continuing his analysis of the 1961 panel study showing that career anchors develop or become manifest early in the career and subsequently serve as constraints on future career decisions. Currently he is working on more general models of how organizations plan for and develop their human resources throughout the life of the individual career occupant. This work is an effort to improve human resource management at all stages of the career, and is summarized in his book, *Career Dynamics: Matching Individual and Organizational Needs*, published in 1978 by Addison-Wesley.

The work on career development is increasingly connecting with the second major research area in the Organization Studies Group conducted by Professor Allen. Professors Allen and Katz, and their colleagues, Professor Roberts and von Hippel continue to unravel the factors which aid or hinder the process of innovation and technology transfer. A decade of research on R&D management has contributed many valuable insights which are summarized in Professor Allen's book, *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within R&D Organizations*, published by the MIT Press in 1977.

Though the research efforts of individual faculty members continue to be largely guided by the requirements of their own projects and the scientific issues they are trying to address, there is a growing communality of both scientific and practical concerns evident in the group. In particular, we see a growing concern for the development of theory in the art of applying knowledge and translating scientific findings into the practical arena of management. Several members of the faculty and staff are engaged in this kind of action research. Professor Beckhard and Dr. Edwin C. Nevis are pursuing a variety of planned change and organization development activities.

Professor Beckhard is focusing on the effects of different kinds of planned change interventions, especially in large and complex systems. Dr. Nevis continues to work on factors relating to creativity. And Professor Leo Moore is currently examining the impact of a Management by Objectives Program on an organization, making a full-scale audit of a Management Development Program, bringing to implementation an Assessment Center, and initiating an integrated Human Resources Program.

Professors Beckhard and Schein have added eight new titles to the highly successful Addison-Wesley series on Organization Development first launched by Professors Beckhard, Schein, and Warren Bennis in 1969. Professors Beckhard and Reuben Harris have summarized much of their work in the book *Organizational Transitions*. Other books in the series deal with Matrix Organizations, New Patterns of Work, Team Building, Organizational Diagnosis, Work Redesign, and Survey Feedback Methods in Organization Development.

Employment and Industrial Relations. Members of this section have been active in a wide variety of research projects during the past academic year. These indicate the breadth and changing nature of research in the field.

Professor Phyllis A. Wallace has continued her research on the upward mobility of women in management. She has surveyed and interviewed graduates from the School's two- and one-year Master's programs (exclusive of the Sloan Fellows) for the classes of 1975 through 1979. Women graduates have been matched with male peers and data will be collected from both groups over a five-year period. Thus far, one-year follow-up interviews have been conducted for the classes of 1975 through 1978 (approximately 250 individuals), and two-year in-depth interviews have been conducted for the classes of 1975 through 1977.

A significant preliminary finding is that two years after graduation, women have done as well as the men, measured in terms of salary increases, bonuses, promotions, performance appraisal, and job satisfaction. The psychic costs for women may have been greater, she concludes. This research has been financed by a small grant from the General Motors Foundation and some assistance from the Industrial Relations Section. Additional funding has recently been received from the Millipore Company for this study.

In addition to this major study, Professor Wallace has completed the first phase of research on how private employers might respond to subsidies and/or tax credits to hire youth under the Youth Employment and Demonstration Project Act of 1977. Two researchers have, to date,

interviewed private employers, employment and training specialists, and others to assess the scope and complexity of youth employment programs in the Boston labor market. Additional funding is now being sought from the US Department of Labor to continue this study.

Other research projects in which Professor Wallace is still engaged include an attempt to link employment policies to issues related to employment discrimination and a study of the social issues in collective bargaining with Professor James W. Driscoll for a forthcoming volume to be published by the Industrial Relations Research Association. She is also developing a monograph from a 1978 symposium she sponsored entitled *Women in the Workplace: Management of Human Resources*. The final draft of her revised manuscript on "Black Women in the Labor Force" is now at the MIT Press for publication.

Professor Thomas A. Barocci is completing his part of a major research project on private investment, public policy, and the decline of older regions (principally the New England economy), in association with colleagues in the Urban Studies and Planning Department at M.I.T. and the Department of Economics at Boston College. The project has been funded by a consortium of the US Departments of Commerce and Labor and the National Institute of Mental Health through the Harvard-M.I.T. Joint Center for Urban Studies. Professor Barocci has been responsible for case studies in a number of industries which he has conducted with the assistance of M.I.T. Sloan School research assistants working on theses. He also has utilized a large micro database especially developed for this joint research. The project outcome is expected to go beyond the final report to the funding agencies and should produce one or two jointly authored books and several papers or monographs.

In combination with this project, Professor Barocci has undertaken special studies of the hospital industry in New England, concentrating on three areas: corporate strategy and planning in non-profit hospitals, labor relations in these hospitals, and a study of the labor market for physicians. One Sloan student and one S.M. candidate have worked with him on these studies which are now almost completed. He also has continued work on theory and methods of planning and evaluating Federally sponsored public works programs. Some work on this topic has been done directly for the Brookings Institution. An earlier study (with R. Jerrett) is being published by Praeger Publishers, New York, this fall.

Professor Driscoll completed in November his research on cooperative problem solving between adversaries in collective bargaining. This centered on three specific cases and was funded by a research contract with the US Department of Labor. A report for the Department has been prepared, and four articles have been submitted to professional publications. Professor Driscoll has been asked to speak on this research to a number of professional organizations, and will make a presentation in July at the University of the Netherlands. A related study is a comparison of 38 labor-management committees in the United States. The study was done with two Sloan Fellows who worked on a joint thesis under his supervision.

Professor Driscoll has begun a major research study of a particular form of labor-management cooperation, the Scanlon Plan. Support for this research has come from a number of Scanlon Plan companies through the Industrial Relations Section, and further funding is being sought from the US Department of Labor. An earlier preliminary study, with assistance from Fred Lesieur (part-time lecturer here and consultant on the Scanlon Plan), is being published this summer by *Organizational Dynamics*. Further research planned by Professor Driscoll includes a study of office automation and the human resource planning process in a number of companies. Preliminary working papers on initial research on these topics are being prepared.

Professor Harry C. Katz worked during the past year on two new research projects: 1) the position of government in the Maine economy, as part of a Boston University Regional Manpower Institute research project on rural development in Maine; and 2) as a result of meetings he and others had with the Joint Committee on Taxation of the Massachusetts legislature, a study of the newly imposed spending cap on budgets of cities and towns. He also is completing some research on labor relations in the Boston public school system (for presentation as a paper at the annual winter meetings of the Industrial Relations Research Association), and has worked on a paper on "Municipal Policy" to be included in a book on economic policy to be published later on economic policy options.

Professor Katz also has completed during the past academic year several papers now accepted for publication in professional journals on the following topics: "Municipal Pay Determination: The Case

of San Francisco;" and "Interest Arbitration, Outcomes, and the Incentive to Bargain: The Role of Risk Preferences" (with Professor Henry S. Farber). He has completed (with Professor Charles Sabel in the School of Humanities and Social Science) a preliminary paper on "Wage Rules: A Theory of Wage Determination." His earlier study on "The Impact of Public Employee Unions on City Budgeting and Employee Remuneration: A Case Study of San Francisco" will be included in a forthcoming volume of studies in economics.

In addition to his joint research with Professor Katz, Professor Farber (Department of Economics) is working on an analysis of final-offer arbitration, particularly as it affects the incentive to bargain and the outcomes of negotiations. This will include an empirical analysis of arbitrators' decisions in final-offer arbitration. Professor Farber is also continuing his research on relative wages and union membership, with an analysis of queuing for jobs in unionized organizations. He also plans to work on an analysis of wage indexation, wages, and contract length; and an analysis of optimal employer offers and learning in the context of a simple model of bargaining.

Professor Farber's earlier research has resulted in publications in professional journals or collections of papers on labor economics on the following topics: "Individual Preferences and Union Wage Determination (the Case of the United Mineworkers Union)"; another on "The United Mineworkers Union and the Demand for Coal: An Econometric Analysis of Human Behavior"; "Why Workers Want to Join Unions" (with Daniel Saks); "Relative Wages, Union Membership and Job Queues: Econometric Analysis Based on Panel Data" (with John M. Adowb); and "Unionism, Labor Turnover and the Wages of Young Men."

Senior Lecturer Stanley M. Jacks has continued his research on labor law questions, particularly US Supreme Court decisions affecting labor issues, broadly defined. Emeritus Professor and Senior Lecturer Charles A. Myers has investigated, mainly through library research, discussion, and correspondence with others, new developments in the management of human resources. This research has been conducted as part of the revision of *Personnel Administration* (with Professor Emeritus Paul Pigors) for the ninth edition to appear late in 1980.

Dean Abraham J. Siegel, a member of the Industrial Relations Section, was editor (along with former Visiting Professor David B. Lipsky) of *Unfinished Business: An Agenda for Labor, Management and the Public*, published by the MIT Press in the fall of 1978. This book presents papers by six former Secretaries of Labor and by present Secretary F. Ray Marshall, as well as some of the panel discussions at the 40th Anniversary Conference of the Industrial Relations Section and the 25th Anniversary of the Sloan School.

Economics and Finance

The Economics and Finance Group is the second basic disciplinary area on which the School's research and teaching programs are built.

Professor Sidney S. Alexander has once again been on leave for the major portion of the past academic year. He has continued during the portion of his time at the School to work on the social foundations of economic policies.

Professor Daniel M. Holland, together with Professor Stewart Myers, continued his research on corporate profitability and capital costs. A monograph reporting their earlier work in this area was published in June 1979 by the Committee for Economic Development. The monograph appears in a volume edited by Robert Lindsay, *The Nation's Capital Needs: Three Studies*. Professors Holland and Myers have also started to disaggregate their data and to look explicitly at comparisons in the trends of profitability and effective tax rates for manufacturing and for all other non-financial corporations. Professors Holland and Myers are also pursuing an analysis of the links between returns to investors in corporations and the returns corporations make on their investments. Dr. Holland also has continued to work on the tax problem in Massachusetts and the City of Boston with Oliver Oldman of the Harvard Law School. He also continues to serve as editor of the *National Tax Journal*.

Professor Lester C. Thurow worked on analyzing the sources of the falling rate of growth of productivity in the United States economy and on the incidence of government expenditures. The latter study is supported by the National Science Foundation. In addition, Professor Thurow is

completing a book for Basic Books on the problems of the economy in the 1980s. In addition to his contributions to several books and to a number of journals on the topics just noted, Professor Thurow was a contributor to a variety of newspapers and magazines. His pieces have appeared in the *New York Times*, *Los Angeles Times*, *Wall Street Journal*, *New Republic*, *Christian Science Monitor*, and *Baltimore Sun*. During the past year, Professor Thurow also has served as a presidential appointee to the National Manpower Commission.

Professor Edwin Kuh has continued his research in conjunction with others at the School's Center for Computational Research in Economics and Management Science and has focused on the area of model reliability. Essentially Professor Kuh's work focuses on the system properties of econometric models when they are subject to parameter perturbations, and the results of this significant work have been published in two papers written in collaboration with Professor Roy E. Welsch. In addition, this phase of the research has been described in a book, *Regression Diagnostics Identifying Influential Data and Sources of Colinearity*, to be published later this year.

Professor Richard Schmalensee's research focused principally on the impact of imperfect information on regulated industries and anti-trust activities. During the past year Professor Schmalensee had a book published on *The Control of Natural Monopolies*, D.C. Heath (Lexington Books). He also has agreed to serve as MIT Press editor of a series on the regulation of economic activity. Professor Schmalensee's research on the Federal Trade Commission's ReLemon case considered existing market definition standards and rules for predatory pricing as well as appropriate market models for similar situations involving the operation of markets in which trademarks are important. Finally, Professor Schmalensee has been working with support from the M.I.T. Center for Energy Policy Research on public policy toward the commercialization of new energy technologies.

Professor Robert S. Pindyck continued his work on the economics of resource exploration and production, on the economics of world energy demand and the world oil market, and on more general questions dealing with energy policy. Professor Pindyck's work on the world oil market has been supported by the RANN Division of the National Science Foundation. Professor Pindyck last summer completed a large econometric study of international demands for crude oil and refined oil products. That work and its implications for economic growth in the industrialized countries has been published by the MIT Press in a new volume, *The Structure of World Energy Demand*. Professor Pindyck has also published several papers with Professor Paul Joskow (Department of Economics) on the question of the desirability of government involvement in the commercialization of nonconventional energy sources.

In related energy research, Professor Martin B. Zimmerman has completed his research on US coal supply and demand and implications for policy action. He currently is preparing a paper aimed at expanding the US coal model to deal with exports of US steam coal. Professor Zimmerman also has completed a report on a study of the implications of taxation by state governments of coal production, produced a paper on the economic analysis of resource and reserve estimates, and finished a study of the effect of regulation on power plant choice by electric utilities.

Professor Carliss Baldwin's principal research has been in the allocation of human and financial capital within the corporation, an industry, or the economy. The main areas of investigation are: 1) optimal investment policies for long-lasting assets when future opportunities are unknown; 2) optimal investment policies for participants in imperfect markets; and 3) effects of information and accounting systems on investment decisions within complex organizations. Professor Baldwin also has been carrying on sponsored research into the profitability of the steel industry and the financing of nursing homes.

Professor Fischer Black has continued his research on business cycles. He believes it is possible to explain business cycles as a natural result of freely operating markets for goods and services and for capital and labor. That means there is nothing the government can do to make the economy work better by reducing the magnitude of business fluctuations. Monetary and fiscal policies are generally ineffective, while policies that do dampen fluctuations will slow the growth of the economy.

He also has been working on a theory of accounting, centering on rules for computing earnings. Economists like to think of a firm's earnings over a year as representing the change in the firm's

value over the year, while financial analysts like to think of a firm's earnings as proportional to the firm's value at the end of the year. Professor Black believes that the financial analyst's view is close to the way earnings are normally computed, and that there is no practical way to apply the economist's view of earnings.

Professor John Cox, visiting from Stanford University, completed several papers on option pricing theory and the term structure of interest rates. He recently has completed a book on option pricing to be published by Prentice Hall.

Professor Robert C. Merton has continued his research on capital markets and option pricing. Specific areas studied were market forecasting and option strategies; the effects of changes in the rate of inflation on interest rate spreads; and the structure of market making when there is differential information. A new area of study is business cycles. His work was supported in part by the National Science Foundation. Professor Merton continues as an associate editor of the *Journal of Financial Economics*, the *Journal of Money, Credit, and Banking*, and the *Journal of Banking and Finance*.

Professor Franco Modigliani's main research interest during the past academic year has centered around the problem of the real effects of inflation and ways to minimize at least the unfavorable ones. It represents a development and partial completion of ideas and hypotheses developed during the previous year. He has completed a thorough revision of the paper with Professor Stanley Fischer (Department of Economics) on "Real Effects of Inflation" developing, in particular, the effects arising from "inflation illusion" -- that is, the inability of economic agents to carry out rational calculations in the presence of high and unaccustomed inflation.

The hypothesis of "inflation illusion" has since been applied and tested in relation to the valuation of equities in the United States market. In the paper in collaboration with Professor Richard Cohn, it was shown that the evidence supports the hypothesis that investors commit two inflation-induced errors: 1) they are unable to correctly measure profits of levered firms tending to underestimate them, and 2) they tend to capitalize these profits at a rate which is upward biased because of the confusion between real and nominal rates of return (or between real and nominal growth). The results suggest that because of these two errors, the market value of equities may be undervalued by as much as 50 percent. This test, based on time series, is being extended to tests relying on cross-sections of firms.

Work in progress, partly in collaboration with Tommaso Padoa-Schioppa, is designed to bring out the extent to which inflation illusion is also producing serious biases in many components of the national income account. In particular, it tends to cause an overstatement of personal income and hence of personal savings which might, to a significant extent, account for the apparent increase in the saving rate during the recent period of inflation in many countries.

He also has done some preliminary work on the distortive effect of inflation on the pension contract. These effects are in many ways analogous to those on the traditional mortgage contract which have been studied in an earlier project under his direction at M.I.T. The interesting issue here is to what extent the remedies proposed for the mortgage contract in that research project might be extended to the pension fund.

A second area of Professor Modigliani's research has centered around the hypothesis of rational expectations and its implications. He has been concerned with the implications of this hypothesis with respect to financial markets and, in particular, with respect to long-term interest rates. He also has been working on the important issue of so-called macro-rational expectations and their implications for stabilization policies, including anti-stagflation policies.

In the area of stabilization policies he completed a study with Lucas Papademos on optimal demand policies against stagflation. In collaboration with Jacques Dreze, he is applying the framework developed earlier on the management of a highly indexed economy, to the case of the Belgian economy. One new angle that is being pursued in this research is the effect of a reduction of working hours on aggregate employment, in an open economy.

In the area of finance, Professor Modigliani also completed a thorough revision of a paper with Robert Shiller on the effect of taxes on the relation between the new issue yield and the yield on seasoned securities, which has been submitted for publication.

The editing work was completed for the three volumes of the collected papers of Franco Modigliani, including an introduction, which is to be published by the MIT Press in the coming year.

Professor Stewart Myers, in addition to his joint work with Professor Holland, also is developing a theory of corporate investment and financing decisions when managers or insiders have information that investors do not have. Also, Professor Myers was recently appointed a research associate at the National Bureau of Economic Research.

Professor Eli Shapiro has been studying the impact of inflation on financial markets and will continue to do so next year. He also completed a paper on productivity developments in the US economy.

Management Science

The Management Science Group is the third of the Sloan School's principal foci of teaching and research. The group is broadly concerned with models, measurements, and information systems and their impact on managerial processes in a variety of settings including planning and control, marketing, and operations management. The research of the group can be divided into context-related research that deals with specific areas of management concern and into methodological research on general tools and techniques. The application contexts can be further subdivided into public and private sectors.

A major concern in the public area has been energy. The work has been heavily interconnected with other parts of the Sloan School and of M.I.T., particularly with the Energy Laboratory. Professor Jacoby is Director of the International Energy Studies Program there and also Director of the Center for Energy Policy Research. Professor Jacoby has been particularly concerned with the analysis of the world oil market and the future of the international nuclear industry, including strategies for assuring uranium supplies. Professor Gordon M. Kaufman is developing methods for predicting future supply of energy minerals as a function of policy choice, process, and regulatory regime. He has conducted an extensive project to model the process of oil and gas exploration and has developed methods to permit better estimates of undiscovered oil and gas reserves. Professor Lilien has been working with the photovoltaics program of the Energy Laboratory to develop and apply a model for assessing the impact of government purchase and demonstration programs on the timing and level of penetration of a new technology. The model is currently being used to help evaluate a proposed eight-year photovoltaic development plan. Senior Lecturer David O. Wood has been active with a wide variety of energy research with special emphasis on energy demand in US industries and policy model evaluation. Senior Lecturer Gordon F. Bloom in his continuing work with the food industry is concerned with energy conservation in supermarkets where refrigeration accounts for substantial national consumption. Senior Lecturer Harlan C. Meal is studying the potential of geothermal energy for industrial use.

Also in the public sector considerable work is in progress on transportation management. Professor Magnanti has been investigating the use of large-scale optimization techniques in network problems, particularly rail freight management and urban traffic equilibria. Professor Barnett has examined airline safety records. Professor Little continues his work on traffic signal optimization.

In other public activities, Professor Barnett has examined the statistical evidence for the effect of gun control legislation on crime rate and finds more effect than has generally been realized.

In the private sector a variety of work has been ongoing, especially in the areas of marketing, operations management, and planning and control. The marketing faculty are continuing their widely known work in marketing models and measurements. Professor Urban has developed techniques for new product design and positioning. Professor Silk has been studying the validity of advertising copy-testing methods and their relationship to expenditures to create advertising copy. Professor Little is exploring the marketing measurement capabilities of point-of-sale data collected automatically through the Universal Product Code system and its implications for a theory of price-setting in supermarkets. Professor Kalwani has continued his development of stochastic models of consumer behavior.

An important and long-neglected research area in marketing concerns industrial products, i.e., those sold to organizations rather than individuals. In the past few years the marketing faculty has initiated a significant research effort in this direction. Professor Lilien has completed a major study, the ADVISOR project, in which a group of cooperating companies has provided cross-sectional marketing data on a large sample of products. The study has shown how industrial marketing budgets relate to product and market characteristics. Professors Kalwani and Silk have been working on an organizational buying behavior project. Exploratory work has been done on the design of a longitudinal panel study of industrial purchasing. The goal is to determine how preferences and attitudes change over time and what factors precipitate the changes. In addition, Professor Urban is continuing his work on laboratory methods to measure the impact of industrial selling and advertising messages. Professor Urban is also Director of the Marketing Center, which coordinates sponsored research in the area.

We are pleased to note that one of Professor Lilien's papers received the Alpha Kappa Psi Award as the best paper in the *Journal of Marketing* in 1978.

Although management science techniques have long been helpful to companies in designing and installing production planning systems, a number of difficulties plague applications. Particularly serious has been the compartmentalization of problems into small systems that really should be connected into large ones. At the same time, large complicated systems have often collapsed as the designers have moved on to other responsibilities. Professors Arnoldo C. Hax and Gabriel R. Bitran are engaged in a project on hierarchical production and distribution systems which seeks to tackle these issues. In this work, models for higher level strategic decisions set constraints for more local tactical decisions from which the latter feed back information to the former. Closely related is the work of Dr. Meal, who is concerned with multiple stage production control. In addition Professor Graves has been developing scheduling policies for a family of products on a single production facility. He also has been studying control and design decisions for robot-operated assembly systems.

Professor Hax has further embarked on new research on strategic planning for diversified operations. This includes a program of methodological and empirical research in the field of mergers and conglomerates. In related work Professor Peter Lorange is studying formal planning systems. His goal is to develop an approach to the design, implementation, and maintenance of effective corporate planning systems. Lecturer J. Morrison McInnes has conducted a study of computer-based modeling activities in the financial planning and planning and control functions of approximately 20 corporations. This is leading to a typology to describe what types of models and systems are useful in what kinds of settings. In the accounting field Professor Michael F. van Breda has been studying the relationship of the accounting rate of return and the internal rate of return under differing asset lines and growth rates with particular concern for the effects of inflation rate.

A major methodological thrust within the group is mathematical optimization. Many large-scale systems are potentially capable of improvement by these techniques. A surge of theoretical developments in recent years has not yet been well integrated into practice because of lack of adequate computational support and because of a few important stumbling blocks in the theory. Recent research by Management Science Group faculty has been directed at these issues. Professor Jeremy Shapiro has been supervising the development of a modular system of mathematical programming packages. He also has focused research effort on certain outstanding issues in integer and mixed integer programming. Professor Magnanti has been attacking problems in combinatorial theory and nondifferentiable optimization. Professor Bitran has completed research on a duality theory for multiple criteria decision making.

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 and model reliability diagnostics. Professor Welsch has been developing robust nonlinear regression techniques and implementing them on easy-to-use computer systems. In addition he has focused on the most widely used multivariate technique, multiple linear regression, and has been developing new kinds of diagnostics for understanding the statistical properties of the results. This is part of a long-range concern for the reliability of econometric models.

Computer-based information systems consume large quantities of resources in the national economy and generate more than their share of concern and controversy. Stimulated in part by the stringent requirements of information systems that can be used for policy analysis, Professors

Donovan and Madnick have been laying foundations for a computer system architecture that allows multi-user access to a single data base and affords access to multiple and potentially incompatible data base management systems. An important motivating concept is that of a decision support system to assist managers and policy makers. Professor Donovan in a cooperative effort involving the March of Dimes and Tufts University has developed a birth defects information system using these ideas. Professor Madnick is pursuing basic research on data base computers using his Infoplex concept. Professor Meldman has been concerned about the interface between computers and law, both from the point of view of legal issues, such as privacy, and applications of computers within the legal system. Professor Toong is studying the impact of microprocessor technology on production and managerial processes.

An emerging topic of increasing interest is office automation. Today, office mechanization technologies such as word processing and electronic mail are coming into widespread use but a more important step will be computer facilitation of office procedures. Professor Zisman has been conducting research on methods of describing office procedures and representing them in computer programs.

The importance of computers and computerized decision support systems is further reflected in the activities of the Center for Information Systems Research (C.I.S.R.), directed by Dr. Rockart. C.I.S.R. draws on industry funds for use in critical management issues involving computers, and performs a key communication function between researchers at the School and potential industrial users of the research. As part of this effort, the Center has organized highly successful seminars on current issues in information systems research. Dr. Rockart himself is engaged in a study of distributed computing power in large organizations. This has become an area of great interest as dropping hardware costs have brought on a new generation of minicomputers and microprocessors with a great potential for improving management processes. Under C.I.S.R. sponsorship Professor Alloway has been conducting a field study of the end-users of data processing.

Finally, we are pleased to report that Professor Little has been appointed to the George M. Bunker Chair in Management. In addition, Professor Little has assumed the position of president of the Operations Research Society of America.

System Dynamics

Development of the System Dynamics National Model continues with effort now being divided between extending the scope of the model and use of the model to examine national policy issues. Financial variables have been added, and household and labor sectors have been assembled along with industrial sectors in a configuration that allows examination of issues surrounding inflation.

Attention has focused on the central role of an expanding money supply in creating sustained inflation. Other issues, such as labor productivity, energy, union bargaining pressures, efforts to control prices, and capital investment are now being integrated into the inflation study.

Emerging results from the System Dynamics National Model have been presented to a wide range of corporate, government, and academic audiences. Testimony has been presented before Congressional committees, and semiannual technical meetings have been attended by sponsors of the research. The program is supported by contributions from some 30 sponsors representing corporations, foundations, and private individuals.

Previous academic subjects in Principles of Systems, Industrial Applications, and the Dynamics of Physical and Social Systems have continued to be taught. During the past year a new subject in Policy Analysis has been jointly developed between the System Dynamics Group and the Department of Urban Studies and Planning. Research programs in the application of system dynamics to corporate policy applications have continued, including a study of how material requirements planning (MRP), as being used in corporate production planning, can cause instability of employment and loss of market share.

Professor Forrester was inducted into the National Inventors Hall of Fame in 1979 for his invention in 1949 of the coincident-current random-access magnetic core storage for digital computers.

Management of Technological Innovation

Teaching and expanded research in this area continued to focus on the problems of generating effective technological innovation. The efforts fall into aspects of R&D staffing, structure and strategy, and their integration in the corporation and/or government agency.

In regard to staffing of research and development organizations, Professors Allen and Ralph Katz are continuing their work on the performance of long duration R&D project groups, under funding from the US Department of Defense. The essential question of this research concerns how R&D groups and projects maintain their effectiveness over extended periods of time. In investigating this issue, they are focusing on several important aspects of R&D groups as a function of group age: supervisory behaviors and skills, various kinds of communication patterns, relative degrees of intragroup homogeneity or heterogeneity along a number of dimensions, perceptions of job and task characteristics, and the reactions of R&D professionals to their work environment. Particular attention is being given to the overall structure of the laboratories (i.e., matrix, project-oriented, or functionally oriented) and to the career and project movements of R&D staff members. Data have already been collected from over 1,000 R&D professionals in more than 50 projects, and the information gathering continues this summer.

Professor Katz also has been collaborating with Professor Michael Tushman of Columbia University on a study of communication effects on R&D performance. The importance of gatekeepers hypothesized by Professor Allen is being tested in this research.

In the area of structure, Professor von Hippel has continued to focus on the relationships between users and manufacturers of innovative industrial goods, under National Science Foundation funding. Professor von Hippel has shown previously that the locus of innovation most frequently resides in the user organization, rather than among the suppliers of scientific/analytic instruments and semiconductor and electronic subassembly production equipment. His manuscript on this work was awarded the "Best Paper of the Year Award" by *R&D Management*. Professor von Hippel has been developing a theoretical framework for linking the locus of an innovation with the ability of an innovator to capture innovation benefits. Professor von Hippel also has been studying with Professor Stan N. Finkelstein the linkages between users and innovators in the area of automated clinical laboratory technology. During the past year Professor von Hippel served on President Carter's Domestic Policy Review Task Force on Innovation.

Professor Allen has continued his studies of technical communication on an international level with his research in the Republic of Ireland. That study has now focused on the mobility of technical personnel.

In regard to strategy, Professor Roberts continued his interests in corporate new venture organizations and in the formation of new enterprises. With Professor Finkelstein, and support from the Whitaker Health Sciences Fund, Professor Roberts will be looking at the determinants of academic medical innovations and their utilization. He also is reviewing the role of technical planning as part of overall corporate strategic planning and is assessing the several new methods that are aimed at integrating technical inputs into financial and marketing-based plans.

Professor Roberts worked on a collaborative study during the year with Dr. James Utterback and Professor Herbert Hollomon of the Center for Policy Alternatives, examining the incentives provided by the State of Israel to encourage industrial product innovation. As part of the research Professor Roberts' methodology for studying new technology-based enterprises has been applied to Israeli firms. In addition a research proposal was prepared by Professor Roberts and Dr. Utterback to update Professor Roberts' 1960s data on new enterprise formation and growth in the Greater Boston area, that research being initiated during the spring term.

A major effort went into the faculty study co-chaired by Professors Roberts and Hollomon to design a new joint Engineering-Sloan School Master's Degree Program on the Management of Technology. The committee proposal has now been approved for submission to the Committee on Graduate School Policy.

Initial designs also were developed for new special management programs aimed at executives of high-technology corporations, as well as senior R&D managers of major firms. Both programs are intended to be launched during the next academic year.

Dr. Zeev Bonen, former director of the Armament Development Agency of Israel, spent the year as a Guest of the Institute. His work on the development of large-scale sociotechnical systems created much interest, leading to the publication of several working papers.

Corporate Strategy, Policy and Planning

Professor Zenon S. Zannetos and Professor Michael Porter of the Harvard Business School are continuing their research on the differences between administrative and market regulation. In their effort to derive policy implications of mergers and acquisitions, they are investigating the changes in the behavior of the acquired firm by performing a "before and after" analysis. The analysis attempts to assess the impact of the administrative regulation imposed by the acquiring firm on the rationality of decisions taken by the acquired firm.

Continuing his work in the area of economic development and transfer of technology, Professor Zannetos expanded his work to include the problem of distribution of incomes. He and a graduate student, Michael Scoufarides, are attempting to test among others the Kuznets hypothesis. In general, the work deals with the relationships between income inequality and economic development.

In the area of oil economics and oil transportation, considerable progress has been realized within the group. Serghios Serghiou, a graduate student, extended a model developed by Professor Zannetos explaining the level and structure of freight rates in the short run. Mr. Serghiou's thesis won the Brooks Prize as the best Master's thesis prepared during the past year. He and Professor Zannetos are collaborating on some joint research further extending the generality of the models they have already developed. Also Professor Zannetos is developing alternative scenarios to assess the impact of high tanker rates on oil prices given the new pattern of ownership of oil producing assets.

Professor Zannetos continues his research in the area of strategy formulation and the strategic planning process. Sheryl Hill, a graduate student at Sloan, is associated with Professor Zannetos in some aspects of this research.

Professor Louis Banks continued his work in the areas of 1) Business and Social Pressures and 2) Business and the Media. Addressing the qualitative aspects of managerial decision making, Professor Banks attempts to explain the development of corporate responsiveness in the current sociopolitical atmosphere and to identify the value system which underlies decisions of the large firm and the sources from which corporate values are derived.

In a more philosophical vein, Professor Bottiglia is examining the underpinnings of our present mixed-enterprise system and the survival of institutions. He attempts to determine critical events in the life of civilizations which threatened their existence, and he derives the possible consequences of crises in modern society. Another aspect of his ambitious work focuses on business ethics/morality and government policy.

International Management

Professor Richard D. Robinson completed a comparative study of foreign investment promotion programs of selected less developed countries. The study, which was conducted for the Overseas Private Investment Corporation, resulted in a Sloan School working paper which will be published by the US Chamber of Commerce.

Professor Donald R. Lessard continues his research in the areas of financial management of the multinational firm, international portfolio investment, and external financing strategies for less developed countries (LDCs), particularly those that derive a substantial proportion of their export revenue from a single commodity. Regarding the financial management of the firm, he has completed a paper applying the adjusted present value technique to the value of foreign capital investment projects by multinationals and has been working on the measurement and management of foreign exchange exposure taking into account recent evidence on the behavior of exchange rates.

Professor Lessard also has completed a study of the optimal structure of international investment portfolios with alternative assumptions regarding equilibrium risk-return relationships in international capital markets and he has completed an overview study on theory and evidence regarding international diversification to be published by Dow-Jones Irwin in the forthcoming *Investors' Management Handbook*. As part of the United Nations Industrial Development Organization joint study of new patterns for international industrial cooperation, Professor Lessard has completed (together with Professor Philip Wellons of the Harvard Business School) a major study of innovations in private capital markets that might benefit LDCs. The major thrust of the report is to identify ways that LDCs could make better use of existing markets. He also has completed (together with Daniel Wisecarver of the Harvard Institute for International Development) a paper on the evaluation of natural resource projects in LDCs.

Professor Stephen J. Kobrin completed empirical work on two projects involving the interaction of international business and the political environment. Using mailed questionnaires (455) and 120 personal interviews in 40 firms, data were gathered for a study of how US international firms assess foreign political and social environments, how the resulting evaluations are integrated into decision making, and the impacts of the entire process on strategy. This research was conducted with The Conference Board. The second project involves use of an extensive data base (compiled during 1977-78) to analyze the determinants of the expropriation of foreign investment in developing countries. Two sections of the study were completed during 1978-79: an analysis of firm and industry factors which increase vulnerability to expropriation and an analysis of political-economic factors which determine the host government's propensity to expropriate. Both resulted in working papers.

Professor Nyhart continued his research on the economics and regulation of deep ocean mining. Work on his cost model focused on: 1) extensions of prior analysis on proposed financial arrangements for contractors under the International Seabed Authority being negotiated in the Third United Nations Conference on Law of the Sea (UNCLOS); 2) development of initial likely parameters of the Authority's operating arm, the Enterprise; 3) analysis of credited deduction treatment of income accruing to deep ocean miners, and of likely tax treatments of other nations; 4) changes in cost, revenue and accounting assumptions used in the model, based on feedback from industry sources. The project resulted in a number of published research reports including a paper in *OCEANS*, 78. In addition, Professor Nyhart conducted research on international legal, political, and institutional aspects of OTEC (ocean thermal energy conversion) demonstration and development. He served as co-chairman of this panel of the American Society of International Law, contributing two chapters to the resulting publication.

Health Care Management

During 1978-79 the Sloan School continued its multi-faceted program in health care management teaching and research, and continued efforts to expand resources in this programmatic area.

The Sloan School continued active collaboration with the Association of American Medical Colleges in a multi-phase program involving the development and presentation of management education programs for the AAMC's constituent medical schools. Professors Beckhard and Roberts, representing the applied behavioral sciences and the management sciences, respectively, exercised joint responsibility for design and leadership of these activities, with active involvement of Dr. Rockart, and numerous faculty recruited from other universities. Phase I has involved nearly every dean of the 130 North American medical schools in a one-week management program. About 80 medical schools already have participated in the follow-up Phase II teams program which emphasizes problem solving of real issues identified by the medical schools, with more than a dozen medical schools returning for a second time to accelerate programs of managerial improvement initiated by the earlier phases. Additional sessions of this M.I.T.-AAMC program are scheduled for the coming year, under the continuing sponsorship of the Robert Wood Johnson Foundation. Additional Phase I-type programs have now been developed and are being presented on a continuing basis to directors of teaching hospitals and to chairmen of academic departments of medicine.

In a related activity with the AAMC, Dr. Rockart conducted an educational effort in financial management for academic medical centers. Sloan School faculty also have been involved in

presenting similar management education efforts to deans of pharmacy schools and chairmen of surgery, radiology, and pathology departments.

During the year Dr. Rockart advanced his research on the possible role of distributed information processing systems to aid patient management in hospitals, and on methodologies for designing hospital information systems. He and Christine Bullen continued studies funded by the Veterans Administration, testing a method for information system structuring at the Boston VA Hospital. Dr. Rockart's initial written description of this work was published in the *Harvard Business Review*.

In another area Professor Finkelstein, Professor Alvin Drake of the M.I.T. Operations Research Center, and Professor Harvey Sapolsky of the Department of Political Science are coauthoring a book-length manuscript on blood banking management and policy, now accepted for publication at the MIT Press.

Efforts continued in the transfer of research approaches developed earlier in the area of management of technology to problems of health care technology. Professor von Hippel collaborated with Professor Finkelstein to examine factors affecting the development and commercialization of health innovations, and they are now focusing on the effect of government regulations. Professor Finkelstein initiated research on the clinician role in the generation and utilization of medical innovations, supported by funds secured by Professors Roberts and Finkelstein from the Whitaker Health Sciences Fund. Professor Finkelstein also continued his research on the relationships between technological change and the utilization of health services. Professors Roberts and Finkelstein are working closely with the National Heart, Lung and Blood Institute of the National Institutes of Health to develop a state-of-the-art conference on the development and dissemination of biomedical advances.

Professor Norman S. Stearns, Associate Dean of the Tufts University School of Medicine, continued his collaborative efforts as Visiting Professor of Health Management at the Sloan School. In addition to his teaching and thesis support endeavors, Dr. Stearns developed a research proposal relating to determinants of the quality of care.

Professor Roberts continued his earlier participation as a member of the "health" team for M.I.T. as part of a joint M.I.T.-French National Research Council research program on "Science and Decision Making." Professor Roberts developed a system dynamics model of the growth and maintenance of the cigarette problem in the US, and of society's coping responses, and has prepared a working paper on that research.

Major efforts have continued to help move the health management area toward a critical mass of program, faculty, and supporting resources. Much time was spent during the year to develop comprehensive plans for launching a major research and teaching center on health care management, and substantial funding has been sought through several proposal efforts in order to implement these plans. Progress continues to be very slow in this regard, although seed funding is being generated from the Veterans Administration.

The health policy and management programs at M.I.T. are included in the Institute-wide formation of the Whitaker College of Health Sciences, Technology, and Management, with Professor Roberts chairing its Health Policy and Management area. A new joint biomedicine-management Ph.D. program was designed during the past year as part of this new Whitaker activity and a broad research program is being planned with special emphasis on policy and management relating to health technology.

The Health Management Executive Development Program saw its fourth year of operation in conjunction with the Sloan Fellows Program. As part of this program Professor Stearns continued his leadership of a year-long Seminar in Health Management, co-taught with Professor Roberts. This seminar, which will continue next year, brought to the Sloan School 20 leaders of medical schools and hospitals, government health agencies, and health-related corporations for comparative assessments of management style and effectiveness. A new group of Health Management Executives has been admitted for the 1979-80 program year and further program development is under way.

Professor James Bush, Associate Professor of Health Policy at the University of California at San Diego, visited on sabbatical leave for the year. He contributed actively to new program

idea-development, while working closely with Professors Forrester and Roberts in the area of health systems dynamics.

STAFF CHANGES, PROMOTIONS AND VISITORS

During the past year Professor John D.C. Little was named the George M. Bunker Professor of Management; Professor Little has been on the Sloan School faculty since 1962 working in the fields of operations research and marketing. Professor Edgar H. Schein, Chairman of the Organization Studies Group, was named the Sloan Fellows Professor of Management to succeed Professor Charles A. Myers who retired this year.

Dr. David A. Kendrick joined the economics area of the Sloan School as a visiting professor. Professor Kendrick, who received his Ph.D. from M.I.T., is associated with the University of Texas at Austin. Dr. James Bush and Dr. John C. Cox joined the Sloan School as visiting associate professors. Professor Bush, whose field is health management, comes to us from the University of California; Professor Cox, who is associated with the economics and finance area, comes from Stanford University.

Professors Arnold I. Barnett, Ralph Katz, and Eric A. von Hippel were promoted to the rank of associate professor. Dr. Eduardo M. Modiano, who received his Ph.D. in operations research from M.I.T., joined the Management Science Group as a visiting assistant professor. Clifford B. Donn, a Ph.D. candidate in the Department of Economics at M.I.T., was appointed instructor in the industrial relations area.

John C. Houghton, a research scientist and project officer at the M.I.T. Energy Laboratory, joined the operations research group as a lecturer. Paul C. Kiley and David Sherman were appointed lecturers in the planning and control group. James L. Paddock, a member of the Sponsored Research technical staff in the Energy Laboratory who received his Ph.D. from the Sloan School in February, was appointed an instructor in the finance area.

There were six additions to the Sloan School staff: Anne S. Wood, Manager of Financial Information and Planning, is a Sloan graduate who previously was associated with Wellesley College. Loren Cox, Executive Director of the Center for Energy Policy Research, formerly was on the professional staff of the US House of Representatives Committee on Ways and Means. Stephen E. Humphrey and Judith Quillard, both Sloan School graduates, joined the DSR staff of the Center for Information Systems Research. Paula B. Cronin, also a Sloan graduate, was appointed Associate Director of Placement.

Professor Lester C. Thurow of the economics area was on leave during the spring of this year.

Dr. Alan F. Kay was a guest lecturer with the System Dynamics Group; Dr. Zeev Bonen was a guest in the Management of Technological Innovation Group; and Leonard Rico was a guest lecturer in the Manpower and Labor Relations Group. Thomas J. DeLong, a Ph.D. candidate at Purdue University, was a visiting scholar in the health and technology area during the spring term.

We record with regret several departures from the Sloan School. Frederick J. Quivey, formerly Manager of Financial Information and Planning, joined the School of Engineering. Professor Edward M. Graham left to accept a position as International Economist for the US Treasury. Professor Ali N. Mashayekhi returned to his home country of Iran.

Finally, two faculty members announced their retirement. Professor William F. Bottiglia, Professor of Management and Humanities, has been a member of the policy area of the Sloan School since 1973. Professor Bottiglia previously had been head of M.I.T.'s Department of Foreign Literatures and Linguistics. Professor Charles A. Myers, Sloan Fellows Professor of Management, retired from the industrial relations area. Professor Myers has been on the Sloan School faculty since 1964. Both Professor Bottiglia and Professor Myers will be continuing to make their contributions to the School as professors emeriti and senior lecturers, part time.

WILLIAM F. POUNDS



School of Science

Science continues to change our view of the world and to increase our power to shape it to our needs. In the past several decades, our knowledge of science has undergone an enormous increase, but we are still aware of the "endless frontier" of Vannevar Bush and the fact that there is so much that we do not understand. This lack of knowledge becomes especially evident when we consider societal problems and cannot answer basic questions about health, environment, energy, and natural resources. This year's annual reports of the departments of the School of Science indicate some of the ways in which M.I.T. faculty members, research staff, graduate students, and undergraduate students have contributed to scientific knowledge.

As usual, this year M.I.T. faculty members have received many honors for their work, but there is one award that deserves special attention. Professor Daniel G. Quillen was awarded the Fields Medal at the International Congress of Mathematicians in Helsinki for his fundamental research in algebra, notably algebraic K-theory, and in topology. This award has been given only 24 times since it was established in 1936. The Nobel Prize is not awarded in mathematics, and so the Fields Medal is sometimes referred to as the "Nobel Prize in Mathematics." Professor Jesse Douglas of M.I.T. received a Fields Medal in 1936, and so this is the second time a Fields Medal has come to M.I.T. Professor Quillen is a very popular teacher of 18.03 Differential Equations.

ACADEMIC PROGRAMS

This year there were 897 undergraduates enrolled in departments in the School of Science. This number may be compared with 959 the year before. The shift of undergraduates to the School of Engineering has continued this year. However, we in the School of Science are encouraged by the fact that the sophomore class in the School of Science is larger than last year by 24 students. This indicates that we are in the process of turning the corner.

The graduate enrollment in the School of Science this year is exactly the same as the preceding year, that is, 1,063. Graduate enrollment in the School has risen steadily since 1971-72 when it was 899.

This year the School of Science took the lead in developing a new type of summer program to be offered in 1979. A ten-week summer program "Principles of Toxicology" was presented in response to the national need for toxicologists. Increasing public concerns about the effects of chemicals in the environment and the workplace and, more specifically, the implementation of the Toxic Substances Control Act of 1976 have increased the national need for scientists who can contribute to the solution of these problems. The Environmental Protection Agency is supporting the summer program with a training grant which provides stipends and tuition for 24 trainees. About 15 employees of the Environmental Protection Agency will take the course which provides 30 credit hours through the Department of Nutrition and Food Science. This special summer program has been developed by a faculty committee chaired by the Dean of Science. Professor Gerald N. Wogan has been responsible for the academic program. The planning and offering of the summer program also has involved the participation of faculty members from the Harvard School of Public Health.

The freshman enrollment in 18.03 Differential Equations continues to increase. From the spring term 1974 to the spring term 1979, freshman enrollments were 411, 440, 574, 507, 599, and 598, respectively. This indicates that more freshmen are completing their calculus requirement earlier and are continuing to take mathematics.

RESEARCH

The research volume of the departments in the School of Science in FY79 was \$26,800,000, compared with \$25,288,000 the year before. This increase just about covered inflation. However, this research volume does not adequately indicate the involvement of faculty members of the School of Science in sponsored research. Because of the involvement of faculty from the School in interdepartmental laboratories, the research volume attributable to the School of Science is about twice as large as the above figures. Actually, faculty members from the School are directors of several of the interdepartmental laboratories. These include: Professors Herbert S. Bridge (Center for Space Research), Ronald C. Davidson (Plasma Fusion Center), Michael S. Feld (Spectroscopy Laboratory), Benjamin Lax (Francis Bitter National Magnet Laboratory), Francis E. Low (Laboratory for Nuclear Science), Salvadore E. Luria (Center for Cancer Research), and Peter A. Wolff (Research Laboratory of Electronics). Professor James L. Elliot, of the Department of Earth and Planetary Sciences, was appointed Director of the George R. Wallace, Jr. Astrophysical Observatory this year. He is a new member of the faculty this year, having come from Cornell University. We are indebted to Professor Herbert S. Bridge for serving as Acting Director of the Observatory.

The Institute Council on Environmental Health and Safety, which is chaired by the Dean of Science, met six times during the year. The Council reviewed the activities of various Institute safety committees and the arrangements for improving safety in the various departments and laboratories where experimental work is done. The hazards of handling certain chemicals received special attention.

FACULTY

This spring Professor Gerald N. Wogan was appointed Head of the Department of Nutrition and Food Science succeeding Professor Nevin S. Scrimshaw. Professor Scrimshaw had been Head of the Department since 1961 and has presided over a period of considerable growth and diversification. Of the current 30 faculty members in the Department, 27 have been appointed since he became Head. The period of his stewardship also has been a period of expansion of the Department and its research activities. The sponsored research volume of the Department is now about \$5 million per year. In 1975 the Department of Nutrition and Food Science assumed responsibility for the Undergraduate Course VII-B in Applied Biology. As an Institute Professor, Nevin Scrimshaw will be devoting a good deal of his research time to the International Nutrition Planning Program, of which he is Director.

Dr. Wogan is Professor of Toxicology and has been at M.I.T. since 1961. His contributions to molecular toxicology have been honored by his election to the National Academy of Sciences. Professor Wogan has recently cooperated with Professor Irving M. London of the Whitaker College and with the Energy Laboratory to develop a project on the health effects of fossil fuel utilization. He began as Department Head on March 1, 1979.

Professor Daniel J. Kleitman was appointed Head of the Department of Mathematics to succeed Professor Kenneth M. Hoffman. Professor Hoffman has served for eight years as Head of the Department. This has been a period of active development of the Department, and Professor Hoffman has made many contributions to the development of new programs and to the strengthening of the faculty. A new group in statistics has been started and a computer (a gift of the Hewlett-Packard Corporation) has been installed in the Department for use in education and research. Before becoming Department Head, Professor Hoffman was Chairman of the Commission on M.I.T. Education. While Head, he has also served as M.I.T. Co-chairman of the Wellesley-M.I.T. Exchange Program and Chairman of the Ad Hoc Committee on M.I.T. and the Intelligence Agencies. Professor Hoffman came to the Institute in 1956.

Dr. Kleitman is Professor of Applied Mathematics and works in the field of combinatorics. In 1976-77 he served as Chairman of the Applied Mathematics Committee in the Department. He has been a member of the Committee on Educational Policy and has recently served on the Provost's Committee on Applied Social Science and Public Policy. Dr. Kleitman has been at M.I.T. since 1966.

Professors Keiiti Aki and Gordon Pettengill of the Department of Earth and Planetary Sciences were elected to the National Academy of Sciences this spring.

Department of Biology

Professors Gene M. Brown (Biology), Daniel G. Quillen (Mathematics), and Carl I. Wunsch (Earth and Planetary Sciences) were elected Fellows of the American Academy of Arts and Sciences.

Two members of the faculty were honored this year by the award of named professorships. Professor George B. Benedek was designated Alfred H. Caspari Professor, and Professor Maurice S. Fox was designated the Lester Wolfe Professor of Molecular Biology.

Professors James M. Austin (Meteorology), John W. Irvine (Chemistry), and Claude E. Shannon (Electrical Engineering and Computer Science, and Mathematics) will become Emeritus Professors at the end of the year. Professor Austin came to the Institute in 1939. He has made contributions to our understanding of quantitative forecasting methods, climatology, and the meteorological aspects of air pollution. Since 1955 he has been Director of the Summer Session. Mrs. Pauline M. Austin has been a senior research associate in the Meteorology Department and has been responsible for the weather radar project. She also is retiring this year.

Professor Irvine earned his Ph.D. at M.I.T. in 1939 and became an assistant professor in the Department of Chemistry in 1943 after serving as a research associate in the Department of Physics for four years. He has made contributions to the production of radionuclides, their separation by solvent extraction and ion exchange, and to the measurement of radioactivity. He has served as Executive Officer of the Department of Chemistry since 1966. As Executive Officer he carried large responsibilities in supervising the construction of the Dreyfus Building and the remodeling of the Eastman Building.

Professor Shannon, Donner Professor of Science and Professor of Electrical Engineering and Mathematics, received his Ph.D. from M.I.T. in mathematics in 1940. He made major contributions to the field of information theory and is known as the founder of that field.

The School of Science lost Professor Isadore M. Singer, Norbert Wiener Professor of Mathematics, to the University of California at Berkeley. Professor Singer has made major contributions to topology, and we wish him the best in his new position. He is currently chairman of the National Academy of Sciences Council on Science and Public Policy. Professor Jack E. Baldwin is returning to England to be Waynflete Professor of Chemistry at Oxford University.

We were saddened by the sudden death on February 19, 1979, of Professor Daniel B. Ray (Mathematics). Professor Ray had been a member of the faculty since 1957. He was an international authority on mathematical analysis, especially the theory of probability. He was a dedicated teacher and also responded positively when his colleagues wanted him to take administrative responsibilities as Chairman of the Committee on Pure Mathematics from 1969 to 1972.

ROBERT A. ALBERTY

Department of Biology

In the past year, 256 undergraduates were listed as majors in Life Sciences and 81 received the Bachelor of Science in Life Sciences. Between July 1, 1978 and June 30, 1979, 14 Ph.D.s were awarded in the Department of Biology, and one Ph.D. was awarded in Biological Oceanography under the Joint Program with Woods Hole Oceanographic Institution. There were 105 Ph.D. candidates registered in the Department and 19 in the Biological Oceanography Program in the past year. The entering graduate class in September 1978 was 26 and the entering class for September 1979 will number 24. In addition, six new students will enter the Biological Oceanography Ph.D. Program.

EDUCATIONAL ACTIVITIES

There have been no substantial changes in the undergraduate curriculum since it was reorganized three years ago. The basic subjects continue to be 7.05 General Biochemistry, 7.03 Genetics, and the introductory laboratory subject, 7.011. All of the upper level subjects in the Department contain one or more of these subjects as prerequisites.

We have been fortunate for the past several years to have had a group of dedicated undergraduate students serve on a special faculty-student committee which monitors all aspects of the undergraduate education program in the Department. The faculty has been pleased to have had valuable advice from these students about departmental programs.

The Department is anxious to provide the opportunity for undergraduates who so desire to acquire experience in research activities. For this purpose, four research-oriented project laboratories are in operation and are staffed with faculty members and other research staff. Up to 50 students per year can be accommodated in these laboratories. Each student enrolled in such a laboratory subject has his or her own individual research project and each student is expected to spend at least 24 hours per week in this activity. These subjects have been exceptionally well received by the students, many of whom continue their projects into the following semester. In addition, we urge students to consider working in the research laboratories of individual faculty members. Any student who wants the experience of being involved in research work can do so with a minimum of effort.

The recipients of the annual John L. Asinari Awards for the 1978-79 year for outstanding research by undergraduates in the Life Sciences were Jan Kronish and Alfred Geller, both seniors, and Irene Goldberg, a sophomore.

One new subject has been added to the graduate curriculum in the past year. Professors Mary Lou Pardue and Harvey Lodish have organized a new subject in Cell Biology, 7.60, which all entering graduate students are expected to take. This subject is designed to introduce students to the fundamentals of cell biology and to prepare them for more advanced subjects in this field.

During the summer of 1978 the Department sponsored a special one-week intensive course in molecular biology for alumni who were interested in learning something about this subject. The course was organized and presented by Professors Maurice Fox, Charles Holt, Graham Walker, and Malcolm Gefer of this Department and Dr. Ray White, a former graduate student who is now a faculty member at the University of Massachusetts Medical School in Worcester. Approximately 50 people attended this course and in all respects it seemed to be a successful endeavor.

RESEARCH

The research activities in the Department are concentrated in the general area of molecular biology, with emphasis on the following specific disciplines: biochemistry, genetics, microbiology, cell biology, biophysics, virology, immunology, and neurophysiology. The research activities of the Department are described in detail in the annual departmental publication, *Research Summaries*. The current edition is available at departmental headquarters.

The departmental Electron Microscope Facility, under the direction of Professor Jonathan King, continues to be a valuable resource which is used by several members of the Department both for teaching and research. During the past year Elaine Lenk, who served with distinction as associate director of this facility for several years, left us to take a similar position at the National Institutes of Health. However, we were fortunate that Erika Hartwig, an experienced and impressive electron microscopist, was available as a replacement.

During the past year we established a new departmental Protein Chemistry Laboratory under the supervision of Professor Robert Sauer, a new faculty member in the Department. This new facility, which is available for the use of anyone in the Department, is something that we have needed for some time and we are very grateful to the General Mills Foundation and the Athwin Foundation for financial support that has helped us to establish this laboratory.

FACULTY

In the past year Dr. Sauer joined our faculty as assistant professor. His research interest is in the area of structure-function relationships in proteins and nucleic acids. He has organized and will supervise the new departmental Protein Chemistry Laboratory as well as maintaining his own research program. Professor Sauer received the S.B. from Amherst College and the Ph.D. from Harvard.

Professor Bonnie Tyler will leave the Department on July 1, 1979 to accept a research position at Merck, Sharp and Dohme. Professor Linda Hall will leave during the summer of 1979 to accept a faculty position at the Albert Einstein Medical School in New York.

Professors King, Holt, Annamaria Torriani-Gorini, and Phillip Sharp were promoted to full professor effective July 1, 1979. Professors Nancy Hopkins and Robert Weinberg were awarded tenure to become effective July 1, 1979. Assistant Professor Linda Hall was promoted to associate professor, effective January 1, 1979, and Assistant Professors Raymond Baker and Michael Bevan were promoted to associate professor effective July 1, 1979.

Professor Holt spent the 1978-79 academic year on sabbatical leave of absence in Göttingen, West Germany, where he is continuing his research on new aspects of the molecular biology of slime molds.

Dr. Marian Koshland, on sabbatical leave from the University of California at Berkeley, spent the past year in the Department in Professor Baltimore's laboratory. Dr. Carlos Hirschberg, from St. Louis University, and Dr. Charles Sweeley, from Michigan State University, also spent sabbaticals in the Department. We were very pleased and it was stimulating to have these visiting faculty in the Department for the year.

Professor Fox was honored during the year by being named to the Lester Wolfe Chair of Molecular Biology.

Professor Christopher Walsh was selected to receive the 1979 Eli Lilly Award in Biochemistry. This award is made to a scientist under the age of 36 for outstanding contributions in research in the field of biochemistry.

GENE M. BROWN

Department of Chemistry

Bachelor of Science degrees in chemistry this year were awarded to 60 undergraduates: 2 in September, 9 in February, and 49 in June. Most of the graduates will be attending graduate school in chemistry, medicine or related areas, or have been employed by industry. The Master of Science was awarded to 7 candidates: 3 in September and 4 in June. A total of 27 Ph.D.s were awarded to 5 candidates in September, 9 in February, and 13 in June. To date, 1,556 Ph.D.s and 380 Master's degrees have been awarded by the Department.

RESEARCH

Research throughout the 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 our laboratories.

One of the major interests in Professor H. Gobind Khorana's research group has been nucleic acids. Professor Khorana and his associates developed techniques in the 1960s for the chemical synthesis

of polynucleotides of completely defined sequences. During the past several years efforts have turned to the total synthesis of a gene. This goal was recently realized, and the gene was shown to have all the expected biochemical properties and biological functions. Currently, attention is being focused on detailed studies of the structure-function relationships in this gene. Since this gene directs the synthesis of a suppressor transfer RNA, and since its transcription is under control of the synthetic promoter, some of the questions that can now be approached at a precise chemical level are: 1) What is the mechanism of the initiation of transcription? 2) How does RNA polymerase recognize the promoter region? 3) What is the role of the minor bases in tRNA and the nature of the interaction between the amino acyl tRNA synthetase and the tRNA?

Other lines of investigation involve 1) the role of the membrane in the replication of DNA and 2) cloning of the genes for membrane proteins such as bacteriorhodopsin, the single protein of the purple membrane of halophilic bacteria.

Chemical studies of biological membranes also are quite actively pursued by Professor Khorana's group. Biological membranes perform a variety of vital functions. Thus, although in the past the importance of biological membranes has often been grossly underestimated, it has become clear in recent years that membranes hold a central position in a multitude of biological phenomena of great importance, including neural function, cell and nuclear division, biological transport, energy metabolism, and macromolecular synthesis.

A number of problems is being investigated in Professor Khorana's laboratory. One central problem is the nature of interactions between membrane components; namely, membrane proteins and phospholipids. Chemical approaches are being developed with the hope of obtaining insights into membrane dynamics. A second general problem is the *in vitro* reconstitution of defined membrane functions and the structures of hydrophobic regions of membrane proteins. Here a number of systems are under study. These include:

1) Cytochrome b₅:Cytochrome b₅ Reductase: Exploring the interaction between phospholipids and cytochrome b₅, it has been found that the latter can be inserted into liposomes consisting of a synthetic phospholipid and, furthermore, that on photolysis, significant covalent crosslinking of the phospholipid to the hydrophobic segment of the protein takes place. Determination of the site(s) of crosslinking is in progress.

2) Glycophorin, the major sialoglycoprotein of the red cell

3) Studies of Ionophores: e.g., Gramicidin A

4) Ca⁺⁺/Mg⁺⁺-ATPase of Sarcoplasmic Reticulum

Finally, a major line of investigation is the purple membrane of extremely halophilic bacteria. Bacteriorhodopsin, a single protein in the purple membrane of the extremely halophilic bacteria *H. halobium* brings about pumping of protons from inside the cell to the outside. Retinal, forming a Schiff base with the protein, is the light sensor. The total amino acid sequence of this protein containing 248 amino acids has been determined. The orientation of the protein in the membrane has been deduced. Studies are in progress on the three-dimensional structure of this protein in the membrane so as to understand how protons are pumped.

Professor Dietmar Seyferth's research ranges broadly in organometallic chemistry, with projects in main group as well as in transition metal chemistry.

In the main group research, Professor Seyferth and his associates are investigating the unusual properties and chemical reactions of the smallest cyclic compounds of silicon known, the siliacyclopropanes and the siliacycloprenes. These compounds are characterized by an extraordinary order of reactivity, due mainly to large ring strain. Many of their reactions are unprecedented in organosilicon chemistry. The synthesis and chemistry of allylic and related organolithium reagents are also being studied, in particular those in which two-reaction termini are unsymmetrically substituted, e.g., *gem*-difluoroallyllithium, Li(CF₂CHCH₂). The factors which affect the regioselectivity of such species are under investigation in order to assess their utility in organic and organometallic synthesis.

In the transition metal area, Professor Seyferth's efforts are focused on the synthesis and reactivity of (organo)metal cluster complexes. To date most of this research has explored the

alkylidynetricobalt nonacarbonyl complexes which contain a tetrahedral core of one carbon and three cobalt atoms. Each cobalt atom bears three coordinated carbon monoxide ligands and the carbon atom bears one sigma-bonded substituent. The latter is capable of wide variation. The organic chemistry of these complexes, i.e., reactions of substitution at the cluster carbon atom and reactions of functional groups attached to the cluster carbon atom, has been explored in some depth. The proximity of the three cobalt atoms profoundly affects the organic reactivity of the novel $S_2Fe_2(CO)_6$ complex in which an S_2 ligand bridges two $Fe(CO)_3$ units which also are connected by an Fe-Fe bond. The main site of reactivity appears to be the S-S bond.

The discovery of unique and valuable new homogeneous catalysts is the ultimate goal of Professor Richard R. Schrock's research. The "cracking" of large carbon-containing molecules into smaller ones which can be purified forms the basis of most of today's chemical industry and will undoubtedly continue to do so, whatever the source of carbon compounds in the future.

One of the most efficient ways of recombining these small molecules, such as ethylene or propylene, into larger useful ones is with homogeneous catalysts. To explore possible new catalysts, Professor Schrock makes new metal-containing molecules having hydrocarbon fragments attached to them, studies how they react with simple small molecules, hoping in the process to discover new principles of catalysis and/or unique catalytic processes.

The metals Professor Schrock's research group is most interested in are niobium, tantalum, molybdenum, and tungsten. The organometallic chemistry of these elements has previously been underdeveloped. So far, one unique catalytic reaction has been discovered, the selective dimerization of simple olefins such as ethylene and propylene.

A new thrust area in Professor Schrock's work is research into methods of reducing carbon monoxide with hydrogen. In the future, coal is likely to be gasified to carbon monoxide and hydrogen and that mixture then used to form other small molecules such as methanol or ethylene glycol. He is presently modeling the hoped-for catalytic reaction.

The bulk of Professor Schrock's work has been with what are called transition metal alkylidene complexes. These appear to be fundamental intermediates in many catalytic reactions, among them the olefin metathesis reaction. It has been discovered that niobium and tantalum will metathesize olefins and are in the process of tailoring catalysts to do given types of transformations, in particular, those involving functionalized olefins.

Professor William H. Rastetter's program in organic chemistry leans heavily toward the application of synthesis in areas of biological interest. A portion of this work entails the total synthesis of natural products or natural product analogues of physiological interest. The bulk of the effort is directed toward the design and synthesis of compounds whose reactivity mimics that of biogenetic intermediates or of intermediates present at enzyme active sites.

Epoxides serve multiple roles *in vivo* as activated intermediates during biosynthesis or as causative agents of mutagenesis and carcinogenesis. The spectrum of reactivity displayed by epoxides is broad and the reactivity of any given epoxide is often difficult to predict. Synthesis of various epoxides, linked with reactivity and *in vivo* activity studies, are being carried out in Professor Rastetter's laboratory, with the ultimate aim of understanding the factors which govern the mode of *in vivo* action of epoxides.

Various mechanisms have evolved in bacteria and fungi for the acquisition and transport of iron from the biological milieu to the cell interior. The siderophores constitute a class of high iron-affinity compounds from microorganisms which are excreted under conditions of cellular iron deficiency. The siderophores bind iron and are transported back into the cell where the iron is released and utilized. The siderophores are of interest to Professor Rastetter's group in relation to the transport mechanism and because of their high affinity for iron. This latter property promises to make synthetic siderophore analogues useful in the treatment of iron-overload diseases in humans. The understanding of the bacterial transport process will hopefully lead to the design of drugs for clinical use which will not foster bacterial growth as a side effect of the drug therapy.

Various biological substrate oxidations have attracted the attention of chemists. The mechanisms of these mild *in vivo* reactions are often complex, and, as of yet, not completely understood. Professor Rastetter is studying chemical model systems for the oxidations mediated by vitamin B₁- and vitamin B₂-dependent enzymes. This work is expected to show how the vitamins function in

complex enzyme systems. Application of this knowledge may provide new ways of achieving oxidations in a mild and selective fashion in the laboratory.

A principal area of research in Professor Jeffrey I. Steinfeld's laboratory involves the study of molecules at high levels of vibrational excitation, such as can be frequently produced by pumping with high-intensity lasers. In such nonequilibrium situations, new types of chemical reactions may occur; there is also the important question of relaxation processes, both intramolecular and those leading to equilibration with the surroundings. Among the systems under investigation are the multiple infrared photon-induced reactions of mono-, di-, and trichloro-substituted ethylenes. Professor Steinfeld and co-workers have established the mechanism for the laser-induced dehydrohalogenation reaction, and have identified a new type of vinylidenecarbene intermediate, $F_2C=C:$; derived from 1,1-difluoro-2-chloroethylene. They also are studying the reactions of systems possessing two or more available channels, such as the decomposition of cyclobutyl chloride, in order to test models for the reaction mechanism by comparison with the very accurate thermal studies available for this system. The possibility of bond-selective or mode-selective excitation is being explored by way of the C-H stretching modes in complex hydrocarbons, which can be excited with a DF laser. A crucial problem in the interpretation of multiple infrared photon absorption and dissociation effects in complex molecules is that of the distribution of vibrational energy among the excited molecules. This question is being examined by spectroscopic methods, including diode-infrared laser double resonance (on sulfur hexafluoride) and infrared-visible double resonance (on biacetyl).

A second line of Professor Steinfeld's research involves the use of laser-induced fluorescence excitation spectroscopy to probe the composition of flames and combustion systems. This work is being carried out as a part of the newly formed Center for Health Effects of Fossil Fuels Utilization. One objective is the detection of polynuclear aromatic hydrocarbons in such sources, and the correlation of these data with other analytical, engineering, and toxicological studies being carried out in the Center. Another area of investigation is the kinetics of nitrogen-bearing species (NH, CN, etc.), which lead to nitrogen oxide formation in such systems.

PERSONNEL

Professor John W. Irvine, Jr., retired after 45 years, 42 of which he was a member of the staff of the Chemistry Department. Professor Irvine has served as the Department's Executive Officer since 1966. Professor Jack E. Baldwin left the Department to accept the position of Waynflete Professor of Chemistry at Oxford University, England. Professor Sidney M. Hecht left the Department to accept a position at the University of Virginia.

Leave of absence has been extended for Professor John M. Deutch, who will continue to serve the United States Department of Energy as Undersecretary.

Professor Edward I. Solomon was promoted to associate professor.

We were saddened by the death of Dr. Henry A. Hill on March 19, 1979. He was a Ph.D. alumnus of the Department and a member of the Chemistry Department Visiting Committee.

Visiting faculty and scientists were as follows: Vladimir A. Batyuk, from Moscow State University, USSR; Derek R. Boyd, Queen's University, Belfast, Ireland; John H. Brophy, University of Leeds, England; Itamar Burak, Tel-Aviv University, Israel; Cheng A. Chang, Wellesley College; Moshe Gitterman, Bar-Ilan University, Tel-Aviv, Israel; B. David Green, M.I.T.; Yehuda Lapidot, Hebrew University, Jerusalem, Israel; John W. Lehman, Lake Superior State College; Michel A. Lhermitte, Université de Lille, France; Arnet L. Powell, Office of Naval Research; Vernon N. Reinhold, Harvard Medical School; Vladislav Shcherbakov, Institute of Chemistry, Gorky, USSR; Mwindace N. Siamwiza, University of Zambia, Lusaka, Zambia; Miriam Sohn, Princeton University; Peter J. Stang, University of Utah; Daniel D. Traficante, Yale University; Frank Vallaccio, College of the Holy Cross.

The Department was privileged to sponsor a series of lectures provided by the Arthur D. Little, Karl Pfister, T.Y. Shen, and Abby Rockefeller Mauzé visiting professorships. Arthur D. Little Lecturer Richard C. Lord's talk was entitled: "The Early History of the Raman Effect." The

Karl Pfister Visiting Professor Robert E. Ireland lectured on the following topics: "The Claisen Rearrangement: A Personal Overview of its Use in Natural Product Synthesis," and "An Approach to the Total Synthesis of Chlorotricolide, a Macrolide Antibiotic." Dr. Julius Axelrod of the National Institute of Mental Health in Bethesda, Maryland was the T.Y. Shen Visiting Professor. His lectures were "Phospholipid Methylation and Membrane Structure Function," and "Regulation of Metabolism and Action of Catecholamine Neurotransmitters." Dr. Isabella Karle, Abby Rockefeller Mauzé Visiting Professor, gave two lectures, "Unusual Molecular Rearrangements, Configurations, and Bonding Established by X-Ray Diffraction Analysis of Single Crystals," and "Confirmations of Oligopeptides in the Crystalline State."

A symposium celebrating the 75th anniversary of the founding of the Research Laboratory of Physical Chemistry was held by the Department of Chemistry on November 17, 1978. The following lectures were presented: Dr. John M. Deutch spoke on "Physical Chemistry in Future Energy Technology"; "Restoring the Environment for Research and Development" was the title of a lecture by Dr. Edward R. Kane, President of E.I. Du Pont de Nemours and Company. Dr. John Ross' lecture was entitled "Physical Chemistry: Trends in a Lively Science," and Dr. Linus Pauling, Karl Taylor Compton Lecturer, spoke on "Arthur Amos Noyes and the Research Laboratory of Physical Chemistry."

JAMES LLOYD KINSEY

Department of Earth and Planetary Sciences

Graduate enrollment in the Department of Earth and Planetary Sciences continues to be nearly constant. During the 1978-79 academic year, we had a total of 123 students enrolled in the Department. Of these, 80 were in Course XII, and 43 in XII-W, the Joint Program in Oceanography with Woods Hole. Eighty percent of the graduate students in Course XII are supported by research assistantships, teaching assistantships, or departmentally awarded fellowships, while 15 percent receive support from outside fellowships. In the Joint Program, all students are supported either by graduate research assistantships or fellowships.

We have experienced a slight decline in our undergraduate enrollment, from 65 to 60, although the quality remains consistently high. But the number of undergraduates doing Undergraduate Research Opportunities Program projects in this Department has risen from 21 in 1977-78 to 28 in 1978-79.

We awarded the following degrees during the period September 1978 to May 1979: 21 Bachelor of Science, 4 Master of Science, 7 Doctor of Philosophy (XII), 1 Doctor of Philosophy (XII-W).

Honors and Awards

The faculty continue to receive numerous awards and honors. Professors Peter Molnar and Tanya Atwater have been recipients of Alfred P. Sloan Fellowships for three-year periods. In addition, Professor Molnar has recently been awarded a Guggenheim Fellowship. Professor John Sclater received the Rosenstiel Award in Oceanography in March 1979. Professor Nafi Toksöz received the National Aeronautics and Space Administration (NASA) Exceptional Scientific Achievement Award. Professor Irwin Shapiro was recently awarded the Benjamin Apthorpe Gould Award by the National Academy of Sciences. Two more members of the Department, Professors Keiiti Aki and Gordon Pettengill, were elected to the National Academy of Sciences, bringing to six the number of Department faculty in the Academy. Professor Roger Burns was elected a Councillor of the Mineralogical Society of America, and Professor William Brace received the award for best paper of the US National Committee for Rock Mechanics.

Curriculum

Our major development during the past year was the addition and successful running of a Geophysics field course. This was a full-year course which was run in conjunction with our already popular

Geology field course. We are encouraged by the enthusiasm of staff and students in these programs, and also by the positive reaction of our Visiting Committee to this expansion of our field-oriented program. The geology course also drew a large enrollment from Wellesley College under the Exchange Program. We hope to be able to continue the operation of the Geophysics course, at least on an alternate-year basis.

Our Crosby Professor this year was Professor Hugh Taylor from the California Institute of Technology. He taught a course entitled "Geochemistry and Petrology of Hydrothermal Systems" and centered it around the primary process by which ore deposits are found -- that of hydrothermal convection in cooling bodies. As usual, it was very well attended.

RESEARCH

The Department maintains a vigorous program in many diverse areas of earth and planetary sciences.

Geology

Professor Clark Burchfiel is studying what appears to have been a major truncation event in the southwestern United States about 250 million years ago. His data suggest that the truncation occurred by transform faulting that juxtaposed slivers of continent 10s to 100s of kilometers long along the west coast of North America from all along the continent from east central California to southern Mexico. These slivers and their boundaries have been deformed significantly by later events. Recognition of these structures and their deformation permits an understanding of the recent evolution of the southwestern part of the North American plate.

One of the largest recirculating open channel flumes in the world for studying sand transport and bed configurations has been operated the past year by Professor John Southard and his collaborators. The water in the flume which is 60 meters long, 2 1/2 meters wide, is heated to change the Reynolds number of the flows. The flume is being used for extensive study of large-scale sand bed configurations (megaripples and sand waves) commonly observed in natural environments but hitherto impossible to study in laboratory conditions. Based upon work in the field, Professor William Pinson has suggested that the buried thermokarst lakes of northern Canada are buried meteorite craters. He has located more than 500 on aerial photographs. These are a new geomorphologic feature.

Geochemistry

Professor Frederick Frey has been studying the Hawaiian Islands-Emperor Seamount chain in terms of the physical and chemical processes of the underlying volcanoes. He has found that the most primitive basalts which erupted along this chain in the last 65 million years have surprisingly uniform geochemical characteristics. Their compositions are distinct from basalts intruded at accreting plate margins. The results imply that the major mantle source for the Hawaiian ridge and Seamount chain is in the lower mantle below a depth of 650 kilometers. Professor Stanley Hart and Dr. Nobumichi Shimizu have placed the ion microprobe in operation this past year. This instrument, operated by an M.I.T./Harvard/Brown consortium, has been in full operation since February. While much of the time to date has been used in evaluating analytical techniques and developing the necessary skills for operating the machine, a number of geochemical projects have begun. They have observed zoning of trace elements in mineral phenocrysts and found that the zoning is stepwise rather than continuous, showing that crystallization in magma chambers is a dynamic process. The high precision with which lead isotope ratios have been measured in galena crystals from ore deposits suggests that the technique has great promise for studies of the chemistry and flow patterns of hydrothermal ore fluids.

Professor Frank Spear has discovered a new rock-forming silicate mineral in which is a sodium analog of the common potassium rich mica, phlogopite. Finding new rock forming silicate minerals is most unusual, and the rock was known theoretically but had never been found, in nature. Professor Spear has shown that the mineral is probably restricted to metamorphic rocks of low CaO

and high MgO and Na₂O contents. Acceptance of the mineral as a new species by the International Mineralogical Association is pending.

The phase changes and metal-uptake capabilities of manganese oxide minerals continues to be studied by Professor Roger Burns and his group. The nodules are enriched in nickel, copper, and cobalt. They are using scanning electron microscope measurements and attempting seafloor mineral exposure experiments on the floor of the Pacific Ocean.

Geophysics and Seismology

Professor Toksöz' research group has changed its primary orientation from space projects to earth applications. They are concentrating mainly on earthquake prediction and studies relevant to petroleum exploration. From work at M.I.T. and elsewhere, there is increasing evidence that major earthquakes are preceded by long-range and short-term precursors. They expect an effective prediction capability for major earthquakes to be found in the next decade. The petroleum exploration research is concentrating on modeling techniques for the evolution of major sedimentary basins which are primary sources of petroleum reserves. Understanding of their evolution histories determines which are favorable places for the genesis and preservation of petroleum deposits.

The thickness of the elastic lithosphere on the moon and Mars as a function of time is being studied by Professor Sean Solomon and his colleagues. Using tectonic plate flexure theory combining gravity, topography, and geological observations of lithosphere failure, they are able to constrain lithosphere thickness in regions of large volcanic load. On the moon, they have shown significant changes of lithosphere thickness with time. Proximity to major volcanic provinces on Mars seems to be the primary factor contributing to an apparently thin lithosphere there. Study of the fundamental properties of the earth by the attenuation of seismic waves is one area of work by Professor Aki. In the past, determination of attenuation has been hampered by the difficulty in separating dissipation of high frequency waves from other effects. Using a new method, Professor Aki has found that the Q of the earth is a strong function of frequency and increases with frequency according to a power law. His results, when combined with earlier results from lower frequencies, give a strong constraint on the seismic attenuation mechanism in the lithosphere.

Deformation of continents under plate tectonic forces continues to be studied by Professor Molnar and his collaborators. They are concentrating their attention on the Tibetan plateau which is a result of the collision between India and Eurasia. The plateau seems to act as a pressure gauge of the deformation forces of the Asiatic continent. Seismic wave studies suggest that temperatures occur that are high enough to melt the crust in the collision. Professor Molnar has been invited to Peking next year and will undertake a two-week field trip to Tibet. Resistivity and self potential monitoring arrays at Hollister and Palmdale in California have been placed by Professor Theodore Madden. He is upgrading these arrays to make them more sensitive to expected stress changes in the area. The region is an intensively studied one and is part of the San Andreas Fault system.

Professor Gene Simmons and his collaborators are continuing their study of microcracks in rocks and there have been two significant developments during the year. They have found that microcracks produced in rocks associated with active geothermal regions have some unique characteristics that can be recognized with optical and scanning electron microscopes. They also have shown that electrical conductivity in rocks *in situ* at depths of a few kilometers in the earth is sufficiently low that electromagnetic communication may be possible for significant distances in the lithosphere.

Oceanography

Professor John Edmond is actively involved in the study of the marine geochemistry of the hydrothermal activity at the oceanic spreading center on the Galapagos Spreading Ridge. This is a region of novel biology, and this year exit temperature water was discovered at values greater than 500°C. Associated with this very hot water is a spectacular and extensive suite of mineral deposits including sulphides of iron, copper, zinc, and mercury with minor silver, lead, and cadmium. This is a unique and important region for understanding the geochemistry of ore formation. Professor Edmond will lead his group back to the site in the coming year to once again use the submarine ALVIN.

A method for analyzing lattice-bound cadmium in foraminifera tests has been developed by Professor Edward Boyle. He is using this method to investigate the relationship between the composition of the tests and the waters in which the organisms grew. The implication is that one can understand the nature of past climates and the climatic changes between stable periods. Professor Sclater has discovered that he can apply his oceanic thermal models to the geophysical structure of continental basins and shelves. With these models he can predict the observed subsidence and heat flow as a function of time. This enables the prediction of the degree of thermal maturation of the sediments which in turn has implications for the geological and geochemical evolution of these basins.

Professor Charles Eriksen has synthesized observations of equatorially trapped waves in the tropical regions of the oceans. The observations come from moored arrays, and he has shown evidence that there may be a universal equilibrium for these motions in analogy to that known at mid-latitudes for ordinary internal waves.

Professor Carl Wunsch and his collaborators have continued their studies of the application of inverse methods for determining the general circulation of the ocean. They are beginning to introduce satellite altimeter data into their models along with various chemical tracer observations, working toward the production of full Atlantic Ocean circulation models.

Planetary Physics and Chemistry

The topographic structure of Venus has been the major research effort this past year of Professor Pettengill. He has discovered, using the radar altimeter on Pioneer, substantial variations in the surface of Venus which imply the existence at some time of tectonic activity. In addition, he has been able to obtain useful radar images of the surface features.

Professor John Lewis has taken the Pioneer Venus mass spectrometer results for the lower atmosphere of Venus in order to test his previous predictions. He finds strong evidence for regulation of the oxidation state of the atmosphere by an FeS_2/SO_4 buffer. He believes it unavoidable that the iron oxide content of the Venus crust is 10 to 100 times lower than that of the Earth. Earth-like (i.e. wet) models for the formation of Venus which involve loss of vast amounts of hydrogen, and absorption of oxygen by the crust, can apparently now be ruled out.

Using radio-interferometric tracking of the Pioneer Venus probes, Professor Charles Counselman and his colleagues have made the first profiles of vector wind velocities as a function of altitude on a planet other than the Earth. They have discovered that winds in the atmosphere of Venus were predominantly easterly at all altitudes with speeds of about 1 meter per second near the surface rising to over 200 meters per second within the clouds. These high velocities are the result of the peculiar radiative balance in the Venus atmosphere. Very long base line radio-interferometry (VLBI) continues to be exploited by Professor Irwin Shapiro and his collaborators. They have found that the anomalously flat spectrum of the BL Lac object 0735+178 is the result of the superposition of the peaked spectra from a number of distinct components (called the "cosmic conspiracy"). Furthermore, he has developed a new technique which allows the relative position of a pair of quasars to be determined with vastly improved accuracy. Application to a particular pair yielded a relative position with uncertainty under 5×10^{-4} seconds of arc. A repetition of this measurement will demonstrate which parts of this complex are expanding apparently with a velocity greater than the speed of light.

Professor James Elliot and his group have obtained the first temperature profiles of the upper atmosphere of Uranus at the 10^{-3} - 10^{-2} millibar level. They use a stellar occultation technique. The mean temperature of 100°K is about 40°K cooler than the upper atmosphere of Neptune, despite the fact that Neptune receives less than half the solar energy received on Uranus. The results show a wave-like temperature variation with altitude that could be caused by photochemical layering or upper atmospheric waves.

PERSONNEL CHANGES

In September 1978, Dr. Frank Spear joined us as assistant professor of Geology. Professor Spear's area of expertise is petrology, with unusual breadth in field, experimental, and theoretical petrology. He comes to M.I.T. from the Carnegie Institution in Washington.

Department of Mathematics

Dr. James Elliot came as associate professor with a joint appointment in the Department of Physics. Previously, Professor Elliot was at Cornell University. He is primarily an optical astronomer with major expertise in the development and use of new instruments. He is best known for his recent discovery by occultation techniques of the rings of Uranus. Professor Elliot also will serve as director of the Wallace Astrophysical Observatory.

Professor Patrick Hurley retired in June 1978 and is now serving as a half-time senior lecturer in the Department. Dr. John Dickey left his position as associate professor of geology in May and has joined the National Science Foundation.

Professor John Sclater has been on sabbatical leave for a full year, pursuing research on a global model for plate reconstruction at Cambridge University in England. Professor Keiiti Aki spent the period of July-December 1978 on sabbatical at the Earthquake Research Institute, University of Tokyo, Japan.

The Department has a new Administrative Officer, Douglas Pfeiffer, who replaced Lynn Dickey in April of this year.

CARL ISAAC WUNSCH

Department of Mathematics

The Report from the Department of Mathematics starts on a sad note, recording the very sudden death of our colleague and friend, Professor Daniel B. Ray, on February 19, 1979. Dan came to M.I.T. as an assistant professor in 1957, being promoted to associate professor in 1960 and to professor in 1964. Not only did he contribute to the Department in terms of his research and teaching activities during those years, but he also made significant contributions in administration, serving as Executive Officer and subsequently as Chairman of the Pure Mathematics Committee. The Department benefited much from his quiet wisdom and dedication in carrying out these responsibilities. A service was held in Kresge Chapel on March 1, at which his family, friends, and colleagues joined in paying tribute to his memory.

Turning to other Department affairs, Professor Daniel Kleitman has been appointed as Head of the Department, to succeed Professor Kenneth Hoffman who steps down on July 1 after eight years in this position. Professors Louis Howard and Franklin Peterson have been appointed Chairmen, respectively, of the Committees on Applied and Pure Mathematics, replacing Professors Willem Malkus and Gilbert Strang, who had each served in these positions for three years. Professor Arthur Mattuck has resigned as Chairman of the Undergraduate Mathematics Committee in order to devote more time to his research and teaching, and to his activities as Class of 1922 Professor. Professor Mattuck was instrumental in setting up the Undergraduate Mathematics Office in 1971 and has been Chairman of it since that time. His contributions to the Department, to mathematics, and to the thousands of M.I.T. students who have been in our courses and programs during those years, are immeasurable. Professor Mattuck's responsibilities will be shared among a group of faculty, with Professor Frank Morgan acting as coordinator.

Undergraduate and Graduate Programs

In a further broadening of the options in our calculus program, this year Professor James Munkres offered a new one-year course, 18.012-18.022 Calculus with Theory, stressing rigorous arguments and proofs of theorems. It was designed for students who have already had extensive high school calculus, and was well received by the 30 freshmen who took it, six of whom have decided to major in mathematics. Next year, students with 12 units of advanced placement credit in calculus will be able to keep 6 units of this credit even if they take the new calculus course; this should encourage some of those with credit for 18.01 to deepen their knowledge of calculus in 18.012 rather than to push on immediately into several variable calculus.

Another new course, 18.07 Numerical Analysis with a Programmable Calculator, jointly taught by Professors Strang and Alar Toomre, also attracted a good audience; it will be repeated next year and we hope will thereafter be a permanent feature of the mathematics program.

In these days, when applications of mathematics are being increasingly stressed, it is interesting to note that pure mathematics has apparently not lost its attractiveness: a freshman seminar in Number Theory offered in the fall was so oversubscribed (over 40 students) that it had to be split into three sections, with yet a fourth being offered in the spring.

The Mathematics Department offered an outstanding I.A.P. program this year, some of the highlights of which were: a two-day public debate on catastrophe theory between Professor Martin Golubitsky (City University of New York), an alumnus of our Department, and Professor Hector Sussman (Rutgers), a leading opponent of the theory; another debate was between Professor Kenneth Brecher, propounding the conventional cosmological "big bang" theory, and Professor Irving Segal, propounding a theory developed by himself and usually called "chronometric" theory. Professor William DuMouchel worked with Dr. Robert Reitano (an alumnus of our Department) of the John Hancock Insurance Company to offer a mini-course to prepare students for the first three parts of the spring actuarial exams. The course was well attended, in part because those who passed the exams were promised summer jobs in insurance companies. On a headier note, Dr. Brian McCay, a first-year instructor in the Department, offered a wine-tasting course to over 20 participants, culminating in a formal banquet. (It was repeated this spring.) And a graduate student, Mark Durst, offered a series of lectures on applied probability theory, culminating in a top-hat-and-tails "Casino Night" at Baker House, stressing the applications to roulette, craps, and blackjack. (A prior request to the I.A.P. Policy Committee for \$85,000 to fly the course participants to Las Vegas was turned down!)

This year has seen the awarding of the first Ph.D. in statistics in our Department. Sixteen Ph.D.s and eight S.M.s were awarded altogether. The number of applicants to our graduate program was slightly down this year, but the number and quality of those who entered the program (32) remain constant. Financial support continues to be the biggest problem for the graduate program.

FACULTY

The Department has appointed two new assistant professors of applied mathematics: Dr. Roberto Rosales and Dr. Ka Kit Tung, both of whom are in fluid dynamics. Associate Professors Richard Melrose (partial differential equations) and Richard Stanley (combinatorics) have been promoted to professor, Dr. Dorian Goldfeld (number theory) has been promoted to associate professor, and Dr. Frank Morgan (geometric measure theory) has been promoted to assistant professor.

The following people held visiting faculty appointments in our Department during the year: Professors P.K. Bhattacharya (University of Arizona), Jane Bridge (Oxford University), Louis Chen (University of Singapore), Joseph Gastwirth (George Washington University), André Lichnerowicz (Collège de France), James Murray (Oxford University), Michael Rabin (Hebrew University of Jerusalem), William Schelker (Dalhousie University), and Audrey Terras (University of California at San Diego).

Faculty members on leave during the year were: Professors Hung Cheng (fall), Dorian Goldfeld (spring), Harvey Greenspan (spring), Francis Hildebrand (spring), Steven Orszag (spring), I.M. Singer (year), and Richard Stanley (year).

It is with regret that we record the early retirement of Dr. I.M. Singer, Norbert Wiener Professor of Mathematics. He will continue his career as Professor at the University of California at Berkeley. Professor Singer's contributions to mathematics, to this Department, and to the Institute over a span of 25 years have been as significant as the efforts of any single faculty member could be: a superb mathematician, a great teacher, a source of wise counsel to us all.

In closing, we would like to record the continuing list of honors awarded to members of our faculty. Professor Quillen was elected Fellow of the American Association for the Advancement of Science, Professors Malkus and Steven Kleiman have been awarded Guggenheim Fellowships for the coming

year, and Professor Sy Friedman received a National Science Foundation National Needs Postdoctoral Fellowship. Also, two of our graduate students who received their Ph.D.s in 1978, David Harbater and Howard Heller, were awarded American Mathematical Society Postdoctoral Research Fellowships. (Professor Friedman was nominated as an alternate for this award.)

KENNETH M. HOFFMAN

Department of Meteorology

During the past year our Department became the first meteorology department in the United States to complete 50 years of activity. To commemorate our anniversary we held a "reunion" on October 27-28, 1978, to which former students and other close associates of the Department were invited. The event was highlighted by the first Victor Paul Starr Memorial Lecture, while the remainder of the program included nontechnical talks by former faculty members.

Enrollment

The past year's enrollment of 56 students included 38 who were pursuing degrees in meteorology and 18 in physical oceanography. Five were women; 13 were foreign students. Five Ph.D.s and four S.M.s were awarded.

RESEARCH

The weather radar project directed by Senior Research Associate Pauline M. Austin has been accumulating digital data for New England storms. These data are being analyzed to provide quantitative descriptions of storm precipitation patterns and to determine their relationship to the larger-scale circulations. Data obtained from one of our radars which was shipborne during the Global Atmospheric Research Program (GARP) Atlantic Tropical Experiment (GATE), an international meteorological experiment conducted during the summer of 1974, are also being included in analytical studies of convective precipitation patterns. In December 1978 further measurements on tropical rain were made over the South China Sea as part of the International Monsoon Experiment (MONEX).

Dr. Mark A. Cane has been working on large-scale atmosphere-ocean interaction, with emphasis on the time-varying equatorial ocean circulation, and studies of satellite-derived oceanographic data, with attention to its potential for weather and marine forecasting.

Professor Jule G. Charney has proposed that certain persistent, large-scale, large-amplitude flow anomalies of the atmosphere, viz. the Pacific blocking ridge which caused the anomalously severe western drought and eastern blizzard conditions in the winter of 1976-77, can be explained as a nonlinear locking-in of the thermally driven flow to a topographically resonant near-equilibrium state. This explanation arose from his finding that there is not one, but a multiplicity, of quasi-steady flow equilibria in which the atmosphere may exist for a given external (solar) forcing, more than one of which may be stable with respect to perturbations of large scale. The transition from one to another of these equilibrium states was found to occur when the mean zonal flow is near a state of resonance with one of the Fourier components of the topography. When the equilibrium flow is in its unstable configuration, a wave perturbation will produce a wave form drag (mountain torque) which will alter the mean zonal flow in such a manner as to force a greater wave perturbation and consequently a greater perturbation in the zonal flow. Professor Charney and Visiting Professor Jagdish Shukla have conducted an empirical study of multiple flow equilibria to test Dr. Charney's theory. Early results have been promising. He and Dr. Shukla also have continued their joint investigation of monsoon circulations and low-latitude predictability.

Professor Glenn R. Flierl has conducted research on the theory of oceanic motions of horizontal scales extending from the mesoscale (around 100 kilometers) to entire ocean basins. He is particularly interested in solitary wave theory as applied to isolated features such as Gulf Stream rings. Models of two dimensionally isolated nonlinear eddies have been constructed; their stability to infinitesimal and finite amplitude perturbations is being investigated. The properties of nonlinear flows perturbed by finite amplitude topography or coastline shape are being examined with applications to the Kuroshio meander and blocking events in the atmosphere.

Research Associate Claude Frankignoul has been investigating the low-frequency response of the upper ocean and the ocean interior to stochastic forcing by the atmosphere. Such forcing plays a part in generating sea-surface temperature anomalies and quasi-geostrophic oceanic eddies.

Professor Edward N. Lorenz has developed a numerical procedure for evaluating the amount of moist available energy in the atmosphere from standard meteorological data. This quantity is an extension of the previously defined available potential energy to the case where water in the atmosphere plays a crucial role. Professor Lorenz also has been using simple but representative systems of difference and differential equations to examine the arrangements of the numerous transitions from periodic to aperiodic behavior, or vice versa, as critical parameters are varied. Such systems are being applied to specific atmospheric problems, such as the underlying physics of geostrophic equilibrium.

The US Executive Office for POLYMODE (Mid-Ocean Dynamics Experiment), a bilateral US/USSR program to study mesoscale dynamics in the ocean, is maintained within the Department of Meteorology. Robert H. Heinmiller is the US Executive Manager. The program involves investigators at approximately 12 US and five Soviet institutions, with the goal of achieving a better understanding of the role of eddy processes in the ocean on scales of 50 to 500 kilometers. The US Executive Office provides coordination and administration for the US efforts and coordination with the Soviet program. The major part of the field program was completed in late 1978, and data analysis and numerical modeling experiments are continuing. Other participants include Professor Flierl and Dr. Frankignoul.

Professor Erik L. Mollo-Christensen has been studying nonlinear wave processes in the atmosphere and the ocean. Among his recent results are exact solutions of equations for geostrophic billows in the ocean and the atmosphere, and for edge waves in a rotating stratified fluid. The former solution represents finite-amplitude disturbances on a front, and may model observed cusped deflections of fronts in the equatorial Pacific Ocean, while the latter may model satellite observations of disturbances on the continental-shelf waters in the Gulf of Mexico. This work is in part a result of attempts to interpret satellite data, especially those patterns visible in infrared images. Further work deals with the consequences of modeling the presence of wave groups in a random wave field, taking advantage of recent work by many others that demonstrates the possibility of envelope solitons in surface wave fields. A random-field model can be constructed from envelope solitons that behave nearly independently of one another, and the field statistics can be described in terms of an ensemble of wavepacket-like particles. This viewpoint is also pursued in a joint investigation of wave generation by wind, by Professor Mollo-Christensen and Research Associate Alfred Ramamonjariisoa, at M.I.T. and also at Dr. Ramamonjariisoa's home institution, the Institut Mécanique Statistique de la Turbulence in Marseille, France.

Professor Reginald E. Newell and his collaborators are engaged in climate diagnostic studies involving the general circulation of the atmosphere, its trace elements and aerosol content, sea surface temperatures of the various oceans, global free air temperatures, polar ice extent, and precipitation on continental scales. They found that the recent Sahelian drought was probably a manifestation of a weakening in the global circulation leading to a decreased transport of moisture to the Sahel, rather than that the Hadley cell did not reach as far north as it usually did in the summer. They found that African winds and dust sources are strongly related through wind transport of moisture, and that the deposition of dust follows wind flow patterns. They have examined the long-term trends and fluctuations of zonal mean sea surface temperatures for the Pacific, Atlantic, and Indian oceans. They also have developed a statistical forecasting procedure for predicting Atlantic and Pacific sea surface temperature patterns one to two months in advance.

Professor Ronald Prinn, together with Research Associates Derek M. Cunnold and Fred N. Alyea, has continued work with a three-dimensional dynamical-chemical model of the upper atmosphere. An expanded version of this quasi-geostrophic model with increased horizontal resolution and

containing some 40 chemical reactions is nearing completion. An older version of this model is presently being used to study the dynamics of sudden stratospheric warmings. Research Associate Tsing-Chang Chen, working with Drs. Alyea, Cunnold, and Prinn, has now completed a paper concerning the energy cycles in this three-dimensional model. Recent accomplishments of the group have included a self-consistent description of the global ozone budget, a definition of the scales and phase relationships involved in eddy transport of ozone, and a study of the possible role of deserts as sinks for fluorocarbons. Visiting their project this year was Research Associate Guido Visconti, who worked on improvements to the treatment of radiative transfer in the three-dimensional model and on the chemistry in a related two-dimensional model. They are continuing their measurement program comprising four globally distributed automated ground stations (in Ireland, Barbados, Samoa, and Tasmania) which are taking roughly four-hourly measurements of CFC13, CF₂C12, CF₃CC13, CH₃CC13, CC14, and N₂O. All these species decompose in the stratosphere, leading to ozone destruction. Measurements have been taken for one full year and will continue for at least two more years. The principal aim is to determine the atmospheric lifetimes of CFC13 and CF₂C12 using the measured concentration trends.

In working on planetary atmospheres, Professor Prinn has constructed a chemical-dynamical model of the Venus atmosphere designed to understand the distribution of various sulfur compounds as measured by the Pioneer Venus probes. He also is working with Professor Charles Counselman of the Department of Earth and Planetary Sciences in interpreting the wind speed measurements determined from tracking the Pioneer probes. In work with Professor John Lewis of the Department of Earth and Planetary Sciences, Dr. Prinn has studied the effects of radial mixing on the chemistry of the primitive solar nebula. Work also has begun on a model designed to predict the molecular nitrogen abundance as a function of vertical mixing rates in the deep Jovian atmosphere.

Professor David Randall has studied the effect of the depth of the layer of cloud-top cooling on stratocumulus entrainment processes. He finds that when the cooling layer is deep the overall structure of a model strato-cumulus layer is very sensitive to the details of the entrainment theory. He also has proposed a theory of the formation and maintenance of mesoscale cumulus cloud, which are observed in almost all convective active disturbances. The theory predicts the observed persistence and geometrically regular spacing of the cloud groups. Finally, he has devised a novel Lagrangian model of a buoyant thermal, based on the theory of a self-advecting vortex sheet. Model results show that for slab-symmetric thermals, turbulence production is most vigorous at the thermal base, while for axisymmetric thermals it is concentrated on the sides.

Professor Eugenia Kalnay de Rivas has worked on the improvement of the fourth-order version of the Goddard GCM. The new fourth-order model is producing remarkably accurate forecasts and will be used for predictability studies. In cooperation with Professor Charney, she has adopted a zonally symmetric Boussinesq model originally designed for Venus, to compute the axisymmetric circulation of an ocean driven by surface heat flux and wind stress; the model has also been coupled with an axisymmetric version of the Goddard GCM. Professor Rivas directed thesis research on the three-dimensional moving-flame effects and their relevance to the circulation of Venus, and directed thesis research on the effects and improvements of top boundary conditions in primitive-equation models. She also developed a modified version of the Matsuno time scheme, which is 40 percent faster and has been tested in the coarse-grid Goddard GCM, and conducted studies on the effect of time-difference schemes on numerical weather prediction. In cooperation with Dr. Lee-or Merkiné, she is studying the interaction between stationary and transient Rossby waves, and in cooperation with Dr. Frankignoul, Professor Rivas is developing a quasi-geostrophic coupled ocean-atmosphere model.

Professor Frederick Sanders and his students have continued work on organized convective systems of the central United States. A major finding is that lines of severe thunderstorm and tornado activity tend to coincide with the location of tropospheric gravity waves. Ongoing research has continued on oceanic cyclones of middle and high latitudes. The goal is to develop a better understanding of the role of cumulus convection as well as sensible and latent heat fluxes across the air-sea interface on storm development. Professor Sanders collaborated with Professor Shukla and Visiting Scientist Dr. Kshudiram Saha on a study of tropical cyclone activity in the Bay of Bengal in association with the Indian summer monsoon. The results to date suggest that many of these cyclones can be tracked as tropical depressions which move westward across Thailand before intensifying over the warm waters of the Bay of Bengal.

Professor Sanders also worked closely with Visiting Professor Lance Bosart on a research project designed to investigate how to make a better rainfall amount forecast given that rain is expected. The skill of the most sophisticated operational rainfall prediction model was assessed quantitatively

for southern and central New England. Investigations began on the long-lived convective event associated with the Johnstown, Pennsylvania flood of July 1977 and the Presidents' Day snowstorm in the Middle Atlantic region of February 1979. These studies have helped to establish the importance of detailed boundary layer structure in making an accurate quantitative precipitation forecast.

Professor Peter Stone has continued to collaborate with the National Aeronautics and Space Administration (NASA) Goddard Institute for Space Studies (GISS) on climate research and studies of planetary atmospheres. They have been developing a hierarchy of climate models ranging from the simplest one-dimensional energy balance models to an efficient three-dimensional general circulation model, and have been applying them to evaluate the climate effects of increased concentrations of carbon dioxide or aerosols, and of changes in the solar constant. Professor Stone is a co-investigator on the GISS photopolarimeter experiment currently gathering data on the Venus atmosphere from its orbit around Venus. Professor Stone and the team have been analyzing the data obtained and using theoretical models of Venusian atmospheric dynamics to help understand the data. Professor Stone is also a co-investigator on the GISS photopolarimeter/radiometer experiment for Project Galileo, the Jupiter-probe-orbiter mission to be launched in 1982. In his individual work, Professor Stone has continued to investigate atmospheric eddy heat fluxes, using both theoretical and observational studies to try to pinpoint the factors which control these fluxes. He has been directing student research on the development of simple one- and two-dimensional climate models, the role of vertical structure and of planetary waves in the baroclinic stability problem and the transport of heat, diagnostic calculations of atmospheric eddy fluxes and temperature structure, the extension of conventional terrestrial dynamical models to conditions appropriate for Jupiter, and the analysis of mechanisms for producing the four-day circulations on Venus.

EDWARD N. LORENZ

Department of Nutrition and Food Science

During the 1978-79 academic year, the Department continued to be active in graduate and undergraduate educational programs, and **productive in research**. Specific research programs and accomplishments of individual departmental faculty members are described in the publication *Faculty Research Summaries*, which is available at departmental headquarters.

EDUCATIONAL ACTIVITIES

Undergraduate Program

Enrollment in the undergraduate curriculum in Applied Biology (Course VII-B) in the spring 1979 term was 73, distributed among 34 seniors, 30 juniors, and 9 sophomores. After having remained relatively constant for several years, the total number of students in this program is beginning to reflect the decline in enrollment experienced by several other departments in the School of Science.

Faculty and staff members have continued to participate actively in several facets of other Institute undergraduate programs. Currently, the Department provides a total of 15 freshman advisors from among its faculty, technical and administrative staffs, and graduate students. During the academic year, a total of 151 students were enrolled as UROP participants in the Department (77 in the fall term, 74 in the spring). In addition, 43 students were engaged in full-time research in the Department during the summer of 1979. Support for 31 was provided by UROP and faculty research funds, and 10 by the National Science Foundation Undergraduate Research Participation Grant. Members of the departmental faculty also offered eight undergraduate seminars and served as premedical advisors for 30 undergraduate students.

Graduate Programs

A total of 180 regular graduate students were enrolled in the Department during the 1978-79 academic year. Proportionate distribution among the several degree programs (nutritional biochemistry and metabolism; food science and technology; biochemical engineering; toxicology; and neural and endocrine regulation) was unchanged from recent years. During the year, 26 students received S.M. degrees and 24 were awarded doctoral degrees.

In the spring of 1979, intensive reviews of all aspects of the various degree programs in the Department were initiated and will continue into the 1979-80 academic year. The overall purpose of these reviews is to provide basis for evaluation of current programs with redefinition of purpose and revision of content as required to provide curricula best suited to departmental goals and objectives.

Conferences and Summer Courses

The 16th Annual Underwood-Prescott Memorial Symposium was held on September 26, 1978 to honor the awardee, Dr. Morley R. Kare, in recognition of his contributions to food science through fundamental research in sensory physiology. Dr. Kare presented the memorial lecture on the subject "Functions of the Sense of Taste."

A 10-week intensive course, "Principles of Toxicology," was offered in the summer of 1979 under departmental auspices. The course was an intensive review of the field of toxicology for scientists entering the field or employed by regulatory agencies and industries, and was supported by a training grant from the US Environmental Protection Agency. Forty-eight trainees attended. The course was organized by a committee appointed by Provost Walter A. Rosenblith and chaired by Dean Robert A. Alberty. Participating faculty included Professors Gerald Wogan, William Thilly, and Paul Newberne of this Department, Professors Christopher Walsh and Klaus Biemann of Chemistry, Maurice Fox and Graham Walker of Biology, Nicholas Ashford of the Center for Policy Alternatives, and William DuMouchel of Mathematics, and also Professors K. Rothman and D. Wegman of the Harvard School of Public Health.

Five one-week summer courses were given in 1978: International Nutrition: Problems, Policies and Strategies, Dr. Max Milner, Director; Advances in Food and Applied Microbiology, Dr. Anthony J. Sinskey, Director; Advances in Food Science and Tehcnology, Dr. Marcus Karel, Director; Fermentation Technology, Dr. Daniel I.C. Wang, Director; and Concepts and Techniques in Experimental Pathology and Toxicology of Natural and Man-Made Agents, Dr. Newberne, Director.

FACULTY

The departmental administration changed when Professor Nevin S. Scrimshaw ended his 18-year term as Department Head. He will continue as Institute Professor, devoting increased efforts to further development of the International Nutrition Program and other activities. Professor Marcus Karel also returned to research and teaching activities as Professor of Food Engineering after a five-year term as Associate Department Head.

Professor Scrimshaw was succeeded by Dr. Gerald N. Wogan, Professor of Toxicology. Professor Wang was appointed Chairman of the Faculty Committee on Food Sciences and Professor Richard J. Wurtman as Chairman of the Faculty Committee on Nutritional Sciences.

Two faculty members were promoted to tenured positions: Dr. Charles C. Cooney as Associate Professor of Biochemical Engineering and Dr. William G. Thilly as Associate Professor of Genetic Toxicology.

Dr. Michael Moskowitz was appointed Associate Professor of Neurosciences. He also holds a joint appointment as Associate Professor in Neurology at Harvard Medical School. Dr. James R. Fox, Director of the Division of Laboratory Animal Medicine in the Medical Department, was appointed jointly as associate professor in the Department. Dr. Alexander Klibanov was appointed Assistant Professor of Applied Biochemistry, effective September 1, 1979.

Three members of the faculty resigned during the year. Dr. Robert M. Suskind became Chairman of the Department of Pediatrics, University of South Alabama College of Medicine in Mobile. Dr. Michael C. Archer accepted the position of Associate Professor of Biochemistry in the Cancer Research Center of the University of Toronto. Dr. Thomas Lockwood is working as a research scientist at Harvard University.

Faculty Awards

Professor Karel was selected for the Food Engineering Hall of Fame by the *Journal of Food Engineering*. Professor Karel also was awarded the fourth Food Engineering Award and Gold Medal presented jointly by the Dairy and Food Industries Supply Association and the American Association of Agricultural Engineers. Professor Scrimshaw was awarded a Medal of Honor by the Foundation F. Cuenca Villoro, Zaragoza, Spain. Professor Wurtman was honored as the first Neurosciences Distinguished Lecturer by the University of Missouri. Professor John D. Fernstrom received a Research Career Development Award from the National Institutes of Mental Health.

GERALD N. WOGAN

Department of Physics

The Department has had another productive year with respect to both the instructional and research programs (described in detail in later sections). The size of the Department remained essentially constant, with a total of 87 faculty, 282 graduate students, and 263 undergraduate physics majors. Degrees awarded during the year numbered 48 Ph.D.s, 19 S.M.s, and 94 S.B.s.

The centennial of Albert Einstein's birth was marked by the Department with a symposium on May 14, 1979, organized by Professor Kenneth A. Johnson and chaired by Professor Philip Morrison, with Professors Jeremy Bernstein, Bernard T. Feld, and Irwin Shapiro as principal speakers. The Department also cosponsored (with the Library-Rotch Historical Collections) the set-up and display of the Einstein Centennial Exhibit prepared by the Center for the History of Physics of the American Institute of Physics.

Another very successful event was an all-day symposium on nuclear physics (the fourth in a series focusing on particular major areas of research in the Department). This was organized by Professor Feld and chaired jointly by Professors Victor F. Weisskopf and Martin Deutsch. The speakers were Professors William Bertozzi, Herman Feshbach, Arthur Kerman, June Matthews, John Negele, and Stephen Steadman.

A major development with respect to the operation of our teaching programs has been the complete remodeling of the undergraduate office complex (Room 4-352). This is one of the principal offices in the whole Institute as far as undergraduate education and contact with undergraduates is concerned. Probably almost every undergraduate at M.I.T. has dealings with this office, and for all physics majors it is their main academic home as well as official headquarters. Thus the improvement of this space into an efficient and congenial complex of offices is a most welcome and valuable achievement.

The Department's Committee on Undergraduate Education, under the chairmanship of Professor Eric Cosman, has had as its main agenda item this year the important matter of undergraduate laboratories. In its discussions the Committee considered all three of the teaching laboratories operated by the Department -- the "Corridor" Laboratory, mostly for freshmen, the Physics Project Laboratory, taken mainly by sophomores, and the Junior Laboratory, which is a central feature in the program of all physics majors. Under the management of Professor John G. King, the Corridor Laboratory is being improved and expanded -- an important goal being to put increasing numbers of experiments back into the corridor, where this laboratory in fact began, so that they are accessible at all hours of the day or night.

Department of Physics

During the year the Department continued to strengthen its ties with industry. We have developed, in association with 12 different industrial laboratories, a program which has two main aspects. The first provides summer employment at industrial laboratories for M.I.T. physics students. For the most part these are students who have just completed their senior year, although occasionally a gifted student who has just finished his junior year or a graduate student might participate. The purpose of this part of the program is to introduce students to industry and vice versa. This is not a pro forma introduction but rather one in which the student is involved profitably and effectively in an ongoing research situation. During this year 16 of our students participated in this program.

The second aspect of this program envisions short visits (one or two weeks) of our faculty members to the industrial laboratories involved, and vice versa. A few of these visits have taken place and there are planned visits which will increase the participation.

The following faculty members received promotions during the year: Associate Professors Wit Busza, Michael S. Feld, and John W. Negele were promoted to professor. Associate Professors John W. Belcher, Min Chen, Robert Jaffe, Paul C. Joss, and Ernest Moniz were promoted to tenure. Philip Myers, Stephen Steadman, and Toyochi Tanaka were promoted to associate professor.

Visiting faculty during the year included Michael Fisher, David Lazarus, Peter Pershan, and Georges Ripka, visiting professor, and Donald Q. Lamb, visiting associate professor.

Leaves during the year included Professors Ulrich J. Becker and Kenneth Brecher, for the academic year, James E. Young for fall term, and Aron M. Bernstein, Wit Busza, Robert Jaffe, and Margaret L.A. MacVicar, spring term.

New appointments included Assistant Professors A. Nihat Berker, Richard Cohen, and Roscoe C. Giles; James Elliot was appointed Associate Professor of Physics and Earth and Planetary Sciences and Director of the Wallace Astrophysical Observatory; Ronald C. Davidson was appointed Professor of Physics and Director of the Plasma Fusion Center.

Professor Herbert S. Bridge was named Director of the Center for Space Research; Professor Francis E. Low was named Director of the Laboratory for Nuclear Science. Edwin F. Taylor, Senior Research Scientist in the Department, was named Director of Educational Video Resources.

Professor Clifford G. Shull has been given a Senior US Scientist Award (Humboldt Award) by the Alexander von Humboldt-Stiftung in Bonn. Professor Anthony P. French was re-elected as chairman of the International Commission on Physics Education and Professor Benjamin Lax was re-elected chairman of the Commission on Quantum Electronics, both of the International Union of Pure and Applied Physics. Professor Roman W. Jackiw was elected as a fellow of the American Academy of Arts and Sciences.

Resigning during the year were Professors Brecher and Dirk Muehlner.

ASTROPHYSICS

The observational and theoretical astrophysics program in the Physics Department extends over astrophysical scales from the solar system to studies of our own galaxy, out to other galaxies and ultimately to the universe itself. The observational program covers a large range of the electromagnetic and particle spectrum, from the radio to low energy gamma rays, using ground-based, balloon, rocket, and satellite observing platforms.

This year marked the end of the SAS-C satellite, which re-entered the atmosphere in April 1979 after about four years of highly productive operation. The data analysis will continue for the next two years. Highlights of SAS-C results this year include further evidence that X-ray burst sources seem to be due to nuclear burning in exploding He shells accreted onto stars. Also, that most O and B stars emit X rays from their corona. The statistics now accumulated from SAS-C, as well as from other X-ray satellite missions, indicate that almost all quasars are X-ray emitters.

The High Energy Astronomical Observatory (HEAO-1) also re-entered the earth's atmosphere this year, after a year and a half of operation. Data from the High Energy X-Ray experiment, a collaboration of the University of California at San Diego and M.I.T., has measured the hard X-ray spectrum of about 40 sources above 13 KeV. Among these sources is the quasar 3C273, which is found to emit energies as high as 100 KeV. A preliminary and fascinating result is that the hard spectrum of compact objects such as neutron stars appears to have a sharp cut-off in emissions about 20 KeV, which may indicate absorption by cyclotron resonance in the strong magnetic fields associated with these objects.

The Einstein Observatory (HEAO-2), launched in November 1978, is the next logical step in X-ray astronomy after the surveys provided by earlier satellites, rocket and balloon observations. HEAO-2 provides unprecedented spatial resolution (a few arc seconds) and high energy resolution for X-ray spectroscopy in the 100 eV to 3 KeV band. M.I.T. is responsible for the Bragg Crystal Grating Spectrometer on board the satellite. The first few months of operation have resulted in the detection of more than a dozen discrete spectral lines in X-ray sources such as supernova remnants, compact objects, and in the intervening plasma of galactic clusters. The analysis of these measurements will be important in unscrambling the excitation mechanisms and elemental abundances in X-ray sources.

Optical astronomy is being carried out at the joint M.I.T.-Michigan-McGraw-Hill Observatory and at the international observatory at Cerro-Tololo, Chile. The primary effort in the optical astronomy program is to correlate the X-ray sky with more established and better studied optical sky. The positional accuracy of the X-ray observations has advanced, over the past few years, to allow unambiguous identification of X-ray objects with their optical counterparts. This has resulted in establishing that quasars are X-ray emitters and that some X-ray variable sources are optical variables, as well. In particular, the X-ray burst source 1735-44 has been found to have an optical display delayed several seconds after the X-ray burst.

Infrared astronomy has been carried out at Kitt Peak National Observatory. Much of the Crab Nebula, due to its proximity, has become the prototype astronomical system to study a supernova explosion; the Orion Nebula, with its shock waves, molecular clouds, and dust, has become the prototype region in which to study proto-stellar evolution. High spectral resolution measurements of carbon monoxide emissions at 2 microns have uncovered a region of only 1 AU or smaller in size in the Orion Nebula in which the temperature of the gas exceeds 2000°K. We may be witnessing the earliest stage of gravitational collapse to the formation of a star before its nuclear energy source is ignited.

Radio astronomy uses the facilities at NRAO, the VLA and the M.I.T.-Lincoln Haystack antenna. This year the three-element 1,000 foot baseline interferometer at Haystack became operational at 22GHz and ultimately will be able to perform at 90GHz. The radio astronomy program continues to study the dynamics and excitation conditions in the galaxy through measurements of Doppler shifts of interstellar lines as well as to explore the chemistry of the interstellar medium by searching for molecular constituents. This year ammonia lines with an exceptionally broad frequency width were discovered in the vicinity of the galactic center, which indicates there are regions of high temperatures or large chaotic velocities in the core of our galaxy. Furthermore, several new regions of the galaxy were discovered, where molecules as large as HC₅N are produced.

Radio ranging in the Viking Mars orbiter and lander experiments has performed the most sensitive test of the Einstein theory of General Relativity to date. The retardation in the propagation of electromagnetic signals by the gravitational field of the sun has been measured to be the value predicted by General Relativity to within 0.1 percent.

In cosmological studies, work is continuing on the planning and prototype instrument development for the COBE (Cosmic Background Explorer) satellite which is to be launched in mid-1984. This mission will measure the spectrum and angular distribution of the cosmic background radiation purported to be a remnant of the primeval cosmic explosion. The mission is designed to observe the infrared background from 300 to 5 microns, as well as to separate the cosmic background radiation from the radiation by more local sources such as emission by interstellar and interplanetary dust.

The major events in the space plasma physics program this year are the encounter of Voyager with Jupiter in March 1979, and the promise of Voyager 2's encounter with Jupiter in July 1979.

The M.I.T. instrument on board the spacecraft is, for the first time, able to measure all three components of the interplanetary magnetic field, as well as the charged particle energy distribution along the same axes. Furthermore, the instrument has a factor of 10 times finer time resolution, of the order of seconds, than previous interplanetary plasma probes.

Preliminary results from the Jupiter encounter show that the Jovian satellite Io has a profound influence on the Jovian magnetosphere. There appears to be a plasma torus associated with the orbit of Io. An unexpectedly large fraction of the Jovian magnetospheric plasma is composed of ions heavier than hydrogen and helium; the source of these ions may well be Io. How these heavier elements are ionized remains an outstanding puzzle. The magnetosphere of Jupiter was found to co-rotate with the planet out to a distance of 10 Jupiter radii; however, beyond this distance it lags the planet.

ATOMIC, PLASMA, AND CONDENSED MATTER PHYSICS

Studies of neutron dynamical diffraction effects in perfect crystals of silicon have led to experimental measurement of neutron energy changes as small as 10^{-8} electron volts which is an order of magnitude smaller than the sensitivity available from other techniques. Further studies have shown the existence of a neutron drift velocity in diffracting crystals which is anomalously slower than the normal group velocity of the neutrons in the crystal.

The Versator II research tokamak is now fully operational. The device is being used primarily as a testing bed for various microwave heating experiments. At this time heating at the lower-hybrid frequency, using a 200kW, 800 MHz microwave supply, are under way. Later this year R.F. heating experiments at the electron-cyclotron frequency will be undertaken. This will be carried out in cooperation with the Naval Research Laboratory where a novel 200 kW, 36GHz gyrotron tube was developed.

Research with relativistic electron beams is being carried out on two experimental facilities: The NEREUS accelerator (500kV, 100 kA, 30nsec) and the Physics International Pulserad 110A accelerator (1.5MeV, 20kA, 30nsec). The Pulserad 110A accelerator was purchased in part from M.I.T. funds and in part from funds obtained from the National Science Foundation. The NEREUS facility is being used in the study of beam dynamics in relativistic electron beam diodes. The Pulserad 110A accelerator is used for the generation of intense microwave and submillimeter radiation. Microwaves of centimeter wavelengths are generated in a novel magnetron device and submillimeter radiation has been produced in a free electron laser.

World record values of the plasma confinement parameter (the product of the particle density and the energy replacement time) have been achieved in the Alcator A device. The Alcator C device, a larger and more advanced version of Alcator A, has been brought to operation and achieved plasma currents close to half megampere. A relatively large-scale program has been undertaken for heating of the plasmas obtained in the Alcator C device. The technique involves injecting about four megawatts of microwave power at the so-called lower hybrid frequency. (Experiments carried out on Alcator A have revealed, for the first time, a sharp increase in the rate of fusion reactions as a result of microwave injection at this frequency.)

A parallel program with a similar goal but adopting a different frequency range is being developed utilizing hardware from a dismantled military radar facility. The experimental effort has been integrated with a theoretical program directed at identifying the regimes of plasma operation that are best suited for this form of external plasma heating.

A series of experiments carried out at Princeton has confirmed a theoretical description of the main physical processes influencing the heating and confinement of thermonuclear plasmas. The theory was developed at M.I.T. in order to interpret the Alcator results. As a result, it is possible to foresee the development of a series of devices similar to Alcator which will achieve the conditions for ignition and thermonuclear "burn" of a plasma composed of deuterium and tritium.

On the basis of recent experimental evidence, theoretical descriptions of the solar corona that were based on a spatially homogeneous structure have been abandoned. A new model developed in collaboration with a team from Harvard described the heating of the solar corona occurring in the

magnetically confined plasma loops of the so-called active regions. The inhomogeneous corona model has attracted a great deal of interest in the solar physics community.

Experiments have been carried out on the properties of gaseous atomic hydrogen at a temperature of 4K and the interaction of atomic hydrogen with a frozen molecular hydrogen surface has been studied by a novel type of electron spin resonance. The results yield values for the absorption energy and various atom-surface interactions. The experiment involves one of the simplest atom-surface systems, making it particularly attractive for comparison with theory. Beyond that, the production of abundant quantities of atomic hydrogen at low temperatures, never before achieved, has important applications to many areas of atomic physics including high resolution spectroscopy and collision studies. The production of cold hydrogen is also an important step in a program for the study of the thermodynamic properties of spin-polarized atomic hydrogen. This substance represents a new state of matter, a quantum-mechanical gas, which is predicted to have properties different from those of any other gas.

Tunneling experiments on systematically deformed niobium confirm that structural perfection plays a pivotal role in determining superconductivity in this material, and suggests that an alternative to conventional theory is required to explain the technically promising superconductivity transition metals. The importance of structural perfection in material properties is underscored by unusual lattice transformation and electronic instability behaviors observed in neutron diffraction studies of single crystal ZrV_2 (available only in our laboratory). It is likely that a charge density wave exists in this material which when coupled to lattice stress produces a structural phase transition. Together the niobium and ZrV_2 investigations illustrate for the first time that demonstrable relationships exist between the macroscopic mechanical natures of transition metal superconductors and their microscopic electronic behaviors.

CENTER FOR THEORETICAL PHYSICS

Nuclear Theory

The structure, collective motions, and reactions of atomic nuclei and the dynamical origin of the underlying nuclear force continue to challenge our understanding of finite, strongly interacting systems. The nuclear theory group has addressed a wide range of problems, including the interactions of nuclei with mesonic and electromagnetic probes, the structure of nuclei spanning the periodic table, and heavy ion reactions from below the Coulomb barrier to relativistic energies.

A substantial theoretical effort directed at understanding microscopically nuclear static and transition densities has been motivated by the high precision electron scattering experiments performed at the Bates accelerator. Attempts to explain the magnetization distribution of ^{17}O have centered upon deformed shell model calculations. The collective g factors for rare earth nuclei have been understood with the use of angular momentum projected Hartree-Fock wave functions. Studies of deep inelastic electron scattering aim at an understanding of the nuclear momentum distribution.

Significant progress was made in nuclear many-body theory and the time-dependent theory of nuclear dynamics. The hypernetted chain approximation, a variational rather than perturbative approach, has been advanced, and the elementary modes of excitation of infinite bose systems are being worked out. Another investigation utilizes stationary phase approximation of a functional integral representation of the evolution operator. A consistent quantized theory of large-amplitude vibrations has been obtained, and the fission lifetime of a model one-dimensional system has been calculated. Work towards a quantum mechanical understanding of nuclear "friction" in heavy ion collisions is advancing.

Nucleon-isobar coupled channel effects have been shown to reproduce the nucleon-nucleon resonances observed recently in polarization experiments. The mesonic and isobaric contributions to the ground state charge and current densities of the deuteron and of closed shell nuclei have been calculated.

Pion nucleus elastic scattering has been described in terms of isobar-nucleon hole collective doorway states, with a complex isobar-nucleus interaction potential playing a central role. An extension of the theory to coherent pion photoproduction has demonstrated the importance of multistep processes

in intermediate energy pion reactions. A large increase in the analog state charge exchange cross section has been found to arise from a delicate interplay between the rapid energy variation of the πN cross section and the nuclear spectral function. Dynamical nuclear polarization in pionic atoms has been largely understood. Serious questions about theoretical description of the pion annihilation mechanism have been raised and are under investigation. Pion condensation has been found to enhance substantially the neutrino luminosity of neutron stars.

Possible collective states in single Λ hypernuclei have been re-investigated, taking up the issue of the U-spin symmetry potential. Large U-spin violation in the baryon-baryon force appears to move the possible strangeness analog resonance to higher excitation energy. It has been found that, within the current quark bag theory, hyperstrange quark matter may be stable to everything but β -decay when the strangeness per baryon is in a small region between two and three.

A general theory of the role of final state fluctuations in two-step nuclear reactions through doorways has been formulated. A unified approach to direct reactions and statistical processes in nuclear scattering has been developed further to include multi-particle final states as well as deformation and charge asymmetry effects. This is needed to explain the large inclusive cross sections as well as the deep inelastic processes observed in heavy ion collisions.

Particle Theory

It is presently believed that the particles which are at the basis of all matter are quarks and leptons. The quarks interact through a vector gauge field with eight internal components which are called "colors." This field is the fundamental basis for the strong interactions which are finally responsible for the nuclear force which keeps together the constituents of the atomic nucleus, protons and neutrons. The weak and electromagnetic interactions are also believed to be governed by a vector field which is coupled in a complex pattern to the different quarks and leptons which are called "flavors." Both of these mathematical theories are being investigated intensively by the particle theorists.

At present, all the predictions from the vector gauge theories of quarks and leptons, in so far as they have been put to direct experimental test, have been borne out. Thus, theorists now have more faith in the correctness of these theories: the Weinberg-Salam model for the weak and electromagnetic interactions, and quantum chromodynamics (QCD) for the strong interactions.

We have studied, on the one hand, the free-particle behavior of quarks in hadrons, as seen in the deep inelastic scattering of electrons and neutrinos, and on the other hand, the permanent confinement of quarks in a hadron evidenced by the failure so far to detect an isolated quark experimentally.

These two aspects of the properties of quark have for years been described by two complementary phenomenological models: the parton model and the M.I.T. bag model, respectively. On the one hand, using the naive parton model as a starting point, all higher order QCD corrections have been shown to lead to a kind of renormalization of parton distributions, thus preserving the basic parton picture. On the other hand, using the naive bag model as a starting point, QCD corrections can be incorporated, leading to more realistic descriptions of the forces between quarks, and structural properties of hadrons.

An improved method of handling the "static" bag model has been developed which when applied to the bag model pi-meson has given promising preliminary indications that the quark model pion and the PCAC pion might be reconciled. For example, with the assumption that the quark model pion has zero mass when the up and down quarks are massless, we have found that the observed mass is obtained with $1/2 (m_{\text{up}} + m_{\text{down}}) = 30 \text{ MeV}$.

As an application to nuclear physics, the tensor component of the two-nucleon interaction has been calculated from the bag model and found to be in reasonable qualitative agreement with phenomenological potentials.

We have just completed an exhaustive study of the two quark-two antiquark hadrons which may be seen as prominent resonances in the scattering of baryon and antibaryon. We are now studying the effect of multi-quark hadrons on the spherically symmetric scattering of ordinary mesons and baryons. This promises to lead to a rather novel interpretation of low energy scattering processes in which color plays an essential role.

A major effort has been directed towards an understanding of "hadronic jets," which involves both of the pictures mentioned above. The approach so far is based heavily on kinematics and phenomenology.

We have studied azimuthal angular correlations for the hadronic jets produced in e^+e^- annihilation, and have shown that it can be used as a model independent test of QCD. The azimuthal correlation for the hadronic decay of S-wave heavy quark-antiquark bound states has been calculated.

Much work has been done on the formal mathematical properties of gauge fields, including investigations into soliton solutions, expansion in inverse powers of the number of colors, and possible mean-field approximations. These have a bearing on a possible unification of the parton model and the bag model, and the derivation of these models from the fundamental field theory, QCD.

EXPERIMENTAL NUCLEAR AND PARTICLE PHYSICS

The Accelerator Physics Collaboration (A.P.C.) group has continued its experiments on particle production at the Fermi National Accelerator Laboratory. The group is leading a consortium called the International Hybrid Spectrometer Consortium, the other member groups being from seven other American universities, eight European universities, three Israeli universities, and one Japanese university. The total number of physicists collaborating on these experiments is 140, probably the largest particle physics collaboration in the world. A carefully worked out "constitution," based on years of experience with collaborative experiments, has proven to be fairly effective in facilitating harmonious and productive efforts by this large and dispersed group of scientists. The words, "Hybrid Spectrometer," in the title stem from the fact that the consortium has built, and is continuing to enlarge, the first major particle spectrometer that combines a liquid hydrogen bubble chamber as both a hydrogen target and a vertex detector with an elaborate spectrometer made of various electronic particle detectors.

The first two experimental runs made with this hybrid spectrometer at the Fermilab have been designed to study particle production by protons, K-mesons, and π -mesons of 150 billion electron volts of energy striking the protons of the liquid hydrogen target. The results have shown how the multiplicity of secondary particles produced in high energy collisions depends on the type and energy of the bombarding particle, how the production of secondary particles can be separated into two classes, diffractive and quark-quark, and how similar the behavior of "virtual" exchange particles is to that of "real" particles.

During this year the group has been building a novel particle identifier to add to the spectrometer for the next experimental run, scheduled to start in June 1980. This device will enable the masses of secondary particles to be determined, thus enabling their identification as protons, anti-protons, K-mesons, or π -mesons. This knowledge will permit the analysis of the quark-quark collisions to determine the relative roles of the original quarks in the colliding particles relative to the quark-antiquark pairs that are materialized from the high kinetic energy of the collisions.

Two experiments are being designed for future runs. One will be at Stanford Linear Accelerator Center (SLAC) in January of 1980 to measure the spin orientation of lambda particles produced when polarized photons strike protons. This will yield evidence on the angular momentum states of the quarks in the proton. The second will be at Fermilab in about 1983, and will study particle production by bombarding particles that have energies of a thousand billion electron volts.

The Counter Spark Chamber group has completed a series of experiments at Fermi National Lab utilizing the particle spectrometer developed by them, in collaboration with physicists from other institutions, to study the strong interactions of protons, pions, and kaons. These experiments have led to a definitive set of data on a wide range of reactions utilizing pure protonic targets and complex nuclei. Over the past year the group has turned its attention to the weak interactions, and is involved in a collaborative effort to construct a major new detector for high energy neutrinos at Fermilab. The initial thrust of this experiment will be the detailed study of the weak neutral currents predicted by gauge theories and discovered experimentally several years ago. Modules of the detector (which will contain 400 tons of instrumented material) are currently being tested, and the first experiment, in what should be a several-year program, will begin in late 1980.

Department of Physics

During fiscal year 1979, the Electromagnetic Interactions group continued to search for new particles up to the highest available mass at the Intersecting Storage Ring Facility at the European Center for Nuclear Research (CERN) in Geneva, Switzerland.

They also have completed the equipment and started taking data for a new experiment at PETRA, the e^+e^- colliding beam device at the German Electron Synchrotron Laboratory (DESY), in Hamburg, Germany. This experiment has confirmed quantum electrodynamics down to distances of 2×10^{-13} cm; it will search for new particles, analogous to the J, but made of heavier quarks; it will search for heavy leptons; and will look for asymmetries produced by electromagnetic and weak interference in the production of μ mesons.

The principal activity in Intermediate Energy Nuclear Physics is centered at the Bates Linear Accelerator. This Accelerator has become the national facility for intermediate energy electron physics, where a major experimental program to study the properties of the atomic nucleus, using intermediate energy electrons and photons to generate a wide variety of reactions, is under way.

Fifteen M.I.T. faculty members and Bates staff physicists, and some 80 user physicists from 35 other universities and laboratories in the US, Canada, and Europe, are at present engaged as initiators or collaborators on experiments at the Bates Accelerator. Twenty-two M.I.T. graduate students were associated during the past year with the Intermediate Nuclear Physics program. One S.M. and five Ph.D. physics degrees were awarded at M.I.T.'s 1979 Commencement to students whose thesis research was carried out at the Bates Accelerator.

The intermediate energy program at M.I.T. continues to center about electron scattering experiments using the Bates high-precision electron scattering spectrometer. This spectroscopic facility is being applied intensively to a majority of the more than 45 experiments authorized for performance at Bates. The balance of these experiments entail mainly studies of photon-induced pion and proton-emitting reactions. The last are also important forerunners of the experimental programs planned for the Laboratory's new large experimental hall, which is now nearing completion and expected to be in active use by early 1980.

Further important developments which will extend both its research domain and, together with the new experimental hall, its ability to meet the increasing requirements of users, are in progress at the Accelerator. These include the planned installation with Yale physicists of a polarized electron beam source; an extension of Bates' computing and data analysis capability; and the initiation of final design studies for a beam recirculation system to increase the Accelerator's maximum energy capability to 700 MeV. Funding for the recirculator is included in the current US Department of Energy presidential budget submission to Congress, with construction of the recirculator planned to begin in October 1979, and early- to mid-1981 as the estimated time of completion and application.

The study of nuclear interactions with beams of energetic heavy ions explores the properties of nuclei which have high angular momentum and high energy and can be of species far removed from the stable nuclei found in nature. Investigations of these properties continue at Brookhaven National Laboratory and at the Lawrence Radiation Laboratory using newly developed tools, including a zero degree beam separator for fusion studies of exotic nuclei and a gamma-ray hodoscope for the study of high angular momenta.

A scanning light ion microprobe has been developed and is being utilized by M.I.T. faculty members in the fields of chemical engineering (studying the distribution of trace elements in coal particles); in biophysics (studying the changes in the distribution of elements during cataract formation); in geophysics (examining volatile trace elements in meteorites); and in nutrition (studying zinc and iron levels in control and in malnourished populations).

HERMAN FESHBACH

Interdisciplinary Science Program

The Interdisciplinary Science Program (Course XXV) is sponsored by the School of Science with the intent to provide special opportunities for graduate and undergraduate students interested in science programs that differ significantly from established departmental offerings. For example, students may concentrate in fields such as astronomy, meteorology, oceanography, human cognition and artificial intelligence, perceptual systems, medical sciences, and environmental sciences. Students in the program arrange their own curricula in consultation with faculty advisors, subject to the approval of a faculty committee consisting of representatives from the Department of Psychology and all departments in the School of Science.

Two degrees are offered under the auspices of the Interdisciplinary Science Program, the Bachelor of Science and the Master of Science in Interdisciplinary Science. The objective of the latter program is to provide an opportunity for graduate study in an interdisciplinary area with a strong science core. Students gain preparation for positions in industry, government, research, education, and medicine where training beyond a bachelor's degree is required. They may choose to follow one of the specified degree options, or design their own program. The guidelines and requirements for each specified curriculum are predetermined by a special faculty committee whose members have expertise in that area. Specified master's programs are currently being offered in Animal Cell and Tissue Culture Science, Environmental Chemistry, Science Communication, and Science Education.

The Science Communication degree option is a new program which has just begun this past year; only one student is currently enrolled in this curriculum. However, there has been an immense amount of interest shown in the program as news of its existence spreads. We have received innumerable inquiries, accepted 11 applications, and expect five of these students to attend M.I.T. beginning in September 1979. Each student's selection of courses will be made to develop an integrated curriculum encompassing the technical aspects of science communication, policy issues involved in science and its public understanding, and a broadened comprehension of various aspects of science at an advanced level. Course options will be selected principally from offerings listed in the School of Science, the School of Humanities and Social Science (Political Science and Humanities), and the School of Architecture and Planning (Architecture). A graduate course in Advanced Science Writing (21.742), taught by Professor Rae Goodell, is now available. Also, Professor John Wilkes will be joining the M.I.T. faculty to augment the program in Science Communication in September 1979.

Requirements for the Master of Science in Interdisciplinary Science with specialization in Science Communication are:

- 1) 42 graduate "A" units, of which 36 are to be in science subjects;
- 2) 48 units in subjects related to science writing, the audiovisual media, or the political, social, or legal aspects of science communication; 24 units of which must be listed for graduate "G" or "A" credit;
- 3) A minimum of 24 units of thesis in science communication.

Students will be allowed to specialize in either the science writing or the audiovisual track but will be expected to obtain some training (at least one course) in the alternate track. An internship at the graduate level will also be possible as part of both tracks to provide practical experience in a specific area of training.

In addition to the existing specified master's programs, provision is made, as in the undergraduate program, for individual proposals which are approved in detail by the Course XXV admissions committee. The criteria for acceptance are that there must be a worthwhile focus to the program that cannot be adequately served by an existing departmental curriculum, and that the program contain a significant number of graduate "A" courses in science among the usual course and thesis requirements.

Interdisciplinary Science Program

The Interdisciplinary Science Master's program received initial approval in the spring of 1975 as a three-year experiment. Subsequently, in the spring of 1977, upon the recommendation of the Course XXV faculty committee, approval was given to extend the experiment an additional three years. The statistics summarized below are an indication of the numbers of students in the program, the concentrations they have chosen, and the students' academic records during the initial three years and during the past year.

Thirty-two students have graduated from the Interdisciplinary Science Program so far, and five are currently enrolled in the program. Eleven are expected to begin in Course XXV in September 1979.

In the designated programs nine students have chosen the option in Animal Cell Science, eight in Environmental Chemistry, six have opted for Science Communication and six Science Education. Individually designed programs fall into the following categories: seven in Biomedical Science, one in Analytical Chemistry, three in Neurobiology and Technology, two in Astroscience, one in Life Science and Nutrition, two in Science and Public Policy, one in Management and Nutrition, one in Psychology and Management, and one in Artificial Intelligence.

Cumulative grades for the initial three years of the program ranged from 3.6 to 5.0; the median was 4.7 and one student with a 4.0 average is still enrolled in Course XXV. Cumulative grades for the past academic year ranged from 3.9 to 5.0; the median was 4.5 and the lowest grade point average of continuing students was 4.2.

During the academic year 1978-79, 14 students were awarded the master of science in Interdisciplinary Science: one in Animal Cell and Tissue Culture Science, three in Environmental Chemistry, and eight in undesignated programs. The bachelor of science was awarded to nine students: one in science education, one in medical sciences, and one in mathematical modeling of the physical sciences. There were 17 graduate and 18 undergraduate students in the Department during 1978-79. Cumulative grade statistics for the undergraduates are given below.

Seniors' cumulative grades ranged from 4.0 to 4.9, with a median of 4.5. Juniors' cumulative grades ranged from 3.6 to 5.0, and the median was 4.2. Sophomores' cumulative grades ranged from 4.1 to 4.4 with a median of 4.3.

PERSONNEL

We are sorry to see Professor James M. Austin retire this year; Professor Austin has been with the Course XXV Committee since its beginning and we will miss him dearly. A fellow New Zealander, Professor Ronald G. Prinn, has agreed to represent the Department of Meteorology on the Committee.

Professor Earle Lomon from the Department of Physics will be on sabbatical during 1979-80; a new representative has not yet been appointed.

Professor John M. Buchanan will continue as the Committee's chairman and registration officer for the upcoming academic year 1979-80.

JOHN M. BUCHANAN

Spectroscopy Laboratory

The Spectroscopy Laboratory is dedicated to advancing our knowledge of the structure and dynamics of atoms and molecules and the properties of liquids and solids, utilizing the techniques of modern spectroscopy. These techniques include the use of lasers and high resolution spectrometers. As an interdepartmental laboratory, the Spectroscopy Laboratory encourages participation and collaboration among staff members in various disciplines of science and engineering. This past year there has been participation from several M.I.T. departments, as well as outside collaborations with Harvard Medical School, Boston University, Wellesley College, and other institutions.

The Laboratory has had a long and distinguished career and has played an important role in areas of classical spectroscopy, including the detailed studies of atomic spectroscopy which led to the M.I.T. Wavelength Tables, and the development of techniques for making optical diffraction gratings of unequalled size and resolution. There has been a new challenge to redirect the efforts of the Laboratory and bring it into the era of modern spectroscopy, especially utilizing the powerful techniques made possible by intense, coherent laser sources. Notable achievements in this area include the initial observations of Lamb dip and superradiance phenomena. The progress made during the past year reflects these goals.

Professor Alexander Rich of the Department of Biology and his collaborators have continued their X-ray diffraction mapping studies of the gene 5 protein of fd-phage, which binds to single stranded DNA and thus plays an important role in the DNA replication process. Three functional sites have now been determined: 1) those involved in binding the protein molecules to form the functional dimer; 2) a groove on the surface of the molecule which has the correct dimensions to serve as a binding site for single-stranded DNA; and 3) a region of the molecule with side chains which interact with each other to form protein-protein binding sites which are important for its cooperative interaction with DNA.

In another project, working together with Drs. Andrew Wang, Frank Kolpak, and Gary Quigley, also of the Department of Biology, a hexamer of DNA has been crystallized and data has been collected to 1 Angstrom resolution. This hexamer contains six base pairs and has the sequence dCpGpCpGpCpG, which is self-complementary. At the present time barium and cobalt derivatives have been prepared, and their three-dimensional coordinates have been refined. The phase information obtained is now being used to produce a three-dimensional electron density map. This should reveal aspects of the structure of DNA which have not been seen hitherto at atomic resolution.

Professor Richard C. Lord of the Department of Chemistry, in collaboration with Dr. William Natter (Chemistry) and Professor Rich, have investigated the conformation of aqueous gene 5 protein from bacteriophage by means of laser-Raman spectroscopy. They have studied this DNA-unwinding protein both in uncomplexed form and as a complex with the self-complementary tetranucleotide dApTpApT, which serves as a model for DNA. The structural changes produced by binding of the protein to the tetranucleotide are minor, suggesting that the protein in its native form is already shaped to fit the nucleotide helix to carry out its unwinding function. In joint research with Professor E.R. Blout and Dr. Andre Galat of the Harvard Medical School, Professor Lord has used laser-Raman spectroscopy to follow the effects on the RNA-cleaving enzyme ribonuclease at selective reduction and reoxidation of the four disulfide bonds of the frame of the enzyme molecule.

Professor Robert W. Field of the Department of Chemistry and his collaborators have investigated electronic spectra of a variety of simple molecules using laser-induced fluorescence, selective excitation with narrow bandwidth fluorescence detection, Lamb dip, optical double resonance, and other laser techniques. Results include definitive assignments of numerous low-lying electronic states of PrO, CeO, and BaO, analysis of hyperfine perturbations in PrO, discovery of several new electronic states of CaF and BaF, and extensive rotation-vibration analyses of the CaF $B^2\Sigma - X^2\Sigma$ and CaO $d^3\Delta_r - a^3\Pi_1$ and $D^1\Delta - A'^1\Delta$ bands. Collaborators are Drs. Joël Schamps and Jean Claude

Beaufils, Université de Lille (PrO); Professor Colan Linton, University of New Brunswick, Canada, and Pierre Carette, Université de Lille (CeO); Dr. Bernard Pinchemel, Université de Lille, France (MnO and CaBr); Dr. Susan Till, National Research Council of Canada and Professor John Hardwick, University of Colorado (CS₂); and Dr. Franck Laloe, Université de Paris (I₂). In addition, studies of the velocity and angular momentum reorientation which accompany specific J-changing collisions have been carried out in collaboration with Professor Stuart Silvers (Virginia Commonwealth University) and Dr. Roger Bacis (Université Claude Bernard, Lyon, France).

During the past year Professor Ralph Staley of the Department of Chemistry has begun two projects in the Laboratory. A source that is generally applicable to the production of any atomic metal cation for studies of its gas phase ion chemistry using ion cyclotron resonance (ICR) spectroscopy has been developed. Pulses from a doubled Nd:YAG laser are focused onto metal rods or wires on the end plate of the ICR cell. Mechanistic and thermochemical ion chemistry investigations for Mg⁺, Al⁺, Ti⁺, Cu⁺, Fe⁺, and Cr⁺ are now being pursued. Also, use of photoacoustic spectroscopy to obtain infrared spectra of surface species on solids is being developed using a line tunable CO₂ laser.

Professor Mark S. Wrighton of the Department of Chemistry also has begun research activities in the Laboratory this past year. In one set of studies, high-power ultraviolet and visible pulsed lasers have been used to excite low-valent organometallic precursors to catalytically active forms. Species under investigation include [Fe(CO)₅], [Fe₃(CO)₁₂], and [W(CO)₆], all of which can be used in conventional photocatalyzed reactions of olefins. The objectives of the research include generating extensively coordinately unsaturated (super active) species which cannot be made by any other procedure and two photon excitation of catalytic activity. Other experiments during the past year have concerned the rate of H₂ evolution from p-type semiconductor photocathode materials (GaAs and GaP) in cells for the photoelectrolysis of H₂O to H₂ and O₂. Data show that >5A/cm² of H₂ evolution current density can be sustained, but the energy conversion efficiency (light to chemical energy) is less than one percent.

Professor Jeffrey I. Steinfeld of the Department of Chemistry has carried out double resonance spectroscopy on the ν_3 band of SF₆, using a CO₂ laser pump and a tunable diode laser probe. Excited-state transitions corresponding to $2\nu_3 + \nu_3$ were observed. From the decay of the double resonance signals, relaxation times $p\tau = (24 \pm 3)$ nsec Torr for 2-level signals and $p\tau = (43 \pm 11)$ nsec Torr for 3-level signals were measured, corresponding to an effective cross section of 170 \AA^2 . Power broadening and evidence of field-induced mixing of nearly degenerate fine-structure levels in the vibrational ground state of the molecule were also observed. These results are of use in evaluating various models for multiple infrared photon excitation.

In another study, spectroscopic data from several sources were combined using a special perturbation analysis to obtain deperturbed vibration-rotation constants of the A²Π and X²Σ⁺ states of CN. The resulting deperturbed constants and interaction matrix elements provide a significantly more accurate representation of all perturbed and unperturbed observed lines than the previously reported values.

Professor Edward I. Solomon of the Department of Chemistry continues to study biological systems of structure-function importance using laser resonance Raman techniques. One class of systems under study is binuclear copper centers in enzymes for which the interaction with oxygen serves a critical biological function. A number of derivatives of the mollusc hemocyanins have been prepared which are active and have spectral features allowing resonance Raman experiments to be performed. One important finding is that the oxygen binds to the active site in a manner which bridges the two copper ions. These studies are now being extended to arthropod hemocyanin and tyrosinase.

Adaptation of the Raman system to a ligand helium Cryotip (5°K) has now been completed, making possible variable temperature resonance Raman spectroscopy. Two types of problems will be studied: observation of ground state electronic levels which have thus far been inaccessible in protein systems by classical magnetic techniques, and determination of active site changes associated with a temperature-dependent transformation of the hemocyanin aggregate.

Professor Ali Javan and Dr. John Thomas of the Department of Physics have developed a precision twin laser spectrometer, consisting of two highly stable N₂O lasers servo-locked in frequency offset, to study three level crossing resonances in N₂O. Quadrupole hyperfine coupling constants for the excited vibrational states were determined. Work is now in progress to measure the diamagnetic shift of the R(O) transition of the 10.6μ band of CO₂.

In another project, performed in collaboration with Professor Michael S. Feld, also of the Physics Department, a continuously tunable CO₂ laser has been used to pump the ν_5 vibration of methyl alcohol and produce far infrared laser radiation at coupled rotational transitions. Several hundred new laser lines in the 46-205 μ region have been produced. Spectroscopic assignments have led to accurate values for the height of the ν_5 hindering barrier for torsional rotation and for other spectroscopic parameters. In a related study, Professor Feld and Dr. Joshua Tenenbaum, on leave from the Nuclear Research Center, Israel, have used the Stark Lamb dip technique to reassign the CH₃OH line in coincidence with the CO₂ 9 μ P(34) laser transition, clearing up a serious discrepancy in the literature.

In an ongoing project, Professors Feld and Javan are studying ground state dynamics and laser kinetics in the xenon fluoride "excimer" molecule. During the past year a sensitive fluorescence technique, developed to measure relaxation processes as fast as several nanoseconds, has been used to study V-T and dissociation rates induced by buffer gases such as helium and neon. One important finding is that the ground electronic state of the XeF molecule dissociates as a whole, indicating fast VT equilibration. Information theoretic (suprisal) techniques are being used to determine individual VT and dissociation rates for the ground state manifold.

Professor Feld's studies of laser-induced nuclear orientation have also progressed. These experiments study the gamma ray angular distribution from an atom, optically pumped by a monochromatic laser field, whose nucleus is in an excited isomeric state. Initial observations of gamma ray anisotropies in ²²Na and ^{24m}Na give the first evidence that laser photons can be used to control gamma rays, and a preliminary value of 0 \pm 200 MHz for the ^{24m}Na isomer shift. A related study has shown that the laser optical pumping process dramatically reduces the saturation threshold. Taking advantage of this knowledge, resonances an order of magnitude narrower than the natural line width have been achieved in atomic sodium. Others participating in these projects are Professor Martin Deutsch of the Department of Physics, Dr. Dan Murnick of Bell Laboratories, and Dr. Thomas K \ddot{u} hl, on leave from Mainz University.

In collaboration with Professor Feld, Professor Samuel A. Latt and Dr. Eli Sahar of Harvard Medical School are pursuing their studies of laser-induced sister chromatid exchanges (SCEs) in Chinese hamster ovary cells. In view of the sensitivity of the SCEs as indices of chromosome damage, as well as increasing evidence strengthening the correlation between SCE induction and mutagenesis, the mechanism of SCE induction is of great interest. Experiments using 8-methoxypsoralen and 10 nanosecond pulses from a 350 nm XeF laser have provided data indicating that 8-methoxypsoralen-DNA monoadducts (the presumptive product of a single light pulse) are sufficient to induce SCEs. Additional studies are attempting a chemical analysis of DNA cross-link formation and cell viability to further compare the chemical, cytogenetic, and biological consequences of DNA damage by 8-methoxypsoralen.

In another collaboration, Professor Theodore Ducas of Wellesley College, Dr. Geza Jako of Boston University Medical School, and Lawrence W. Ryan, Jr. of the Department of Chemistry, have used photoacoustic spectroscopy (PAS) to perform infrared absorption measurements on rat and mouse tissue, using CO₂ laser radiation in the 9.2 to 10.8 μ m range. Characteristic spectral features of different kinds of rat tissue -- liver, cartilage, and muscle -- have been observed. Preliminary results indicate a difference between the spectra of normal and cancerous tissue. Such information may prove useful in characterizing different forms of tissue and the influence of radiation on the tissue. This is of particular interest because of the use of CO₂ lasers in surgery. Work is in process to determine thermal conductivities by observing the PAS signal as a function of chopping frequency.

This past year has been one of renewal and change for the Laboratory. There was an increase in the number of Laboratory projects, an increase in the number of research participants, and an increase in the number of interdepartmental collaborations. Renovation of the 10 meter walk-in spectrograph to house the new tunable laser facility is nearing completion. The new facility, equipped with a set of state-of-the-art pulsed and C.W. tunable visible lasers, will be available to qualified users throughout the Institute for fundamental and applied spectroscopic studies. It is a pleasure to acknowledge the contributions to the development of this facility from Lawrence W. Ryan, Jr., Dr. Carter Kittrell, and Professor Robert Field.

MICHAEL FELD

George R. Wallace, Jr. Astrophysical Observatory

The George R. Wallace, Jr. Astrophysical Observatory is a teaching and research observatory, located in Westford, Massachusetts. Its facilities consist of a 24-inch reflecting telescope, a 16-inch reflecting telescope, and a small building that houses a workshop, darkroom, computer, and observers' quarters.

This past spring Professor James L. Elliot assumed the directorship of the Observatory from Professor Herbert S. Bridge, who has served as Acting Director for the past two years. Dr. Edward Dunham also joined the staff.

The main activity this past year has been the design and construction of a new gear system and electronic controls for the 24-inch telescope. This work was initiated in response to major problems experienced during the previous year, and is now nearly complete. The new drives and the telescope have been installed. After a checkout period this summer, normal operation of the 24-inch telescope should begin next fall. Other instrumental work this past year included the construction of a high-speed data recording system by Dr. Dunham. The system is controlled by a microprocessor, so that it will be readily adaptable to virtually all of the data recording needs of the Observatory.

Although the 24-inch telescope has been out of commission, the 16-inch telescope has been used regularly by Professor William Pinson's students in his astronomy courses 12.111, 12.112, 12.113, and 12.114. Altogether, about 70 students used the Observatory during the fall term of 1978 and the spring term of 1979.

JAMES L. ELLIOT

Vice President and Dean of the Graduate School

Annual reports on Student Housing, for the Registrar, and for the Medical Department -- including those for the Environmental Medical Service, Division of Laboratory Animal Medicine, and the Radioactivity Center -- follow the reports on the Graduate School which my associates in the Graduate School and I have prepared.

DEAN OF THE GRADUATE SCHOOL

The continued vitality and viability of the Institute's graduate programs are evident in the continued growth of our graduate population. As the data in Table I show, each of the five schools experienced a modest growth; the total regular graduate student enrollment in October stood at 3,944, an increase of 120 over 1977-78 and a continuation of past trends. My associates, Dean Jeanne Richard and Dean John Turner, provide additional insights on women and minority graduate students and my assistant, Yvonne Whitaker, has provided a brief report on graduate study abroad in the sections which follow.

Foreign Students

Although our foreign student enrollment showed a very modest decrease this year, the number (-6) is not significant in light of total enrollment of 1,145, which is 29 percent of the total graduate population. This overall enrollment percentage has remained quite stable over the past several years although foreign student enrollments in the many departments have fluctuated.

National surveys indicate that the number of doctoral degrees awarded each year in the technical disciplines to American citizens is falling in comparison to the number awarded to foreign citizens. We have recently completed a study of these patterns at M.I.T. and the results are set out in Table VI. The number of doctoral degrees awarded each year for the past decade is presented as is the "normalized" number of degrees. The latter numbers are fractions of the total relevant population who received degrees in any given year and are reported to take into account the changes in the graduate populations over the decade.

There appear to be no significant changes in the "three small schools" over the decade but the fractions of the total student body going on to doctoral degrees appears to be declining slightly in science and particularly in engineering. These trends apply for both foreign and American citizens. Much additional study will be required to gain greater insight. However, it is probably reasonable to surmise that the students' perception of the economic advantage of the doctoral degree in engineering relative to the master's degree has declined.

At the national level there is growing concern with the potential impact of the very large increments in numbers of foreign students enrolled in American post-secondary educational programs. The total number of these students during this past year is estimated to be about 235,000 -- up from about 100,000 some 10 years ago. Although graduate deans traditionally have taken considerable interest in foreign student matters on their individual campuses, their national organizations have not engaged the issues in a concerted fashion. National concerns usually have been addressed by such "advocate" organizations as the National Association of Foreign Student Advisors and the Institute of International Education. Now, the national deans' groups -- the Association of Graduate Schools and the Council of Graduate Schools -- have begun to address questions of objectives and relevance of graduate education for foreign students, their financing, potential "campus political problems," tightening of regulations of the US Immigration Service, and the like.

Vice President and Dean of the Graduate School

Because M.I.T. traditionally has enrolled more foreign graduate students than most other universities, we now find ourselves being approached to lend our "expertise" to these emerging national discussions.

As one example of our presumed expertise and one which has received considerable attention by these national groups, I cite a new program in testing and teaching of English as a foreign language. This program was begun on an experimental basis this past September as the result of a new and concerted effort of the modern languages staff of the Department of Humanities, the Committee on Graduate School Policy, and the staffs of the Office of the Advisor to Foreign Students and the Graduate Office. While we have required certain minimum scores on TOEFL examinations (Test of English as a Foreign Language) for foreign students whose native language is not English and also have offered some subjects of instruction in English as a foreign language, our experience indicates that many foreign students did not have adequate competence in English to function effectively in academic and/or social settings. With the strong support of Deans Hanham and Blackmer of the School of Humanities and Social Science, Professor Margery Resnick of the foreign languages group of the Department of Humanities took the leadership to seek new approaches to this difficult set of problems.

Professor Resnick and her staff developed a new testing program which emphasized oral as well as written communication skills and a new sequence of subjects of instruction to rectify deficiencies at various levels. The tests were first offered on a volunteer but "strongly advised" basis to new foreign students during the September 1978 orientation period. The students' performance was analyzed by Professor Resnick and her staff in an intensive effort so that faculty advisors had the results available on registration day and thereby were able to advise individual students on appropriate remedial action.

An analysis of the new program was prepared by Professor Resnick and her colleagues and several recommendations for improvement were suggested. The Committee on Graduate School Policy reviewed both the analysis and recommendations, and lent strong support to implementing the recommendations. We expect the resulting second phase of the experimental program to be implemented at the opening of the fall term 1979. Advisors to the Educational Testing Service (sponsors of TOEFL) and the Council of Graduate Schools have indicated keen interest in following and perhaps supporting further refinements to this innovative effort.

A prime example of a "political problem" which graduate schools faced during this past year was the problem faced by Iranian students as the result of the overthrow of the Iranian government. Most of the Institute's Iranian students had come with financial support from Iranian governmental organizations or closely related institutions. Thus, in addition to the personal trauma and conflict the overthrow brought to these students, they found themselves unable to finance their tuition costs and, in some cases, personal living expenses. As an emergency measure, effective only during the remainder of the academic year 1978-79, the Institute temporarily waived the usual financial requirements for continuation and the limitations concerning foreign students' eligibility to borrow through the Student Financial Aid Office. When we adopted this stance -- at the height of the confusion in Iran -- we estimated that a maximum exposure of loan funds might be as much as \$250,000. I am pleased to report that at the close of the academic year this exposure appears to be only about \$10,000. The reopening of financial support from Iran, direct assistance to students from relatives or friends in the US, and extraordinary efforts by departments and individual faculty to provide employment combined to produce this favorable outcome.

Earlier in the year, it appeared that the reopening of relations between the US and the Peoples Republic of China, particularly the great emphasis on scholarly exchanges, might result in an extraordinary number of new applicants for graduate admission. With advice and strong support from an ad hoc group of staff and faculty, many of Chinese heritage, we reaffirmed our long standing admissions policy of considering applicants on individual bases and not entering into "blanket" admissions and/or exchange arrangements which would circumvent in any way the process of evaluating individual credentials by relevant departmental faculties.

As matters have developed, we have had only a handful of applications at the undergraduate and graduate levels; there also have been a few postdoctoral arrangements made by individuals, however, the Institute has been almost literally deluged with groups of Chinese visitors seeking to visit some or all parts of the Institute for very short periods of time.

Given the instabilities and uncertainties in international matters, it is becoming increasingly clear that, while we may be experienced "old hands" in matters relating to foreign students and foreign staff and visitors, we will be well advised to undertake an intensive internal study over this next year. In this way, we can help both to keep ourselves "current" and to assist in the national efforts to which I referred earlier.

Tuition

Two significant changes in the Institute's tuition policies were adopted over this past year -- both to become effective July 1, 1979.

The first change affects all students -- undergraduate and graduate, regular and special. This change is the elimination of the separately stated student health fee which for many years has been a required fee for all regular students and an optional fee for all special students. Effective July 1, 1979, all students will be eligible to participate in the student health program of the Medical Department as a consequence of paying tuition.

The announced increases in regular tuition and the part-load fees associated therewith were established to take into account both inflationary cost increases and the elimination of the former separately stated student health fee. There are a number of temporary adjustments which will be necessary as we implement this new policy. In making these adjustments we will make every effort not to "double-charge" continuing students.

The second change affects only some graduate students who are doctoral candidates.

For many years, our graduate tuition policy has required that any graduate student "making progress" toward his/her degree must register as a full-time student and pay full tuition. Students pursuing thesis research *in absentia* have also been required to pay full tuition. In certain disciplines where doctoral thesis work does not entail use of on-campus laboratory, computer, or design studio facilities and/or does require considerable work in areas remote from the Institute, this tuition policy has come to be regarded as unfair by both students and their faculty advisors. Consequently the policy has not been monitored by individual faculty or departments. In addition, disciplines most affected generally do not have the strong sponsored research volume to support graduate students as research assistants or the heavy undergraduate teaching loads to support graduate students as teaching assistants. Further, the problem is compounded by the tuition policies of many universities with whom we are "in competition" in the affected disciplines. In most instances, these universities have tuition policies under which tuition charges drop significantly after the first few years in residence, particularly for the dissertation phase of doctoral study.

After many attempts to resolve the problems, we have finally formulated and adopted a policy which we hope will respond to many of these problems in such a way as to be seen as fair and equitable to all concerned. Doctoral candidates who have successfully completed their general qualifying examinations and have an approved proposal for thesis research will be eligible to apply for a new category of registration -- as a non-resident doctoral thesis candidate -- if during this period of their research, they will not be utilizing office, laboratory, design studio, computer, or housing facilities of the Institute and will not receive financial support from sources administered within the Institute. (Other limitations on eligibility and procedure also have been established).

Students for whom this category of registration is approved will be charged tuition rates at about 15 percent of the regular full tuition and they will be granted certain advantageous tuition arrangements for early completion of their theses during their final term -- which must be a term in residence. Conversely, students who withdraw completely for a period of time and then apply for readmission to present their theses will be required to pay a minimum tuition charge upon return equal to 150 percent of regular tuition.

Initial response to this plan from departments most affected has been positive. Indeed, the faculty see this category of formal registration as a useful vehicle through which to continue to maintain relations with students engaged in dissertation research and to encourage completion of doctoral programs as expeditiously as possible. There will undoubtedly arise a number of unforeseen problems

during this coming year of transition to the new policy but it is our intention to try to resolve these on individual bases.

Graduate Student Financial Support

The generally pessimistic tone of my report for last year on financial support for graduate students probably best characterizes our experience during 1978-79, although there have been a few encouraging developments. The data in Tables III and IV (which are presented in the same format as the corresponding data for last year) indicate that there has been little change overall in the pattern of support for our graduate students.

In an effort to gain a better understanding of the patterns of support, we undertook (at mid-year) another more detailed study of support using the extrapolated data for the nine-month academic year 1978-79. In this study we sought to identify support for living expenses as well as tuition. Because some forms of support provide tuition only, or part tuition only, and some provide stipends -- and that at various levels -- we chose as the "base" with which to compare all forms of support going to the student, a "typical" budget of \$8,600 per student for the 1978-79 *academic* nine-month year.* We simply multiplied the number of students registered by this budget to estimate the total dollar volume of support necessary. We then compared this total with the totals of all categories of support we could identify. The results of this comparison for the entire institution are set out in Table V. These data supplement those in Tables III and IV and illustrate how truly small our institutionally controlled resources are in comparison to the total required to support students' tuition and modest living expenses. The total of the general and endowed funds available through departments or the Graduate Office for fellowship or scholarship support is only 3.9 percent of the total support. Indeed, this total is smaller than the amount borrowed through the Student Financial Aid Office (4.5 percent). Note that the largest single category of support, at 34.3 percent of the total, is the "difference." We do not know the sources which make up this difference; some is supplied directly to students by outside sponsors to meet their living expenses (e.g., to Naval Officers in Course XIII A), but a much larger part of this difference is most likely provided by the students or their parents, by borrowing, and, I suspect, by living at standards lower than we chose as a reasonable base for the study.

We also have carried out a similar analysis for each graduate department. While I choose not to report the numerical results for each department here, I can report that the results served to document the general understanding we have developed regarding the wide disparity of support available among the disciplines. Generally, our student support problems are most serious in the School of Humanities and Social Science, in the School of Architecture and Planning, and in the doctoral programs in the Sloan School. With these new data as further justification for relief to these areas, we hope to be able to provide modest additional general funds to some of the departments most seriously impacted.

Although the amount of College Work-Study Program (CWSP) support utilized at the graduate level is relatively small, it is nevertheless a very significant help, particularly to those departments with needy students and few resources to meet their need. Further, there is ample reason to believe that the Federal support for CWSP will continue and perhaps grow. In an effort to utilize most effectively the CWSP at the graduate level, the staffs of the Student Financial Aid Office (who are responsible for the administration of this program at M.I.T.) and my office have cooperated in developing a new approach to utilize the CWSP for support of eligible teaching and other departmental assistants. While this approach has achieved some success, we believe far better utilization could be made if we were permitted to compensate these assistants in the usual and customary way -- by monthly salaries -- rather than the hourly based, weekly compensation mandated by current CWSP regulations. In addition, we believe some relaxation of the expected levels of parental support required to establish need of graduate students should be made. We recently have been joined by several other universities in seeking these changes in the regulations governing the CWSP. Because allocation of CWSP funds to institutions is very dependent on our providing "hard" data on the financial need of graduate as well as undergraduate students, we also are taking steps to seek greater cooperation of graduate students in filing need analysis data with the Student

* Note that \$8,600 provides for tuition and a cost-of-living budget for nine months approximately midway between the Bureau of Labor Standards' fall 1978 low and moderate budgets for a single person in the Boston area.

Financial Aid Office, whether or not they are applying for and/or will receive need-based financial support. We hope to get sufficiently high levels of cooperation so that we will not have to require graduate students receiving Institute financial support to file such information.

There is emerging a concerted effort by the Association of Graduate Schools, the Council of Graduate Schools, and other national organizations to seek congressional recognition of the financial problems facing graduate students in the context of the current review of the Higher Education Act of 1965. In particular, Title IV of that Act has been the key vehicle through which the Federal government has supported the CWSP, Guaranteed Student Loan Programs, Basic Educational Opportunity Grants (BEOG), and Supplementary Education Opportunity Grants (SEOG). The emphasis in Title IV programs has been primarily on undergraduate needs. Thus, the new efforts of the graduate community are on seeking greater recognition of the financial problems now being faced by graduate students. Although specific recommendations are still being formulated at this writing, it appears that requests will be made to ensure access to graduate education (a "graduate SEOG"), a modified loan program which calls for more realistic assessment of parents' ability to support graduate students, a simplified mechanism for judging and funding "forgiveness" of loan indebtedness based upon manpower needs, and modifications in regulations regarding the utilization of CWSP funds for graduate support, as mentioned earlier.

While M.I.T. continues to be in the enviable position of attracting very high fractions of those awarded Federal fellowships (e.g., some 10 to 11 percent of all new National Science Foundation (NSF) Fellows typically choose M.I.T. each year), the Institute does face financial problems with Federal fellows programs because neither the current cost-of-education allowances or stipend levels have been increased over the past several years to keep pace with inflation. Thus, the Institute has been faced with a substantial shortfall in tuition and fee income, in amounts which are increasing each year. Individual departments are also attempting to supplement the fellows' and trainees' stipends to bring them somewhat closer to the cost of living in the Boston area.

For 1978-79, our 12-month mandatory fee was \$6,462. With the cost-of-education allowance fixed at \$3,400, there was a shortfall of \$3,062 for each fellow or trainee registered for the full 12 months and \$1,477 for those registered for the academic year. The total shortfall for 1978-79 was slightly over \$450,000, of which 88 percent was attributable to NSF fellows and trainees.

The NSF fellow's stipend has been \$325 per month and the trainee's stipend has been \$300 per month. These are far below living costs (some \$200 less than the Bureau of Labor Standards' estimates of Boston-area moderate budget cost of living for a single person in the autumn of 1978) and much less than the stipends established by the Institute for Research Assistants and Teaching Assistants. A survey of our departments indicates that the departmental supplements to the Federal stipends totaled about \$140,000 over the year.

Given the combined "loss" of almost \$600,000 for 1978-79 and an estimated "loss" for next year of about \$650,000, we formally approached the National Science Foundation in the spring to seek relief. We were joined in this effort by a few other universities. I am pleased to report that we have just received notice that the NSF has increased the Fellows' stipends to \$360 per month effective September 1, 1979. While there remains a considerable deficiency in the stipend level -- even at this new figure -- and there certainly remains a major problem in the cost-of-education allowance, we have hopes that the Foundation's recognition of the problem will be followed by changes to assist us in meeting true costs.

Private foundations also are facing severe problems in maintaining fellowship programs in the face of rapid escalations in tuition and living costs. Just as universities' endowment income has not kept pace with inflation, the foundations' endowment income has also fallen behind. In recognition of this problem, the Danforth Foundation announced in December that it would no longer support the total of tuition and fees at the institutions chosen by the Danforth Fellows. The Foundation stated that it would reduce this support to \$4,000 annually and "expected that the university -- would make up the difference -- rather than to lose the student to an institution with a lesser tuition/fee schedule."

The Institute was joined by a number of other private universities in protesting this action since it was seen as passing on the Foundation's financial problems to the universities who have very similar financial problems brought on by the same phenomenon. M.I.T. refused to accept Danforth Fellows under these conditions, and the Foundation has stated it will neither expect the Institute to make up the difference nor counsel Fellows to seek admission to less expensive institutions. The future of the Danforth Fellowship Program is currently under review by the Foundation. While the disciplines in the Institute's graduate programs are such that we do not attract large numbers of Danforth Fellows, I cite this problem as probably typical of several we and other institutions will face as inflation continues to plague us all.

I close this section of my report on a very bright note. In an extraordinary example of enlightened industrial support for higher education, the US Industrial Chemicals Company has established a new "National Distillers and Chemical Corporation Fellowship Program" to support seven Fellows each year for the next four years in our Departments of Biology and of Nutrition and Food Science. The Fellows will be chosen by the departmental faculties guided by the Corporation's interest in fermentation, cellulose hydrolysis, ethanol, and hence, in biochemical engineering, applied microbiology, biochemistry, genetics, and genetic engineering. The fellowships will provide tuition and stipend support for 12 months -- approximately \$12,000 for 1979-80 to be increased in succeeding years to account for inflationary impact on tuition and living expenses. This commitment of approximately \$400,000 with so "few strings attached" is a most welcome addition to our graduate support program, and we are most grateful for the sponsor's confidence in our graduate students and faculty.

Miscellany

The new Federal Copyright Law which took effect January 1, 1978 caused many problems throughout the Institute. One such problem had to do with ownership of copyright to theses prepared for both undergraduate and graduate degrees. The faculty regulation which has governed this area in the past did not speak to copyright but did state that "a thesis is the permanent property of the Institute" and required that the author request permission prior to publishing the thesis or parts thereof.

Since the new law provides that ownership of copyright must reside with the author unless the written document is the result of "work for hire," the Institute's policy had to be revised to conform to the new law. A multiplicity of complications arose during our efforts to formulate a suitable revision of the governing faculty regulation and the operational procedures dependent upon it. With the cooperation of the Director of the Libraries, the staffs of the Office of Sponsored Programs and the Patent and Copyright Office, the Committee on Copyrights and Patents, the Committee on Educational Policy (for undergraduate theses), and the Committee on Graduate School Policy (for graduate theses), we were able to arrive at a revised policy accepted by the faculty in May. Under the revision, the Institute will retain ownership of copyright to a thesis if all or a portion of the research was performed with financial support from funds administered by the Institute and/or if any or all of the research was performed utilizing facilities or equipment provided to the Institute under conditions imposing copyright restrictions. In all other cases, ownership of copyright will reside with the author, but the author must, as a condition of degree award, grant royalty-free permission to the Institute to reproduce and publicly distribute copies of the thesis.

Last spring, with the support of Dr. Carola Eisenberg, then Dean for Student Affairs, I suggested that her staff and my staff cooperatively sponsor a low-key study of actions which might be undertaken in the near future and in the longer range "to improve graduate student life" at M.I.T. We brought together a few concerned members of the faculty, the graduate student body, and members of the staffs of the Planning Office, the Student Affairs Office, and the Graduate Office to work with the assistance of Dober and Associates, Inc., an outside planning consultant firm. The group functioned most cordially and, I believe, effectively. Recommendations for improvements which resulted are set out in the report summary as follows:

The report presents a current assessment of graduate student life outside the classroom and laboratory at M.I.T., as examined by an ad hoc study group assembled for that purpose. The report includes a series of recommendations for improving graduate student life, taking into consideration

the needs, the most beneficial places for intervention, and the scarcity of resources available to affect early changes. Within that perspective, the study committee believes significant improvements should be carried out now at the departmental and Institute-wide level and thus urges early action on these recommendations:

- *Stronger Institute recognition of and support to departmental and sub-departmental efforts to improve graduate student life, inasmuch as it is at that level that the most significant contact and communication occurs among graduate students, faculty, and staff.*
- *Strengthening the Graduate Student Council by providing suitable places and budget for its work and sponsored activities.*
- *Appointment of a full-time staff member, to an appropriate Institute Office, to be charged with the responsibility for fostering graduate student life.*
- *Further study of ways in which Walker Memorial might be physically improved to serve the needs of graduate students, particularly for social, cultural, and physical recreation activities...*

These recommendations were made in the late fall to the Committee on Graduate School Policy (C.G.S.P.), where they were received with considerable positive enthusiasm, and to several concerned members of the administration. However, further review and action on the recommendations have been delayed. Dean Eisenberg's resignation late last summer to go to the Harvard Medical School resulted in the Chancellor's asking Vice President Constantine Simonides to undertake a thorough review of the Office of the Dean for Student Affairs and other student-related organizations. It has not seemed appropriate to press forward with the "Dober Report" recommendations until Mr. Simonides is further along in defining responsibilities for various programs.

The report did, however, provide considerable assistance to the Graduate Student Council (G.S.C.) and to those staff members who participated in the meeting of the Corporation Visiting Committee on Student Affairs last fall. Although formal action was not taken nor sought on the recommendations, the reaction of the Visiting Committee was positive.

Hopefully we can initiate some more definitive actions during 1979-80.

Changes and additions to the Institute's graduate academic programs continue to reflect the faculty's ever-expanding interests in interdisciplinary research. One example is the formalization of a graduate program in the Center for Transportation Studies based upon earlier interdisciplinary programs for individual students. In September, Professor Daniel Roos Director of the Center, brought to the C.G.S.P. a proposal for a formal master's level program in transportation. The C.G.S.P. approved the program and recommended that the faculty recommend to the Corporation the establishment of a new interdisciplinary master of science in transportation. Faculty and Corporation approval were given last fall.

The C.G.S.P. also reviewed and approved a new program in toxicology to be offered during the summer of 1979 under the auspices of the Department of Nutrition and Food Science. The program is an ambitious undertaking to be taught by faculty of M.I.T. and the Harvard School of Public Health with invited lecturers from government, industry, and other universities. The program will provide education in basic principles and techniques of toxicology, analytical chemistry, epidemiology, and risk assessment in the area of toxic chemicals to scientists and engineers from various disciplines and backgrounds. The C.G.S.P. and its subcommittee on Subjects of Instruction approved the granting of 30 units of graduate credit for this program to the participants who will be admitted as special students subject to the usual qualifying evaluations for admission of special students at the graduate level.

In May, upon the request of Professors Alexander Carmichael and Henry Marcus of the Department of Ocean Engineering, the C.G.S.P. approved the change in title of Course XIII-B

from Shipping and Shipbuilding Management to Ocean Systems Management. The Committee recommended that the faculty recommend to the Corporation that the Master of Science in Shipping and Shipbuilding Management be discontinued and replaced by a new Master of Science in Ocean Systems Management. This motion will be placed before the faculty in the fall of 1979.

KENNETH R. WADLEIGH

GRADUATE WOMEN

Although the number of women graduate students reached an all-time high of 606 this year, this growth reflects no dramatic changes in applications, enrollment, or advanced degrees awarded to women by M.I.T. graduate departments.

The total number of women applicants increased by 7 percent but, as shown in Table VII, this represents an increase in applicants to Architecture and Urban Studies and Planning (39 percent), Humanities and Social Science (2 percent), and the Sloan School (20 percent), while the Science and Engineering departments show fewer applicants (-6 percent and -9 percent respectively). These data are in contrast to last year, when the School of Engineering had a substantial increase (34 percent) in women applicants.

Of the total population of 606 women pursuing advanced degrees, 218 are first-year graduate students, only 26 more than in the fall of 1977 when 192 women entered graduate programs (Table VIII). These numbers compare to 992 first-year male students in the fall of 1977 and 1,041 in the fall of 1978. Therefore the percentage of women students in the Graduate School has increased almost imperceptibly from 14.6 percent in 1977 to 15.4 percent this past year (Table IX). The School of Engineering represents 46 percent of the total graduate students in 1978-79, but only 8 percent are women and thus we are disappointed in the number of women applicants in this School.

Each year for the past several years the total number of degrees awarded to women has increased; however, the past two years have seen a reversal of this trend. Both this year and last, as indicated in Table X, women were awarded 13 percent of the total number of master's and doctor's degrees. Table XI indicates that the number of master's degrees awarded women has continued to increase, but an alarming decrease in the number of women completing doctoral degrees is recorded. From a high point of 50 women in 1976-77, in 1978-79 only 29 women received their doctorates, a decrease from 11 percent of the total to only 7 percent. The greatest decrease is in the School of Humanities and Social Science where the number dropped from 12 to four. A decline in the School of Science from 25 to 19 is also troublesome.

A big jump in the number of women awarded master's degrees from the School of Engineering was indicated last year (Table XI) and this trend continues with a slight increase from 42 to 51 women awarded S.M.s in engineering this year. On the other hand, in the School of Architecture and Planning, where the number of women completing master's degrees decreased last year (23), the number is back up again in 1978-79 (33). However, on the whole, the number of women completing advanced degrees at M.I.T. remains comparatively small and until M.I.T. enrolls more women in science and engineering the proportion of women degree recipients will not grow.

As Dean Wadleigh observed earlier in this Report, continuing decreases in financial aid plus rising tuition costs and living expenses continue to plague graduate education. Although an increase in research assistantships has resulted from increased research and development support grants, at the same time the general picture shows a shift to self support, including greater reliance on loans, for support of one's graduate education. These facts influence enrollment of all graduate students but, perhaps disproportionately, enrollment of women. This is particularly true at M.I.T. where the largest proportion of women continue to be enrolled in those programs whose financial resources are most limited.

This year we have completed our sixth annual competition for the Ida M. Green Fellowships. Seven awards (including one honorary award) were made bringing the grand total for six years to 36 women so honored. Also, one continuing woman graduate student was awarded a Collamore-Rogers

Fellowship. These represent the only endowed funds earmarked for the support of women at M.I.T. A cross section of M.I.T.'s departments is represented by these women scholars and such funds are important in attracting and increasing qualified women in M.I.T.'s graduate programs.

Women at M.I.T. have also been recipients of awards from the International Business Machines Corporation and the Xerox Special Opportunity Fellowship Programs for Minorities and Women pursuing graduate study in specific areas of interest to these companies.

Graduate women also received dissertation fellowships from the American Association of University Women and five women received awards from the Danforth Foundation. Other women students received fellowships in national competitions from the National Science Foundation, the Hertz Foundation, the National Institutes of Health, and Bell Laboratories for their graduate studies at M.I.T. Minority women at M.I.T. continue to be successful in obtaining fellowships from the National Fellowships Fund; there were four such recipients this year. One of the two recipients of fellowships from the Graduate Fellowship Fund for Mexican Americans, Puerto Ricans, and Native Americans was a woman.

Within the discussions related to the reorganization of the Office of the Dean for Student Affairs and other student-related offices, considerable attention has been given to discussing issues related to graduate student needs. As part of these discussions, issues of particular concern to women have been raised. It is clear that although the number of women has been increasing, there are many areas in which women still feel isolated, particularly in the physical sciences and engineering departments. Also of concern are the traditional problems of mentorship, relationships with faculty advisors, and general acceptance into the mainstream in fields in which women have been underrepresented. Since the largest numbers of graduate students at M.I.T. are enrolled in these traditionally male-dominated fields, it is important for M.I.T. to encourage women to enter these fields by improving the academic and social environment.

JEANNE RICHARD

MINORITY GRADUATE STUDENTS

One year ago today (June 28, 1978), the Supreme Court issued its first major affirmative action decision, upholding the consideration of race in college admissions programs (the Bakke decision). That case dealt with Title VI of the 1974 Civil Rights Act, which prohibits discrimination in programs receiving Federal funds. After the smoke had cleared from the Bakke decision, those of us who supported civil rights and affirmative action programs were not sure what the curious configuration of opinions among the nine justices meant. The recent decision by the Supreme Court in the Brian F. Weber vs. Kaiser Aluminum case in ruling in favor of Kaiser's affirmative action plan appears to have given a green light to affirmative action and to have done away with the issue of reverse discrimination. The Weber case dealt with Title VII of the 1964 Civil Rights Act which does allow the voluntary use of affirmative action programs to correct the underrepresentation of minorities and women. The decision in the Weber case, along with the Bakke case, should help facilitate and support those institutions and employers who choose to take an aggressive and affirmative step into the 1980s with regard to attracting and retaining more minorities and women. We are pleased to state that, even while these cases were being debated in the courts, M.I.T., through its "affirmative actions," has not relented in its efforts to increase the number of minority graduate students at the Institute.

The highlight of the academic year for minority graduate student affairs came at this year's Commencement. We graduated the largest number of blacks with Ph.D.s in the history of the Institute. A total of 14 minority graduate students (not including Asian Americans) received the Ph.D. during academic year 1978-79. This number includes 11 blacks and three Hispanic students. In the same time period a total of 42 graduate degrees was earned by minorities including master's engineer's, and doctor's degrees (Table XII). As seen in Table XIII, our minority Ph.D. recipients have obtained excellent jobs in industry, higher education, and government which further amplifies the credible job our faculty and students are doing in the classroom and laboratory.

We are very proud of these new graduates. We are also very proud because this accomplishment offers confirmation of several facts:

- 1) M.I.T. is truly serious about its commitment to attracting and graduating minority graduate students, a commitment we have been pursuing for a number of years.
- 2) The supportive mechanisms needed at a large research institution to generate the highest quality scholarship have been operative for minority students as well as majority students.
- 3) Black and other minority graduate students can and have performed superbly in rigorous academic programs of high standards, contrary to commonly held views outside M.I.T. that blacks and other minority students can't compete in science, engineering, and technology.
- 4) Through the assistance and support of the President, Chancellor, and Dean of the Graduate School, a considerable amount of financial support has been provided to minority graduate students to study at M.I.T.
- 5) Many members of the M.I.T. faculty have done a splendid job in encouraging and supporting minority graduate students in the classroom and research laboratory as well as facilitating their inclusion into the mainstream of life at M.I.T. and in their respective disciplines.
- 6) The large number of blacks graduating with Ph.D.s will help increase the national pool of desperately needed minority professionals in science and engineering.

Perhaps more significant than any of the above is the sense of individual accomplishment for these young people who, for the most part, are first generation college graduates. They will enter the marketplace as positive role models for countless minority youngsters all around the country who can now say that "I would like to be an engineer, a physicist, an economist, or a chemist, just like that person who graduated from M.I.T.!"

Enrollment figures for minority graduate students have leveled off in some departments and decreased in others for 1978-79. The total fall enrollment for 1978-79 for minority graduate students was 147 compared to 157 the previous year (Tables XIV, XV, XVI). The reduction can be attributed to several factors:

Many minority undergraduates are opting for the more lucrative choice of taking a job at a high salary in industry or business versus attending graduate school, especially those black students who graduate with a bachelor's degree in engineering. Secondly, the social science departments have had difficulties finding adequate financial support for their graduate students which has had a tremendous negative impact on minority students since there is a larger pool of minorities in the social sciences than in the physical sciences and engineering at the undergraduate level. Thirdly, the Sloan School had a miserable year in recruiting minorities for its programs. And finally, there is a continuing national trend of declining enrollments for majority as well as minority students at the graduate level.

Although the enrollment figures for minorities were down some 17 percent in 1978-79 (147) from our highest enrollment year of 1976-77 (178), we are not overly concerned because the decrease is in areas where minorities are already heavily represented. While we were experiencing a decrease in enrollment in Architecture, Urban Studies and Planning, and Humanities and Social Science, we were seeing an increase in engineering and a leveling off in science departments. We have been emphasizing increased enrollments in engineering, science, and management as we will continue our focus on these areas in the years to come because minorities are highly under-represented in these areas and there is adequate financial support for students pursuing degrees in these disciplines.

During the fall of 1979 we will mount a stepped-up recruiting program including campus visitations around the country and workshops at M.I.T. during which invited faculty and students from black engineering schools will come to our campus to meet faculty and tour our facilities. We hope to create and expand our network of contacts and friends who can refer students to us. These activities will be augmented by personal letters to prospective students, mass mailings, participation in the Minority Locator Service and the Name Exchange Program, and assistance to the academic departments in their special recruitment programs for minorities.

Funds have been made available for these activities as part of the US Department of Health, Education and Welfare's institutional grant to our office in its "Graduate and Professional Opportunities Program." We also received eight fellowships from the Office of Education for 1979-80 for minority graduate students to study in the Schools of Engineering and Science. There are nine minority graduate students already receiving fellowships in this program and with the eight additional fellowships we will have a total of 17 fellowships for 1979-80.

The Graduate School Office sponsored a number of activities during the academic year for minority graduate students as well as for the general M.I.T. community. These activities included: Minority Graduate Student Orientation Program; a retreat at M.I.T.'s Talbot House in South Pomfret, Vermont; "Ebony Affair" dance and cabaret in the Sala de Puerto Rico; (some 350 people attended this annual activity); publication of *Minority Graduate Student Directory*, a 42-page book on resources and minority people at the Institute, including pictures for the first time in its three-year existence.

Also held this year was a Minority Graduate Student Lecture Series with the theme, "The Full Participation of Blacks in the Marketplace: A Challenge for Historically Black and Predominantly White Institutions." We invited four distinguished black college presidents to speak on this theme. They were: Dr. Herman Branson, President of Lincoln University (Pennsylvania), respondent, Dr. Paul E. Gray, Chancellor, M.I.T.; Dr. Frederick Humphries, President of Tennessee State University, respondent, Dr. Charles Willie, Professor of Education and Urban Studies, Harvard University; Dr. Walter J. Leonard, President of Fisk University (Tennessee), respondent, John Wynne, Vice President, M.I.T.; Dr. Elias Blake, President of Clark College (Georgia), respondent, Dr. Lester Thurow, Professor of Economics, M.I.T. This event has been by far the most significant activity of the year with regard to impact and interest among the general M.I.T. community.

Other activities sponsored during 1978-79 were Minority Awards Day, a reception for minority student graduates and their parents on Commencement Day, and a dinner and reception for the Lincoln Laboratory summer work-study students from black colleges.

This year was a good year for minority graduate students at M.I.T. with respect to graduation numbers, programs, and activities as well as acquiring a stronger sense of "belonging" at the Institute. Given this success we are excited about plans and activities for next year. Minority graduate students feel that they are an integral part of the fabric of this institution and that the future of minorities at M.I.T. cannot be separated from the future of M.I.T. To have one is to have the other!

I wish to give special acknowledgement to my secretary, Leslie McIntyre, for her outstanding work and good nature throughout the year.

JOHN B. TURNER

GRADUATE STUDY ABROAD

This year the Committee on Foreign Scholarships reviewed 17 applications from seniors and graduate students for three competitions for grants for graduate study abroad. Eleven applications were submitted for the Fulbright-Hays Program administered by the Institute of International Education (IIE), and three applications were submitted for the German Academic Exchange Service (DAAD) Scholarship Program and for the Winston Churchill Foundation Scholarship Program.

Of the 11 Fulbright applicants, six passed the National Screening Committee's preliminary application stage and three were awarded Fulbright-Hays grants for 1979-80. They are: John C. Dunlap, a senior in Mathematics, for graduate study in Germany; Martha Pollak, a graduate student in Architecture, for study and research in Italy; and Heinz Stubblefield, a graduate student in Ocean Engineering, for study in Germany.

The Committee nominated three students for the DAAD Scholarship Program for graduate study in the Federal Republic of Germany. Two of these nominees won Fulbright-Hays grants to Germany (above) and the third, David G. Mohr, a senior in Aeronautics and Astronautics, was awarded a DAAD scholarship.

M.I.T. is among the 36 colleges and universities invited to nominate two candidates each year for the Churchill Foundation Scholarship Program for graduate study at Churchill College, Cambridge University. One of the M.I.T. nominees, David W. Mead, a senior in Chemical Engineering, was selected as a recipient of a Churchill scholarship for the 1979-80 academic year.

Although the M.I.T. Committee on Foreign Scholarships is not directly involved in the Marshall Scholarship competition, it should be noted here that three M.I.T. students won Marshall scholarships to pursue two years of graduate study in the United Kingdom beginning next fall. They are: Daniel A. Galson, a senior in Earth and Planetary Sciences, Scott W. Lewis, a graduate student in Mechanical Engineering, and Beth A. Marcus, a senior in Mechanical Engineering.

This fall, Eugene R. Chamberlain, Advisor to Foreign Students, assumed the chairmanship of the Committee on Foreign Scholarships bringing to the Committee the benefit of his enthusiasm for, and experience in, international education. Under his guidance, this spring we brought together students from the United Kingdom who are currently studying at M.I.T. with US students who will be doing graduate work in the UK next year.

During the coming year, the Committee intends to continue its efforts to increase the pool of applicants for these scholarship programs for graduate study abroad. Toward this end, a letter was sent this May to all members of the faculty informing them of these opportunities and encouraging them to bring the programs to the attention of any undergraduate or graduate students whom they feel would benefit from a period of study abroad.

YVONNE L. WHITAKER

HOUSING

Last year I reported that we clearly needed another new undergraduate house with a capacity of about 300 but that the continued dearth of capital resources to finance construction made it highly unlikely that we could undertake new construction in the near term. Over this past year, demand for on-campus housing by undergraduates continued to grow so that fall-term crowding was even greater than we had anticipated. Spurred on by this discomfort, we undertook in early fall an intensive study to update earlier studies of alternative strategies which might be implemented to relieve the overcrowding.

Not surprisingly, this effort resulted in our recommending to the senior administration and the Executive Committee of the M.I.T. Corporation in mid-winter that we begin construction of a new 300-bed dormitory at a cost of about \$10 million. The site recommended is the last of the West Campus riverfront sites facing Memorial Drive and is located between the new West Campus houses and Tang Hall. We predicted that we could have the building available for occupancy in September 1981 if approval to begin design was given by April 1979. While the senior administration and the Executive Committee were entirely sympathetic with the recommendation, the continued lack of sufficient promise of the necessary gift capital made it impossible to authorize our proceeding by the April deadline. Nevertheless, a client team of faculty, students, and staff, chaired by Robert Sherwood, Associate Dean for Student Affairs, continued to work diligently over several months to develop the program for what came to be known as "Next House." Their goal was to define a program to permit us to proceed immediately into design stages once funding became available.

Fortunately, as the spring term drew to a close, President Wiesner succeeded in his efforts to find sufficient "up front" capital to warrant our moving ahead. An anonymous donor announced his intention a day or two before Commencement Day, and on that day, the Corporation and administration decided to proceed. We have revised the design and construction schedule. We now hope to have "Next House" available for occupancy at the opening of fall term 1981.

Luckily, our independent residences continue to prosper as they function as strong, contributing components of our undergraduate housing program.

With the encouragement of the Interfraternity Conference (I.F.C.), the Alumni Interfraternity Conference (A.I.F.C.), and concerned members of the administration, a new colony, Zeta Psi, was established during the year. The undergraduates and corporate officers of that group struggled valiantly during the greater part of the year to locate a suitable building in which to house Zeta Psi. As we worked with them, it became increasingly obvious that the growing complexity of zoning regulations, safety codes, financing, and political problems made it highly unlikely that any volunteer group could succeed in such an endeavor.

Thus, in late spring, with the support of I.F.C., A.I.F.C., and key members of the Institute's administration, we modified our long-standing policy of not acquiring properties for rental and/or sale to fraternities. On an experimental basis, we propose to acquire, renovate, and re-sell to fraternity corporations suitable housing. We are currently engaged in the first step of this "experiment" during which we hope to acquire an old Back Bay house, renovate it in accordance with applicable safety and zoning codes, and resell it to the Zeta Psi group. At this writing, the major hurdle for the successful completion appears to be the acquisition of approvals for fraternity occupancy in a zone in which such use is permitted only as a variance.

While our undergraduates are certainly affected by the continued decline in satisfactory rental units within reasonable commuting distance of the Institute, our graduate students find it increasingly difficult to cope with this situation. Most of the better, older apartments off campus have been or are being converted to condominiums. Essentially all new construction of multi-dwelling units is for condominiums and/or luxury rental units. On-campus we have not been able to respond to graduate needs by building new housing because the costs are so high that any self-amortizing rental structure would call for prohibitively high rents. Thus, the problem for graduate housing continues to be the shortage of sufficient gift capital to permit subsidizing new construction to a point where rentals are tolerable to our single graduate students and married student families.

Partially to assist in this dilemma, we did explore over this year the acquisition of an old hotel which came on the market briefly in Boston. Although we estimated the renovation cost to be four or five times the acquisition cost, the project might still have provided student housing at cost slightly less than one-half the costs of new construction. However we were forced to abandon further exploration of this project when the City made clear its strong opposition.

The Report of the Dean for Student Affairs contains additional information concerning our student housing programs and problems.

KENNETH R. WADLEIGH

Vice President and Dean of the Graduate School

For simple comparison with data for 1977-78, the following statistical information for 1978-79 is presented in the same format. Numbers in parentheses indicate the changes from 1977-78 to 1978-79.

Table I REGULAR GRADUATE STUDENT ENROLLMENT, FALL TERM 1978

	Foreign*	Women**	Minority***	Total
School of Architecture and Planning	91(+15)	127(+23)	46(+2)	335(+42)
School of Engineering	635(- 7)	146(+28)	44(+4)	1853(+54)
School of Humanities and Social Science	85(+ 8)	66(- 7)	16(-5)	299(+14)
Sloan School of Management	102(- 6)	79(- 3)	13(-7)	388(+ 4)
School of Science	232(-16)	188(+ 6)	28(-4)	1069(+ 6)
TOTAL	1145(- 6)	606(+47)	147(-10)	3944(+120)

* Includes Canadians

** See also Table IX

*** Includes Black Americans, Puerto Ricans, Mexican Americans, and Native Americans

Table II GRADUATE DEGREES AWARDED, 1978-79

Advanced Degrees Conferred	M.C.P., M.Arch., M.Arch.A.S.	S.M.	Engineer	Sc.D.	Ph.D.	Total
September 1978	17(+ 5)	185(+10)	11(-12) 1(WH)*	13(+ 3)	83(-34) 4(WH)*	314(-28)
February 1979	18(+ 7)	207(n.c.)	20(-13)	19(- 1)	103(+ 4) 3(WH)*	370(- 3)
June 1979	63(+10)	484(+ 8)	30(-18) 3(WH)*	19(+ 4) 1(WH)*	134(-20) 2(WH)*	736(-16)
TOTAL	98(+22)	876(+18)	65(-43)	52(+ 6)	329(-50)	1420(-47)

* Woods Hole Oceanographic Institution

Table III

A "SNAPSHOT" OF GRADUATE STUDENT SUPPORT "FULL AWARDS"

The following sources provided at least full tuition support for graduate students during the fall term, 1978. Total regular graduate student enrollment was 3,944.

	Numbers of Students	Percent Total Enrollment	Change From 77-78	Percent of Difference
FELLOWSHIPS AND TRAINEESHIPS AWARDED BY M.I.T.				
NIH and NIMH Traineeships	126		+ 2	
NSF Energy and National Needs Traineeships	9		-10	
DOE (Formerly ERDA) Traineeships	6		+ 1	
HUD Minority Intern Program	10		-	
HEW Domestic Mining and Mineral Fuel Traineeships	13		+ 3	
HEW Graduate and Professional Opportunities Program Fellowships	9		+ 9	
HEW Public Service Education Traineeships	4		-	
M.I.T. Endowed and Other Fund Fellowships	208		-19	
Industrial and Foundation Fellowships	130		+22	
SUBTOTAL	<u>515</u>	<u>13%</u>	<u>+ 8</u>	<u>- 1%</u>
FELLOWSHIPS AWARDED BY SPONSORS TO M.I.T. STUDENTS				
NSF Graduate Fellowships	130		- 3	
NIH and NIMH Fellowships	8		+ 2	
Hertz Foundation Fellowships	31		+ 2	
EPA Fellowships	1		-	
Department of Labor Fellowships	1		+ 1	
SUBTOTAL	<u>171</u>	<u>4%</u>	<u>+ 2</u>	<u>- 1%</u>
STUDENT ASSISTANTSHIPS				
Research	1,444		+ 71	
Teaching	481		+ 43	
Instructor-G	16		- 1	
SUBTOTAL	<u>1,941</u>	<u>49%</u>	<u>+113</u>	<u>+ 1%</u>
SPONSORED STUDENTS				
Many students receive support from employers and sponsors. The following reflect Student Accounts billings for tuition to employers and sponsors who presumably provide stipends to students by private arrangements.				
US Army, Air Force, Coast Guard	36		-*	
US Navy and Related Programs	28		-*	
Foreign Countries and International Programs	310		+87	
Industry and Foundation (US)	117		+ 6	
SUBTOTAL	<u>491</u>	<u>12%</u>	<u>+93*</u>	<u>+ 2%*</u>
SUMMARY BY SOURCES - FULL AWARDS**				
Federal Fellowships and Traineeships	317	8%	+ 5	-
Graduate Student Staff	1,941	49%	+113	+ 1%
Industrial and Foundation Awards	161	4%	+ 24	-
M.I.T. Endowed and Budgeted Funds	208	5%	- 19	- 1%
Students Sponsored by External Sources	<u>491</u>	<u>12%</u>	<u>+ 93*</u>	<u>+ 2%*</u>
TOTAL AWARDS	3,118	79%	+216*	+ 2%*

*Based on corrected figures for military programs. In this table in preceding years, the statistics reflecting Student Accounts billings for military programs included undergraduate students supported by R.O.T.C. programs.

**Based on corrected figures.

Table IV
TRENDS IN GRADUATE STUDENT SUPPORT

The values reported are the annual sums in thousands of dollars. To "normalize" these data, the total dollar values have been divided by the product (total regular graduate students registered fall term) (tuition for the 9-month academic year).

	Fellowships Traineeships Scholarships*	Staff Tuition Awards (TA)	Staff Salaries (RA & TA)	LOANS		Including Outside Agencies
				M.I.T. Only	na	
1968-69	4,994 (.710)	1,033 (.147)	6,015 (.855)	646 (.092)	na	
1969-70	5,197 (.712)	1,056 (.145)	6,815 (.934)	470 (.064)		643 (.088)
1970-71	5,396 (.655)	1,182 (.143)	6,850 (.831)	483 (.059)		672 (.082)
1971-72	5,076 (.589)	1,294 (.150)	7,086 (.823)	696 (.080)		827 (.096)
1972-73	4,687 (.486)	1,432 (.150)	7,991 (.828)	754 (.078)		916 (.095)
1973-74	3,930 (.378)	1,453 (.140)	8,781 (.844)	852 (.082)		1,014 (.097)
1974-75	3,693 (.318)	1,738 (.150)	9,760 (.840)	1,075 (.093)		1,293 (.111)
1975-76	3,447 (.259)	1,878 (.141)	10,878 (.816)	1,141 (.086)		1,407 (.106)
1976-77	3,454 (.229)	2,065 (.137)	11,654 (.772)	1,419 (.094)		2,013 (.133)
1977-78	3,418 (.205)	1,978 (.118)	12,479 (.750)	1,391 (.084)		2,201 (.132)
1978-79	3,667 (.198)	2,355 (.127)	15,251 (.823)	962 (.052)		2,387 (.129)

*Administered by the Graduate School Office.

Table V

DISTRIBUTION OF FUNDING FOR GRADUATE STUDENT
TUITION AND LIVING EXPENSES

Academic Year (9 months) 1978-79

Estimated Total Requirement (3,885 students multiplied by \$8,600 per student)	\$33,411,000*	(100%)
Support by Category		
Research Assistantships	\$10,596,612	(31.8%)
Teaching Assistantships	3,522,022	(10.5%)
College Work-Study Program	440,000	(1.3%)
Federal Fellowships and Traineeships	2,477,102	(7.4%)
General and Endowed Support (departmentally controlled)	725,928	(2.2%)
General and Endowed Support (Graduate Office)	570,486	(1.7%)
Outside Sources Administered by Departments	1,273,268	(3.8%)
Outside Sources Administered by Graduate Office	171,941	(0.5%)
Outside Sources, Direct Billing by Institute, Tuition Only	<u>2,180,900</u>	(6.5%)
Total Identified Support	<u>\$21,958,259</u>	(65.7%)
Difference	\$11,452,741**	(34.3%)

* Tuition and Medical Fee component approximately \$19 million.

**Toward meeting this difference, students borrowed through the Student Financial Aid Office \$1,547,399, which is 13.5 percent of the difference or 4.5 percent of estimated total requirement for nine months.

Table VI

DOCTORAL DEGREES AWARDED EACH YEAR BY SCHOOL AND CITIZENSHIP

Each number is the total of the degrees awarded in September, January, and June of the academic year indicated. The numbers in parenthesis are the number of degrees awarded divided by the corresponding enrollment.

Academic Year		Arch.	Eng'g.	Hum. & Soc. Sci.	Sloan	Science	Total
1969-70	Citizen	3 (.024)	111 (.103)	42 (.206)	9 (.041)	135 (.171)	300 (.125)
	Foreign	<u>2</u> (.035)	78 (.162)	<u>14</u> (.180)	<u>5</u> (.045)	<u>40</u> (.156)	<u>139</u> (.141)
	Total	5	189	56	14	175	439
1970-71	Citizen	2 (.011)	116 (.108)	30 (.152)	10 (.043)	144 (.190)	302 (.124)
	Foreign	<u>1</u> (.026)	<u>59</u> (.123)	<u>7</u> (.125)	<u>2</u> (.022)	<u>29</u> (.134)	<u>98</u> (.114)
	Total	3	175	37	12	173	400
1971-72	Citizen	5 (.028)	102 (.095)	36 (.191)	4 (.019)	149 (.212)	296 (.126)
	Foreign	<u>1</u> (.020)	<u>60</u> (.123)	<u>9</u> (.143)	<u>3</u> (.030)	<u>49</u> (.249)	<u>122</u> (.136)
	Total	6	162	45	7	198	418
1972-73	Citizen	4 (.022)	112 (.107)	34 (.160)	4 (.017)	122 (.169)	276 (.115)
	Foreign	<u>1</u> (.020)	<u>54</u> (.114)	<u>17</u> (.274)	<u>3</u> (.024)	<u>45</u> (.208)	<u>120</u> (.129)
	Total	5	166	51	7	167	396
1973-74	Citizen	6 (.034)	93 (.088)	29 (.136)	5 (.021)	129 (.179)	262 (.109)
	Foreign	<u>1</u> (.016)	<u>49</u> (.099)	<u>18</u> (.273)	<u>6</u> (.052)	<u>42</u> (.196)	<u>116</u> (.122)
	Total	7	142	47	11	171	378
1974-75	Citizen	7 (.037)	104 (.095)	31 (.143)	10 (.040)	110 (.146)	262 (.105)
	Foreign	<u>2</u> (.033)	<u>56</u> (.107)	<u>10</u> (.154)	<u>8</u> (.080)	<u>24</u> (.110)	<u>100</u> (.103)
	Total	9	160	41	18	134	362
1975-76	Citizen	1 (.005)	83 (.073)	49 (.232)	12 (.055)	126 (.162)	271 (.106)
	Foreign	<u>1</u> (.019)	<u>67</u> (.114)	<u>7</u> (.119)	<u>2</u> (.017)	<u>42</u> (.180)	<u>119</u> (.113)
	Total	2	150	56	14	168	390
1976-77	Citizen	6 (.026)	79 (.068)	33 (.155)	2 (.007)	125 (.156)	245 (.090)
	Foreign	<u>4</u> (.071)	<u>64</u> (.106)	<u>19</u> (.264)	<u>1</u> (.010)	<u>46</u> (.199)	<u>134</u> (.126)
	Total	10	143	52	3	171	379
1977-78	Citizen	5 (.023)	111 (.096)	50 (.240)	8 (.029)	119 (.146)	293 (.110)
	Foreign	<u>3</u> (.039)	<u>66</u> (.103)	<u>13</u> (.169)	<u>15</u> (.139)	<u>35</u> (.141)	<u>132</u> (.115)
	Total	8	177	63	23	154	425
1978-79	Citizen	10 (.041)	80 (.066)	35 (.164)	10 (.035)	126 (.151)	261 (.093)
	Foreign	<u>3</u> (.033)	<u>64</u> (.101)	<u>11</u> (.130)	<u>9</u> (.088)	<u>33</u> (.142)	<u>120</u> (.105)
	Total	13	144	46	19	159	381

Table VII

COMPARISON OF ADMISSIONS STATISTICS FOR GRADUATE WOMEN AND GRADUATE MEN

Number of Applicants 1977/Number of Applicants 1978

Numbers in parenthesis indicate the % change in number of applicants from 1977 to 1978.

	<u>Women</u>	<u>Men</u>
School of Architecture & Planning	238/330 (+39%)	578/ 547 (- 5%)
School of Engineering	193/180 (- 6%)	2317/2273 (-2%)
School of Humanities & Social Science	163/166 (+ 2%)	517/ 453 (-12%)
Sloan School of Management	243/293 (+20%)	1172/1214 (+ 4%)
School of Science	403/366 (- 9%)	1446/1314 (- 9%)
	1240/1335 (+ 7%)	6030/5801 (- 4%)

Table VIII

WOMEN GRADUATE STUDENT ENROLLMENT

(% of Total 1973-1978)

<u>Fall Term</u>	<u>New</u>			<u>Continuing</u>			<u>Total</u>		
	<u>Women</u>	<u>Total</u>	<u>% of Women</u>	<u>Women</u>	<u>Total</u>	<u>% of Women</u>	<u>Women</u>	<u>Total</u>	<u>% of Women</u>
1973	105	1080	10%	213	2278	9%	318	3358	9%
1974	140	1061	13%	265	2407	11%	405	3468	12%
1975	175	1113	16%	312	2490	12.5%	487	3603	13.5%
1976	185	1220	15%	361	2554	14%	546	3774	14%
1977	192	1184	16%	367	2640	14%	559	3824	14.6%
1978	218	1259	17%	388	2685	14%	606	3944	15.4%

Table IX

WOMEN GRADUATE STUDENT ENROLLMENT

Comparison of Fall Term Enrollments - 1977 & 1978

	<u>Number of Women</u>		<u>% of Women in Total Enrollment</u>	
	<u>1978</u>	<u>1977</u>	<u>1978</u>	<u>1977</u>
<u>School of Architecture & Planning</u>				
Architecture IV	60	56	32	32
Urban Studies & Planning XI	67	48	46	41
	<u>127</u>	<u>104</u>	<u>38</u>	<u>35</u>
<u>School of Engineering</u>				
Aeronautics & Astronautics XVI	7	5	5	3
Chemical Engineering X	27	28	14	15
Civil Engineering I	15	15	6	7
Electrical Engineering & Computer Science VI, VI-A, VI-W	45	26	9	5
Materials Science III, III-B, III-W	24	18	15	12
Mechanical Engineering II, II-T, II-W	16	13	5	5
Nuclear Engineering XXII	9	9	5	5
Ocean Engineering, XIII, XIII-A, XIII-B, XIII-W	3	4	2	3
	<u>146</u>	<u>118</u>	<u>8</u>	<u>6.5</u>
<u>School of Humanities & Social Science</u>				
Economics XIV	16	16	13	14
Philosophy/Linguistics XXIV	18	16	39	37
Political Science XVII	23	31	23	32
Psychology IX	9	10	36	38
	<u>66</u>	<u>73</u>	<u>22</u>	<u>26</u>
<u>Sloan School of Management</u>				
Management XV	68	75	22	24
XV-A (Fellows)	5	4	9	7
XV-B (Operations Research)	6	3	26	27
	<u>79</u>	<u>82</u>	<u>20</u>	<u>21</u>
<u>School of Science</u>				
Biology VII	34	36	32	33
VII-W	5	4	28	25
Chemistry V	34	28	19	17
Earth & Planetary Sciences XII	15	13	18	14
XII-W	13	8	30	23
Mathematics XVIII	13	13	12	12
Meteorology XIX	2	3	5	6
XIX-W	3	2	20	13
Nutrition & Food Science XX	51	50	29	26
Physics VIII	14	22	5	8
Interdisciplinary Science XXV	3	3	21	25
HST	1		16	
	<u>188</u>	<u>182</u>	<u>18</u>	<u>17</u>
TOTALS	606	559	15.4	14.6

Table X
Comparison, in Numbers, of Degrees Awarded to Men and Women
 1973-74 to 1978-79

	Master's		Doctor's		Engineer's		All	
	Women	% of Total Women	Women	% of Total Women	Women	% of Total Women	Women	% of Total Women
1973-74	58	7%	34	9%	3	3%	92*	7.6%*
	832		378		102		95	7%
1974-75	80	9%	32	9%	0	0%	112*	9%*
	856		362		107		112	8.4%
1975-76	93	11%	32	10%	2	2%	125*	13%*
	862		320		94		127	10%
1976-77	145	15%	50	13.4%	2	2%	195*	14.5%*
	971		379		91		197	13.7%
1977-78	134	14%	48	11%	5	5%	182*	13.4%*
	934		425		108		187	12.7%
1978-79	146	15%	29	7%	2	3%	175*	12.8%*
	968		387		65		177	12.3%

* without Engineer's degrees

Table XI
Degrees Awarded to Women by School

	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
Architecture & Planning								
Master's	12	23	13	23	23	34	23	33
Doctor's	1	1	1	2	0	2	4	3
Engineering								
Master's	12	14	22	16	21	28	42	51
Doctor's	2	0	3	3	3	8	4	4
Humanities & Social Science								
Master's	2	0	3	4	3	5	4	3
Doctor's	5	10	10	8	10	10	12	4
Sloan								
Master's	10	3	11	21	26	46	40	45
Doctor's	0	0	0	0	0	0	2	0
Science								
Master's	6	11	9	16	19	32	25	14
Doctor's	23	13	20	19	19	28	25*	18
Operations Research	0	0	0	0	1(SM)	0	1(SM)	0
							1(Ph.D.)	
WHOI	0	0	0	0	1(Ph.D.)	2(Ph.D.)	(2 Ph.D. included in VII & XI)	0
Totals	42	51	58	80	93	145	135	146
Doctor's	31	24	34	32	33	50	48	29

* Includes 2 WHOI degrees

Table XII

Minority Degree List

September, February, June
1978-79

	<u>Blacks</u>	<u>Hispanics</u>	<u>Native Americans</u>	<u>Totals</u>
Master's	19	3	4	26
Engineer's	0	2	0	2
Doctor's	11	3	0	14
	—	—	—	—
TOTALS	30	8	4	42

Table XIII

Black Ph.D. Recipients

1978-79

(September, February, June)

<u>Name</u>	<u>Department</u>	<u>Position After Graduation</u>
Robert Anderson	Mathematics	Assistant Professor, Tufts University
Jerry L. Bryant	Biology	M.I.T., Postdoctoral Fellow, Department of Biology
Randolph Burton	Chemistry	Bell Laboratories
William A. Darity	Economics	Assistant Professor, University of Texas at Austin
Linda P. Datcher	Economics	Assistant Professor, University of Michigan
David L. Douglass	Chemistry	Dupont Laboratories
Lucia K. Edmonds	Urban Studies & Planning	
Douglas Johnson	Urban Studies & Planning	Assistant Professor, University of Rhode Island
Donald King	Mathematics	
Harry F. Minor	Urban Studies & Planning	M.I.T., Postdoctoral Fellow, Department of Urban Studies and Planning
William B. Pollard	Physics	M.I.T., Postdoctoral Fellow, Department of Physics; US Naval Research Laboratories; Assistant Professor, Atlanta University

Table XIV
 Total and Minority Regular Graduate Enrollment
 Fall Term 1978

	<u>BA*</u>	<u>PR</u>	<u>MA</u>	<u>AI</u>	<u>Total Minority Graduate Students</u>	<u>Total Graduate Students</u>	<u>% of Total</u>
<u>Architecture & Planning</u>							
Architecture	14(7)**	1(1)	3(1)	2	20(9)	189	10.6%
Urban Studies & Planning	18(11)	3(2)	3	2(1)	26(14)	146	17.7%
	<u>32(18)</u>	<u>4(3)</u>	<u>6(1)</u>	<u>4(1)</u>	<u>46(23)</u>	<u>335</u>	<u>13.7%</u>
<u>Engineering</u>							
Aeronautics & Astronautics	5(2)	0	1	0	6(2)	149	4.2%
Chemical Engineering	5(3)	2	0	0	7(3)	196	3.6%
Civil Engineering	5(4)	1	1	1	8(4)	243	3.3%
Electrical Engineering and Computer Science	10(3)	3(1)	1(1)	0	6(2)	149	4.2%
Materials Science and Engineering	1	0	0	0	1	158	0.6%
Mechanical Engineering	3	1(1)	0	0	4(1)	304	1.3%
Nuclear Engineering	2(1)	0	1	0	3(1)	172	1.7%
Ocean Engineering	1(1)	0	0	0	1(1)	137	0.7%
	<u>32(14)</u>	<u>6(2)</u>	<u>4(1)</u>	<u>1</u>	<u>44(17)</u>	<u>1,853</u>	<u>2.4%</u>
<u>Sloan School of Management</u>	12(5)	0	0	1	13(5)	388	3.4%
<u>Humanities & Social Science</u>							
Economics	6(2)	2	0	0	8(2)	126	6.3%
Linguistics and Philosophy	0	0	0	0	0	46	0.0%
Political Science	7(1)	0	0	0	7(1)	102	6.8%
Psychology	1	0	0	0	1	25	4.0%
	<u>14(3)</u>	<u>2</u>	<u>0</u>	<u>0</u>	<u>16(3)</u>	<u>299</u>	<u>5.4%</u>
<u>Science</u>							
Biology	3	2(1)	0	0	5(1)	125	4.0%
Chemistry	4(1)	3	0	0	7(1)	176	3.9%
Earth & Planetary Sciences	0	1	0	0	1	127	0.8%
Interdisciplinary Science	0	0	0	0	0	14	0.0%
Mathematics	2	1	0	0	3	111	2.8%
Meteorology	0	0	0	0	0	54	0.0%
Nutrition & Food Science	3(1)	0	0	0	3(1)	174	1.7%
Physics	8(1)	0	1	0	9(1)	282	3.2%
Health Sciences and Technology	0	0	0	0	0	6	0.0%
	<u>20(3)</u>	<u>7(1)</u>	<u>1</u>	<u>0</u>	<u>28(4)</u>	<u>1,069</u>	<u>2.6%</u>
TOTALS	110(43)	19(6)	11(2)	6(1)	147(52)	3,944	3.7%

* BA - Black Americans PR - Puerto Ricans MA - Mexican Americans AI - American Indians

** () = new students

Table XV
 Minority Applicants Admitted and Enrolled
 1977-78 vs. 1978-79

	1977-78			1978-79		
	<u>received</u>	<u>admitted</u>	<u>enrolled</u>	<u>received</u>	<u>admitted</u>	<u>enrolled</u>
<u>Architecture & Planning</u>						
Architecture	16	5	3	15	9	9
Urban Studies & Planning	39	15	6	60	15	14
	<u>55</u>	<u>20</u>	<u>9</u>	<u>75</u>	<u>24</u>	<u>23</u>
<u>Engineering</u>						
Aeronautics & Astronautics	1	1	1	2	2	2
Chemical Engineering	5	5	1	4	3	3
Civil Engineering	10	6	3	12	8	4
Electrical Engineering & Computer Science	24	8	7	16	7	5
Mechanical Engineering	4	2	2	5	2	1
Materials Science & Engineering	3	2	2	1	0	0
Nuclear Engineering	2	1	1	3	2	1
Ocean Engineering	0	0	0	1	1	1
	<u>49</u>	<u>25</u>	<u>17</u>	<u>44</u>	<u>25</u>	<u>17</u>
<u>Sloan School of Management</u>						
	51	17	10	29	11	5
<u>Humanities & Social Science</u>						
Economics	11	4	1	13	3	2
Linguistics & Philosophy	0	0	0	0	0	0
Political Science	9	5	2	2	1	1
Psychology	4	0	0	2	0	0
	<u>24</u>	<u>9</u>	<u>3</u>	<u>17</u>	<u>4</u>	<u>3</u>
<u>Science</u>						
Biology	8	1	1	9	1	1
Chemistry	4	5	3	4	3	1
Earth & Planetary Sciences	1	1	0	1	1	0
Interdisciplinary Science	0	0	0	0	0	0
Mathematics	6	2	1	3	0	0
Meteorology	0	0	0	0	0	0
Nutrition & Food Science	1	1	1	5	2	1
Physics	10	8	4	9	2	1
	<u>30</u>	<u>17</u>	<u>10</u>	<u>31</u>	<u>9</u>	<u>4</u>
TOTALS	209	88	49	196	73	52

Table XVI
Trends in Minority Graduate Enrollment at M.I.T.

Minority Graduate Enrollment

<u>School</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>
Architecture & Planning	40	41	41	50	59	44	46
Engineering	19	25	38	38	44	40	44
Management	10	9	10	9	17	20	13
Humanities & Social Science	22	28	34	30	27	21	16
Science	17	18	28	28	31	32	28
Total Minority	<u>108</u>	<u>121</u>	<u>151</u>	<u>155</u>	<u>178</u>	<u>157</u>	<u>147</u>
Total All Graduate Students	3,328	3,358	3,468	3,603	3,774	3,824	3,944

Black Graduate Enrollment

<u>School</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>
Architecture & Planning	34	33	34	39	45	34	32
Engineering	10	16	26	25	25	25	33
Management	9	8	10	8	13	17	12
Humanities & Social Science	19	24	31	26	23	17	14
Science	15	16	22	21	24	21	20
Total	<u>87</u>	<u>97</u>	<u>123</u>	<u>119</u>	<u>130</u>	<u>114</u>	<u>111</u>

Minority & Black Graduate Enrollment as % of Total Graduate Enrollment

<u>Year</u>	<u>Total Grad. Enrollment</u>	<u>Minority Grad. Enrollment</u>	<u>%</u>	<u>Black Grad. Enrollment</u>	<u>%</u>
1970-71	3,296	-	-	55	1.6%
1971-72	3,250	-	-	88	2.7%
1972-73	3,328	108	3.2%	87	2.6%
1973-74	3,358	121	3.6%	97	2.9%
1974-75	3,468	151	4.3%	123	3.5%
1975-76	3,603	155	4.3%	119	3.3%
1976-77	3,774	178	4.7%	130	3.4%
1977-78	3,824	157	4.1%	114	2.9%
1978-79	3,944	148	3.8%	111	2.8%

Medical Department

At a little after 1 pm on November 14, 1978, the Public Health Council voted to approve M.I.T.'s application for a Certificate of Need for a new building for the M.I.T. Medical Department. On this joyful note ended a process which had begun in earnest about 18 months before, and which had consumed uncounted person-years of work as well as other resources almost as precious. During this arduous exercise, we learned a good deal about ourselves, and our community; the price of this information seems rather excessive. We also, perforce, learned a lot about the process of acquiring a Certificate of Need; we fervently hope that this information will remain irrelevant. Kudos belong to Laurence Bishoff whose great skill, unflagging energy, and exquisite attention to detail brought us through.

In the ensuing months, the exciting task of actually planning the new building has been essentially completed. A client team was created to work with Campus Architect Harry P. Portnoy and, through his skillful and thoughtful liaison, with the outside architects. The team included not only representatives of the physician, nursing, and administrative services in the Department, but also three members of the Medical Advisory Board, representing our patients. At this point, we are content that we have had full opportunity to shape the building to accommodate our needs.

Meanwhile, progress has been made on several program issues in the Department. The health surveillance program, long anticipated, has begun with a pilot program of Health Plan members. The program offers a system of health surveillance for the entire community and will supplant the Faculty Health Survey, Staff Survey, and the many other individual programs that have "grown like Topsy" through the years. It seeks to integrate health surveillance into an ongoing health care system, and offers periodic examinations and health screens whose components are determined by medical factors, such as age, sex, and known risk factors for the individual.

We also re-examined the pre-employment health screening program. As previously noted, very few applicants have been refused employment because of findings on pre-employment health screening; indeed, there have been none for the past two years and less than 0.5 percent for the 15 years before that. At the same time, the Institute's experience with work-connected illness and injury does not suggest that many people have been inappropriately placed in jobs at M.I.T. The cost of performing over 1,000 such examinations annually is, moreover, substantial. For these reasons, we will discontinue the pre-employment screening program with the end of this fiscal year.

From the viewpoint of the Medical Department, there is likely to be a positive benefit from this change. It will make it possible to introduce new employees to the Department and inform them of its functions and availability in a friendly and supportive setting, rather than risking the Department's being seen as a potential barrier to employment, representing exclusively the interests of the employer.

As anticipated in the last report, a Quality Assessment Committee was formed with representatives from the Utilization Review and Medical Records committees, and the Records Service. It has conducted two audits around clinical subjects and will soon increase the intensity of its efforts. We hope that it will serve to focus the activities of the several quality assessment programs in the Department.

Pauline Jones, Director of Nursing, who provides staff support for this Committee, has continued to visit students and Health Plan patients who are admitted to nearby hospitals, providing a link of continuity for them with this Department.

Our participation in a training program for residents in primary care has continued. We are currently providing electives for senior residents in this program in rheumatology and dermatology. We anticipate further expansion to include a full-time primary-care resident perhaps as soon as a year hence.

In addition, we were able to provide material for and to interact with two groups of students from the Sloan School, who studied some aspects of health-care delivery in the Department. In this area, we feel that the Department may, in the future, play a role of increasing importance particularly in relationship with the developing programs at the Whitaker College of Health Sciences, Technology, and Management.

Level of Activity

The total number of visits to the Department this year (117,236) was modestly increased over that of a year ago (114,885), representing an increment of about 2.4 percent. If Dental Service, Off-hours Service, and Lincoln Laboratory Service are excluded, the increase in visits is 4.6 percent (4,191). There was increased use of the primary-care services (medical, surgical, pediatric, and psychiatric) by 5.2 percent as well as several of the specialties.

The increasingly important role of the non-physician specialist is dramatically apparent in the latter areas. In orthopedics, for example, fewer patients were seen by the surgeons this year compared to last, but the total number of patient visits increased by 1,047 (37.5 percent) due to the activity of the non-physician orthopedic assistant. Similarly, in obstetrics/gynecology, there were fewer patient visits to physicians because we were without the services of one of our physicians for several months. Nonetheless, the total number of visits to the Service increased over 7 percent because of the active participation of the nurse-midwife.

The Dental Service experienced a 15 percent decrease due in part to a change in policy which will redefine the role of that Service as a primarily student-oriented activity. Use of the Off-hours Clinic also declined by 12.8 percent, reversing recent trends.

Within these overall statistics are some very interesting variations by population group. Health Plan members continue to use our facilities quite heavily: 6 visits per member per year. The increase in Health Plan membership this year accounted for an increment of 5,418 visits (excluding Dental), a rise of 16 percent.

Among students, however, there was a slight fall in intensity of use; this year students made 4.5 visits per student as compared with 4.6 a year ago. The total visits made by students (excluding Dental and Social Work Services where this categorization is not available) fell by 1,719 or 4.3 percent. The pattern of utilization further reveals that visits by students to physicians declined while visits to non-physician providers increased substantially. Of all visits made to the surgical physician assistant, for example, 63 percent were made by students; they made 51 percent of all visits to the orthopedic assistant. To place this in perspective, it should be noted that students made 38.6 percent of all visits to the Department (excluding Dental, and Lincoln Laboratory Services).

We hope that this indicates that our students find it more convenient and satisfactory to see non-physician providers. We do need to be careful, however, that we are not, all unknowingly, erecting barriers between students and physician providers. This will be carefully watched. A decline in use of medical services by students has been apparent and the subject of comment by our colleagues for the past couple of years. However, 4.5 visits per year still represents substantial use of our services.

The number of admissions to the Infirmary increased slightly (1.7 percent), although the Observation Unit admissions decreased by 15 percent. Among admissions, surgical patients increased by 25 percent, representing in part increased utilization of the Infirmary postoperatively for patients operated on at other hospitals. The Utilization Review Committee, chaired by Dr. Samuel W. Stein, has focused its attention on the use of the Observation Unit and has recommended changes which should increase both the quality and efficiency of care.

Because of the decrease in use, we removed from service 10 of our 28 beds. These beds may be reinstated within a year, if needed, by application to the licensing authority. It seems unlikely that we will need to do this.

Overall, we anticipate further increases in utilization of the Department, chiefly to accommodate the needs of the Health Plan as it continues to grow. If the current pattern is maintained, the

role of non-physician providers, particularly in specialty areas, will grow in importance. Utilization of the Infirmary, it is hoped, will continue to increase as it is used as an alternative to hospitalization in other more intensive (and expensive) hospitals in the area.

Student Health

The new health form for entering students, devised by Dr. Edward S. Rendall, has exceeded our expectations. Essentially all entering freshmen have submitted a completed form, providing us with useful information in timely fashion. This information will be used to identify students who may be at increased risk for the development of health problems, some of which we may, it is hoped, avert. For example, a bit less than 10 percent of these students smoke cigarettes.

Last fall, two students experienced cardiac arrest while playing intramural sports. Stimulated by these unhappy accidents, and with the full participation of Professor Ross G. Smith and the staff of the Athletic Department, a task force for cardiopulmonary resuscitation (CPR) was formed. All coaches and trainers have now had the basic CPR course. Starting this coming fall, all student intramural officials will be expected to undertake this training, and it will, in addition, be offered to students during IAP and to other members of the Institute community as resources permit.

Personal Assistance Program

This new endeavor within the Social Work Service is worthy of special note. Last fall, Ronald Fleming joined the staff as coordinator of this program which seeks to provide assistance for all M.I.T. employees whose work effectiveness is declining because of personal problems. After the development of policy and procedural guidelines, information about the program was provided to the community through distribution of these guidelines to approximately 3,600 supervisors, faculty members, and laboratory directors. Announcements appeared in *Tech Talk* and the Draper Laboratory's *D-Notes*, and orientation and training sessions were provided to supervisory and administrative personnel. Thus far, orientation and formal training has been provided to 475 people from groups as diverse as Physical Plant, Accounting, Draper, and Housing and Dining. Lincoln Laboratory supervisors recently have begun formal training as well. In addition, meetings have been held with groups with special interests, such as the Women's Forum and labor union stewards.

Although the impact of these efforts is just beginning to be felt, 32 supervisors have already made contact with Mr. Fleming for help in assisting troubled employees. Clinical services have been provided for 61 people, comprising almost 400 individual sessions. It is fair to assume that the number of referrals will continue to increase as the training efforts continue and the value of the provided services becomes appreciated throughout the community. Mr. Fleming has launched the program splendidly.

Non-Physician Providers: Protocols, Checklists, and Teams

Computer-audited checklists derived from protocols continue to be used for the evaluation and care of patients with a range of common acute illnesses. A new checklist covering minor surgical problems and soft tissue infections has been completed and will shortly be put into use. When this is effected, the majority of patients who come to the walk-in service for care (exclusive of traditional nursing services) will fall into one of the categories covered by the checklists. When that occurs, probably during this coming year, we plan to redefine the walk-in service's function. Patients whose illness is covered by a protocol checklist will be cared for by the non-physician providers; all others will be referred to physicians.

The development of these checklists and our plan for their use has made it possible for us to reassure the licensing authority that our nurse-practitioners are governed by written guidelines. The statutes which govern hospitals require that medical records be signed by physicians. This has been interpreted to indicate that physicians must countersign all of our nurse-practitioner records, a requirement which would work havoc on the operation of this Department. The licensing authority has offered, pending expected new regulations concerning nurse-practitioners, to waive this requirement if we demonstrate that our nurse-practitioners practice under the aegis of written protocols ("guidelines") and if we meet certain other criteria, which we are prepared to do.

The three teams of physicians, nurse-practitioners, and physician-assistants continue to operate. Further expansion of this mode of practice is limited by inadequate space. With the solution of the space problem in our new building, however, the experience gained by team members will be valuable in the development of decentralized clusters of primary care physicians and non-physician providers which will constitute the basic module of the Department's ambulatory services.

As noted earlier, the non-physician specialists continue to demonstrate their value. We currently enjoy the advantage of having a pediatric nurse-practitioner, a dermatology nurse-assistant, an orthopedic assistant, a nurse-midwife, two optometrists, and an optometric assistant on our staff.

Staff Changes

It is always sad to note the departure of valued colleagues and friends. There are some this year who need special mention.

Samuel Levin, Institute Radiation Protection Officer, has decided to take advantage of the Institute's early retirement option. Sam has been an invaluable asset to the Environmental Medical Service and to the Institute. The radiation protection program was, in large part, shaped by him and he has for many years carefully overseen it. Despite our distress at his leaving, we can understand the seductive lure of a quiet home on a fish-filled lake on Cape Cod.

Drs. Gordon Winchell and Charles Keevil have for over 20 years been associated with the medical program at the Lincoln Laboratory. During that time, they have provided highly skilled and thoughtful care to patients there. Unfortunately for us, they were unable any longer to take sufficient time from their busy practices to accommodate the growing needs of the service at the Laboratory. We are grateful that they will continue to be available for us to call upon for the care of patients in the area.

Dr. Owen Kite has been Chief of the Dental Service since its establishment in 1970. He is leaving now to address a new career as a dental management consultant. We envy those who will have the benefit of his considerable skills both as a clinical dentist and a manager.

The following appointments were made this year in the Department: Sheldon Binder, M.D., Surgeon; John Daly, M.D., Urologist; Michael Erard, P.A., Orthopedic Assistant; Barry Eton, D.M.D., Dentist; Gerald Fallon, Assistant Radiation Protection Officer; Ronald C. Fleming, M.S.W., Social Worker; Gregory Gauvin, M.D., Consultant in Pathology; Fruma Ginsburgh, M.D., Obstetrician-Gynecologist; Shirley Hjort, M.S., Marketing Representative, M.I.T. Health Plan; Geoffrey Linburn, M.D., Psychiatrist; Katherine McDonough, R.N.P., Nurse-Practitioner; James Nolan, M.D., Consultant in Pathology; Iris Ponzetti, M.P.H., Assistant Coordinator, Health Education and Information; David Reisen, M.D., Psychiatrist; Margaret Ross, M.D., Psychiatrist; Colleen Ryan, R.N.P., Nurse Practitioner; George Simpson, M.D., Otolaryngologist; Cynthia Stevens, D.D.S., Director of Dental Services; Roger Weiss, M.D., Psychiatry, Postdoctoral Fellow; and Mary Zook, R.N.P., Nurse-Practitioner.

Two of our staff members were promoted this year: George Christman, D.M.D., to Assistant Director, Dental Services; and Martha Loss, B.S., to Manager, Medical Records and Data Processing Services.

The following resigned from the Medical Department this year: Celia Beaucage, M.Ed., Microbiologist; Hubert Bird, M.D., Consultant in Pathology; Carlton Cappuccino, D.M.D., Dentist; Peter Cuevas, M.D., Surgeon; Richard Cutler, M.D., Psychiatrist; Barry Eton, D.M.D., Dentist; Robert Foster, M.D., Orthopedic Surgeon; Charles Keevil, M.D., Physician; William Kettyle, M.D., Endocrinologist; Owen Kite, D.M.D., Director of Dental Services; Joan Liem, Ph.D., Postdoctoral Fellow, Psychiatry; Irene Merwin, M.S.P.H., Assistant Coordinator, Health Education and Information; Jacob Rice, M.D., Ophthalmologist; Richard Schwartz, M.D., Postdoctoral Fellow, Psychiatry; Shailini Singh, M.D., Obstetrician-Gynecologist; Elissa Sloan, R.N.P., Nurse Practitioner; Howard Smith, M.D., Otolaryngologist; Robert Watton, D.M.D., Dentist; Gordon Winchell, M.D., Physician; and Tetsuo Yamazaki, Visiting Engineer.

Retiring from the staff were: Edward Dyer, M.D., Physician, and Samuel Levin, S.B., Executive Officer and Radiation Protection Officer in the Environmental Medical Service.

Obstetrical and Gynecological Services

The number of deliveries again increased significantly (17 percent) reaching 123. This year, the first delivery of an M.I.T. Health Plan patient by a nurse-midwife occurred. At this writing, Barbara Merrifield, C.N.M. has accepted the responsibility for six patients, five of whom have already been delivered. The program for midwife deliveries, eagerly awaited by some of our patients, has thus come into being.

This service was particularly hardworking this year because of the absence of one of the full-time obstetrician-gynecologists for several months. Dr. Charles Eades somehow was able to cope with a very demanding schedule and still maintain his equanimity. Assistance was also ably provided by Drs. Samuel Clark, Ruby Jackson, Valentina Donahue, and, of course, Ms. Merrifield.

As the Health Plan continues to grow, it is realistic to expect the level of activity in this service to increase *pari passu*. We welcome Dr. Fruma Ginsburgh whose demonstrated skills will, we are confident, stand our patients in good stead.

Psychiatric Service

As has become a tradition, Dr. Merton J. Kahne, Psychiatrist-in-Chief, offers a characterization of the past year:

The year has been a relatively quiet one. Students, faculty, and other members of the M.I.T. community have concentrated their efforts on doing what they do, well. The campus, as elsewhere, seems to be marking time, waiting expectantly through uncertainty. The crosscurrents of economic difficulties, energy shortages, and uncertain work futures dampen even the most effervescent among us.

There was little change either in the number of persons using the psychiatry service or in the number of visits made compared with a year ago. Visits by Health Plan members continued to increase -- this year by an increment of 10.6 percent -- to the point that they comprise about 40 percent of outpatient visits. Students made 43.8 percent of these visits.

There is continuing concern about the large number of the M.I.T. community who seek therapy under private auspices outside of M.I.T. The cost of such treatment is very high and the quality of services very uneven. The psychiatry service is happy to help plan outpatient therapy with any member of the community, offering its guidance in selecting from the large pool of talented therapists available.

In connection with this, the service has initiated an experimental psychotherapy program. Under the guidance of Dr. Joseph Brenner, it will offer experienced M.I.T. therapists for patients who require continuing treatment. Fees will be equal to or below those generally charged in the community. The program will be closely monitored and, if successful, may be continued.

Under the energetic leadership of Dr. Rochelle Friedman, the service gave a seminar "On Death and Dying." Responding to interest expressed by the nursing service, the program reviewed the problems and issues which professionals working with dying patients often confront. This was the first educational activity in the Medical Department which has been accredited as meeting the requirements for continuing professional education.

Dr. Margaret Ross, who has been with the service as a Postdoctoral Fellow since January 1979, will continue as a member of the staff. Her presence has helped greatly to relieve the pressure for women therapists which we have experienced for a number of years.

The psychiatry service sadly reports the death on January 16, 1979 of Dr. Richard Cutler. Although he had officially retired, Dr. Cutler had maintained close contact with several of his colleagues here and his loss is deeply mourned.

Social Work Service

The most dramatic change this year was the initiation of the Institute Personal Assistance Program referred to earlier. With the activity generated by that program, there was a substantial increase in the number of visits to and by the service (26 percent). However, this actually represents a modest decrease in visits when group activities and the new program are set aside. The reasons underlying this are not currently understood. A study will be undertaken soon to identify what factors may be involved.

Group activities continued with the participation of Myra Rodrigues in the foreign wives, minority student, and nightline discussions. Nightline, a student-run "hot line," was started in October 1978. Ms. Rodrigues, who had participated in the planning of this activity, has continued to provide weekly supervision to the 11 students who staff it.

Health Information and Education

A change in staff and staffing pattern occurred this year. Irene Merwin resigned in October 1978 to pursue a doctoral degree. She was replaced by Iris Ponzetti, M.P.H., who comes to the Department as full-time assistant coordinator for this service.

Three issues of the M.I.T. Health Plan *Newsletter* were published this year. A student health guide and a guide to the obstetrical services are being prepared for publication.

A group of lecture programs was presented throughout the year. Dr. Stein presented a very popular talk on Reducing Risk of Cardiovascular Disease on three occasions. Dr. Bruce Biller and Ms. Merrifield presented a program on contraceptive methods and Dr. John Moses gave a session on infectious diseases called "Is It Catching?" Plans for the coming year include an expansion of this activity.

The ongoing group programs were continued. Five programs of 10 sessions each were offered on Weight Control. One of these was, for the first time, at the Lincoln Laboratory. Follow-up sessions for participants in previous programs continue to be held. Smoking cessation (10 sessions, 30 participants), prenatal and parent groups (2 meetings per month), Lamaze childbirth review class (11 classes for 4 to 8 couples each), and cardiovascular risk (4 sessions) were the topics for an active program.

In addition, talks were given to housemasters, the house presidents, and women faculty members. Patient advocacy was discussed on a program broadcast on M.I.T.'s radio station, and Constance Bean, coordinator for Health Information and Education, gave a paper at the annual meeting of the American College Health Association on our prenatal and parent education programs.

Patient advocacy continues to be an important function of this service. It offers to all of our patients the opportunity to express grievances, questions, and perceived needs regarding their medical care. Problems receive prompt attention and are followed through to resolution, with the further option of appeal to the Medical Advisory Board. This year, 117 contacts were made by patients regarding medical, dental, or administrative questions. This is a reduction of 31 percent compared with last year.

M.I.T. Health Plan

Laurence H. Bishoff, Associate Director for Administration and Chief Administrative Officer of the M.I.T. Health Plan, offers the following reports concerning the M.I.T. Health Plan and the administrative activities in the Department.

The M.I.T. Health Plan ended its fifth year of operation with over 3,200 subscribers and within 47 members of the 7,000-member level. Enrollment represents 30 percent of the eligible M.I.T. population and one-quarter of the employee group at the Draper Laboratory. Enrollment among new employees for the time in which statistics are available (January to May) is well over 50 percent, auguring well for the continuing increase in membership.

Medical Department

Financially, the Plan has arrived at maturity. In this year, all expenses have been allocated net of the primary care subsidy given for all employees. This allocation provides significant relief to the Medical Department budget; marginal costs have increased significantly less than the \$1.1 million charged to the Plan as its pro-rated share of expenses.

This financial condition has led to a reformulation of pricing policy in the new year for members. This policy should place the M.I.T. Health Plan in a competitive position to retain its membership in the face of other similar programs now developing in the Boston area which should become available during the next five years.

Utilization of services by Plan members remains high, and its control has demanded continuous attention. Members visit the Department an average of six times per year, the highest utilization of any program reported in the national health maintenance organization census. Hospital utilization has been greater than planned during the year, due in large measure to the very high number of days devoted to inpatient psychiatric stays. At the same time, Infirmary use is less than planned for the year. Laboratory use is also very high.

During the year, the Plan acceded to a request from the Harvard Community Health Plan (HCHP) to offer the Plan to HCHP employees. Although the M.I.T. Health Plan is a program addressed to the needs of the M.I.T. community, this exception was made in view of the longstanding relationship between the Department and the Harvard Plan. Enrollment will be opened in the new fiscal year to 700 employees of the Harvard Plan. Only minimal impact on the Plan is forecast.

With the postponement of mandatory retirement to age 70, a study group mounted an effort to incorporate M.I.T. Health Plan membership with Medicare coverage for employees age 65 and over. This choice is expected to be made available by September 1979.

Claire Recker, who had conducted enrollment programs since the Plan's inauguration, resigned to raise her family. Shirley Hjort has been appointed marketing representative and brings experience in college health settings and as a community health planner. Strong continuous marketing efforts will be required to meet the increased competition in the coming years.

Administrative Activities

The major activity absorbing our energies was pursuit of a Certificate of Need for the Department's proposed new building on which application had been filed the previous year (January 3, 1978). We had been advised that the Certificate would not be granted lightly; the Massachusetts Department of Public Health (DPH), led by its Commissioner, had acquired a national reputation for rejecting applications in an effort to hold down capital expansion of health care facilities. During this period, hospitals proposing to build major new ambulatory facilities had been working without success for up to five years. Thus the prospect of being permitted to construct our building -- even with M.I.T.'s significant capital commitment -- was worrisome, to say the least.

A small departmental task force, including legal and technical consultants, monitored the process as the year began and the DPH began its analysis. The health systems agency (the Health Planning Council of Greater Boston) had recently issued an advisory opinion in favor of the application. Both that agency and the DPH's Certificate of Need Office had undergone a major turnover in personnel during this period; therefore, time was consumed in educating and re-educating new staff members. A major hurdle was passed with the issuance of the staff report in November; after considerable analysis, a tour of the facilities, and many exchanges of memoranda, the DPH staff analyst had recommended the Certificate be granted with the exception of one X-ray unit.

On November 14, 1978, the Public Health Council voted to award M.I.T. its Certificate, bringing the process to a successful conclusion less than one year after filing. With all the uncertainties in the process -- nearly 100 people, two separate agencies, three volunteer committees, and two separate staffs had directly considered the application -- it was indeed gratifying to have "won the game." In retrospect, the process also required that the Department thoroughly review and give careful thought to its long-range plans, thus proposing a rational plan of action.

It is now possible to shift our attention to the design of the new building; a client team from the Department, working with the architects and Planning Office, had been guiding the development of a consolidated facility, incorporating all the Department's outpatient services and an 18-bed inpatient unit. The 10-bed reduction from the Department's current 28 licensed bed capacity was made in the face of Certificate of Need examination and the actual occupancy experience. The 58,000 new square feet in the new building will nearly double the present space, provide a pleasant setting for patients, and an efficient operating environment for staff with some future expansion space built in.

While awaiting the new facility, it was necessary to complete interim renovations, focusing this year on the M.I.T. Infirmery building to assist the outpatient users crowded into the first floor. These expenditures, funded by the M.I.T. Health Plan, should alleviate some of the operating deficiencies which the present quarters have presented.

Management improvements were made in the Department's budgeting system through the introduction of service-specific cost projections. Reorganization of personnel in the accounting area resulted in improved effectiveness and billing activities. Income forecasts have been more closely aligned with actual trends. Combined sales for the M.I.T. Health Plan and fee-for-service revenues approached the \$2 million level for the year, providing great relief to M.I.T. general funds. Large problems remain, however, in meeting planned revenues for the Dental Service.

During the year, an independent management study of the record room was undertaken to evaluate the Department's record room operation. Significant changes in record procedures have resulted which should lead to improved operational effectiveness and increased responsiveness. A revision of the X-ray record system was also undertaken to make it consistent with the general record system.

The Department fulfilled a major commitment stated in its affirmative action plan by completing the appointment of the Department's nurses to staff status. With the cooperation of the M.I.T. Personnel Office, the Department carefully examined the merits of this action with the inpatient nurses affected. At the conclusion, the consensus was that such a step was desirable and deserving of consideration. The action brings over 25 of these professionals employed in the Department into the Institute's staff category.

The Department and its consumer advisory group had long advocated the inclusion of the student health fee in the tuition fee. Much to our surprise and delight, the Institute this year acceded to our perennial request effective with the September 1980 tuition charge. Tangible benefits to students will include the coverage of health care services through awards and fellowships. The Department will be relieved of the burden of administering the fee and adjudicating exceptions. Perhaps the greatest benefit though will be the psychological removal of any barrier to services.

The Institute assumed the risk for actual experience of student hospital insurance last year. In this year, the experience continued to be excellent, well within the revenues collected. The policy benefits constitute one of the most generous university student health insurance plans.

During this year, two separate groups from the Sloan School used the Department as a field site. The projects included an evaluation of primary care teams and an industrial dynamics modeling of the M.I.T. Health Plan.

Division of Laboratory Animal Medicine

Health-related research, much of which uses animals, continues to grow at M.I.T. to the point where nearly one-third of all research at the Institute is in this category. The activities of the Division reflect this fact.

Renovation of existing animal facilities has continued; the Building 56 complex will have been completed by the publication of this report and the renovations in E18 will commence immediately thereafter. Planned improvements to the Department of Psychology's facilities in Building 37, however, will be modified because of the availability of new animal quarters in Whitaker College. This will provide space for animals used by investigators at the College as well as certain members of the faculty in the Department of Psychology and in neurosciences. Upon completion of the new building, then, the animal facility in Building 37 will no longer be used.

Medical Department

Due in part to these extensive renovations, but also reflecting the excellent performance of the Division under the direction of Dr. James Fox, the Institute has been granted full accreditation for another three-year period by the American Association for Accreditation of Laboratory Animal Care.

The daily census of animals involves 15 species and averages 13,000 to 15,000. Total animal utilization, including both purchase and breeding, approaches 400,000 per year.

The Animal Research Diagnostic Laboratory has completed its third year of operation, and a competitive three-year renewal application for funding has, we are delighted to report, been approved. The Laboratory not only provides diagnostic resources for the laboratory animal medicine program for the Institute but also provides services to several research institutions in the area. These include Massachusetts General Hospital, Brandeis University, Northeastern University, Forsyth Dental Center, West Roxbury VA Hospital, Boston VA Hospital, and Arthur D. Little, Inc.

The Division continues its active program in clinical examination and disease surveillance for all animals at M.I.T. In addition, an environmental surveillance program has been developed for monitoring bacterial contamination of water, equipment, autoclaves, and animal quarters. Moreover, a surveillance program for rodent vendors is operating. Evidence of clinically silent disease is also sought through pathological evaluation of every primate housed at M.I.T. after the conclusion of the experimental study.

Some of the diseases diagnosed in animals at M.I.T. and at participating institutions follow: *Primates*: tuberculosis; simian hemorrhagic fever; arteriosclerosis; glomerulosclerosis; enteric, hepatic and respiratory parasitism, shigellosis, salmonellosis; *Dogs*: distemper; tracheobronchitis; external and internal parasitism; dirofilariasis; streptococcal pneumonia and septicemia; klebsiella pneumonia; *Cats*: panleukopenia; rhinotracheitis; streptococcal septicemia, pneumonia and peritonitis; dermatomycosis; cheyletiella mites (two publications); phycomycosis and aspergillosis (one publication); pyometra; visceral larval migrans; external and internal parasitism; bordetella pneumonia; salmonellosis (five publications); *Rabbits*: pasteurellosis; cysticerocosis; encephalitozoonosis; hepatic and intestinal coccidiosis; treponematosis; cestodiasis; mucoid enteropathy; idiopathic enteritis; congenital entropion (one publication); *Guinea Pigs*: streptococcal septicemia, pneumonia, and peritonitis; *Rats*: diplococcal pneumonia, pleuritis and peritonitis; mycoplasmosis; external and internal parasites; sialodacryoadenitis; streptococcal pneumonia; klebsiella pneumonia; periarteritis nodosa, ulcerative dermatitis (one publication).

Similar lists can be generated for mice, hamsters, degus, gerbils, frogs, fish and chameleons! A particularly interesting observation in degus was amyloidosis of the islets of Langerhans associated with diabetes mellitus.

The value of the clinical and diagnostic capability of the Division was further illustrated by the delineation of the importance of *salmonella* in cats. A screening program revealed *salmonella* carriers at an incidence of 10.6 percent in cats supplied by commercial dealers. Thirteen of the isolates (81 percent) were, moreover, resistant to one or more antibiotics. Of these, 10 transferred a portion of the resistance pattern to an *E. coli* K-12 recipient. The fact that these organisms were shed by clinically normal carriers is of particular importance and has led to the recommendation that laboratory cats from a rural source be screened for enteric *salmonella*.

Study of an outbreak of tuberculosis in rhesus monkeys at a Boston teaching hospital demonstrated a correlation among numbers of circulating T cells, duration of skin allograft survival, and the appearance of tuberculin skin-test sensitivity. With the help of the Division, an adequate tuberculosis control program was established.

Investigation of unexpected illness and death in a strain of mice led to the discovery of mouse hepatitis virus infection. Changes in handling techniques and the establishment of a new mouse colony apparently solved the problem.

Research activities have been actively pursued by the D.L.A.M. staff individually and in collaboration with other investigators. Three possible new animal models for the study of human disease have been developed: study of lipotrope and alcohol in the etiology of fatty liver and cirrhosis in alcoholics, diabetes mellitus in the degu, which is exploring the possible role of a

virus discovered in the pancreas of diabetic degus, and pectus excavatus in the cat. In addition, studies are under way to explore the relationship between *Mycoplasma pulmonis*, sendai virus and lung tumor development with nitrosamines in rats and mice.

Teaching activities in the Division continue. A summer training program for veterinary students has been established and a fellowship program in laboratory animal medicine is also offered. Members of the staff teach in the course Laboratory Animals: Usage in Biomedical Experimentation, and will participate in a course in the Department of Nutrition and Food Science.

Environmental Medical Service

In the fall of 1978, a Task Force was selected to consider the Environmental Medical Service, assess its present activities, and to make recommendations about its future role. This was, in part, occasioned by the growing interest and involvement of the staff in research and teaching, the increasing demands of regulating agencies on their time and talents, and continuing concerns about the necessity for functioning in the dual roles of valued friendly resource and police officer.

Chaired by Dr. Melvin Chalfen, the group includes Dean Robert Alberty, Vice President Philip Stoddard, Professors Nicholas Ashford, Gene Brown, Ernest Cravalho, Peter Demos, and Gerald Wogan, and Dr. Warren Wacker, Director of Health Services at Harvard University. We anticipate a report in the fall.

Dr. Chalfen, Head of the Environmental Medical Service, offers the following report:

Day-to-day activities of the Environmental Medical Service have continued to increase in every area.

Samuel Levin, the Institute Radiation Protection Officer and head of the Radiation Protection Office for many years, decided to take an early retirement. Although we are all happy for Sam, his retirement will leave a great void as his expertise and leadership have contributed immensely to the R.P.O. and to the entire E.M.S. Fortunately, Murray Bolton has agreed to be acting Radiation Protection Officer while a national search is conducted for Mr. Levin's replacement.

A major problem for the R.P.O. and for the Institute has been the disposal of radioactive waste. Last year's report pointed out both the increasing cost and the possibility of decreasing sites. At present, the nearest disposal site at Barnwell, South Carolina, is no longer available for organic liquid waste. Such waste is a large fraction of our radioactive waste. The only two other sites are Nevada and Washington. The cost of radioactive waste disposal may increase to three to four times the present levels, which are currently higher than those of a year ago. Much effort both at M.I.T. and other universities has been and continues to be made in the area of solving this problem. Decrease in the amounts of material used will help to some extent. Incinerator use has been delayed due to the need for better incinerator development, cost and compliance with local, state, and Federal regulations.

The mission of the Radiation Protection Office at the Reactor under Edward Karaian has been successful in that no personnel have had exposures above permissible maximal limits. Monitoring and surveillance continues to increase both at the Reactor and in the environment surrounding it. All findings have been satisfactory.

The Radiation Protection Office at the Bates Linear Accelerator has expanded as new construction and additional research work demands have increased. Much time is spent analyzing the needs and methods for protection as the new Experimental Hall nears completion.

The Biohazards Assessment Office laboratory was completed this year and has proved to be a valuable resource. Not only has the laboratory allowed Dr. Daniel Liberman, Biohazards Assessment Officer, to conduct his planned work, but it has allowed investigators to expand aspects of their work because of the laboratory's special equipment that is not available in their own laboratories. This use of the laboratory as an Institute resource has been an important and welcome find. Development of monitoring techniques for biological work of potential hazard increases as the types of investigations grow and diversify. Dr. Liberman has been sought by many groups both in Cambridge and in other areas of the country for advice and lectures on his work.

Medical Department

The Industrial Hygiene Office finds that there have been increases in requests for air samples in various areas, especially in those where there may be asbestos. The general increase in public awareness of potential hazards has resulted in further identification of areas where E.M.S. advice and help can be given -- the continuation of a welcome trend as it results in increasing control of potential exposures. Formal programs of interaction of I.H.O. members with the staff of the Physical Plant in the area of asbestos exposure control have grown and expanded. Another example of the usefulness of the cooperation of Institute committees with E.M.S., and with the joint membership principle, is the action this year of the Committee on Toxic Chemicals to endorse a policy of I.H.O. evaluation of all new hoods, biocabinets, etc. This practice not only assures equipment which functions properly, but avoids future problems both by maintenance programs and the placement at the onset of new hoods and biocabinets which don't unbalance previously existing ventilation systems.

On the negative side, because of new building plans, I.H.O. space in Building E15 (about 1,200 square feet) will be lost -- a serious loss as the functions of testing in that space are essential to the engineering control aspects of the I.H.O. programs in evaluating new hoods and ventilation equipment.

Of great interest and importance this year has been the formation of an E.M.S. Task Force to assess our present activities and to make recommendations for ways to further strengthen the Service. In my opinion these ways would include adequate staffing for additional teaching and research activities. The value of these activities was strongly pointed out in the Annual Reports of 1969 and 1970 by Harriet Hardy, M.D. The interest by the Medical Department Visiting Committee of December 1977 and the Medical Department Administration led to the formation of the Task Force.

The Radioactivity Center activities have continued as in the past, but inflation and budget limitations may have more import this coming year than in the past.

MELVIN H. RODMAN

Registrar

Data on student enrollment and degrees awarded are presented in the following tables in a format consistent with prior years.

The Registrar's student data base was expanded this year to include student financial aid information. This development included new computer programs which will meet the reporting requirements of the Office of Student Financial Aid, access and update this information through remote, visual display terminals, and transfer the appropriate data to other offices. Visual display terminals for rapid access to the student files were also installed at their request in the offices of Student Loans, the Dean for Student Affairs, the Dean of the Graduate School, the Medical Department, and Housing and Food Services. The access of each of these offices was limited to a relevant portion of the file to preserve privacy of information.

The perennial problem of maintaining and updating classrooms was given increased attention this year. While the locations of the smaller rooms tend to shift, subject to changing space needs, the larger lecture rooms generally remain fixed. A study is now under way to determine the cost and desirability of alternative plans for improving the older lecture rooms and also to investigate the scheduling process for the classes in these rooms.

WARREN D. WELLS

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	1904-05	1,561	1943-44	1,579
1866-67	137	1905-06	1,466	1944-45	1,198
1867-68	167	1906-07	1,397	1945-46	1,538
1868-69	172	1907-08	1,415	1946-47	5,172
1869-70	206	1908-09	1,461	1947-48	5,662
1870-71	224	1909-10	1,479	1948-49	5,433
1871-72	261	1910-11	1,506	1949-50	5,458
1872-73	348	1911-12	1,559	1950-51	5,171
1873-74	276	1912-13	1,611	1951-52	4,874
1874-75	248	1913-14	1,685	1952-53	5,074
1875-76	255	1914-15	1,816	1953-54	5,183
1876-77	215	1915-16	1,900	1954-55	5,348
1877-78	194	1916-17	1,957	1955-56	5,648
1878-79	188	1917-18	1,698	1956-57	6,000
1879-80	203	1918-19	1,819	1957-58	6,179
1880-81	253	1919-20	3,078	1958-59	6,259
1881-82	302	1920-21	3,436	1959-60	6,270
1882-83	368	1921-22	3,505	1960-61	6,289
1883-84	443	1922-23	3,180	1961-62	6,454
1884-85	579	1923-24	2,949	1962-63	6,695
1885-86	609	1924-25	2,938	1963-64	6,925
1886-87	637	1925-26	2,813	1964-65	7,151
1887-88	720	1926-27	2,671	1965-66	7,408
1888-89	827	1927-28	2,712	1966-67	7,567
1889-90	909	1928-29	2,868	1967-68	7,730
1890-91	937	1929-30	3,066	1968-69	7,764
1891-92	1,011	1930-31	3,209	1969-70	8,024
1892-93	1,060	1931-32	3,188	1970-71	7,799
1893-94	1,157	1932-33	2,831	1971-72	7,717
1894-95	1,183	1933-34	2,606	1972-73	7,850
1895-96	1,187	1934-35	2,507	1973-74	7,888
1896-97	1,198	1935-36	2,540	1974-75	8,050
1897-98	1,198	1936-37	2,793	1975-76	8,482
1898-99	1,171	1937-38	2,966	1976-77	8,597
1899-00	1,178	1938-39	3,093	1977-78	8,712
1900-01	1,277	1939-40	3,100	1978-79	8,881
1901-02	1,415	1940-41	3,138		
1902-03	1,608	1941-42	3,055		
1903-04	1,528	1942-43	3,048		

*From 1943 to 1946 Army and Navy students are omitted (see Table III-B in reports for 1943 to 1946).

Table I-A Student Registration in the Summer Session since 1948

Year	*In Regular Subjects	+In Other Subjects	Year	*In Regular Subjects	+In Other Subjects
1948	2,146	-	1965	2,090	1,568
1949	1,875	171	1966	2,054	1,787
1950	1,852	259	1967	2,218	1,829
1951	1,861	813	1968	2,490	1,739
1952	1,689	832	1969	2,241	1,719
1953	1,672	1,289	1970	2,185	1,666
1954	1,675	1,398	1971	2,197	1,109
1955	1,619	1,653	1972	2,121	1,235
1956	1,553	2,497	1973	2,205	1,367
1957	1,548	1,757	1974	2,153	1,701
1958	1,650	1,752	1975	2,238	1,430
1959	1,635	1,510	1976	2,317	1,614
1960	1,600	1,696	1977	2,321	1,724
1961	1,668	1,412	1978	2,344	1,611
1962	1,748	1,763			
1963	1,808	1,397			
1964	1,882	1,492			

*Students attending regular subjects from M.I.T. curricula

+Students attending professional and technical subjects which are not part of M.I.T. curricula and in general carry no academic credit

Table II Academic Staff Count

	Professors	Administration also	Professors	Institute Professors	Emeriti-Part Time	Adjunct Professors	Associate Professors	Assistant Professors	Sr. Lecturers & Emeriti	Sr. Lecturers	Lecturers	Sr. Research Scientists	Instructors	Technical Instructors	Sr. Research Associates	Postdoctoral Associates	Research Assistants	Teaching Assistants	Instructor Grad	Total	Visiting Professors	Others ¹
Institute Professors	8	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	2	2
Institute Lecturers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
School of Architecture and Planning																						
Architecture	12	1	-	3	-	14	11	-	-	2	-	1	7	-	-	-	14	22	1	88	1	2
Urban Studies and Planning	9	1	-	1	-	16	3	-	-	2	-	1	-	-	-	-	22	-	10	65	2	11
Total	21	2	-	4	-	30	14	-	-	4	-	2	7	-	-	-	36	22	11	153	3	19
School of Engineering																						
Aeronautics and Astronautics	1	5	-	-	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	10	-	2
Chemical Engineering	22	3	-	-	-	6	4	2	4	13	-	-	2	2	2	1	91	3	-	153	3	9
Civil Engineering	12	2	-	-	-	5	7	-	1	3	-	3	2	2	-	-	72	32	-	139	-	9
Electrical Engineering	17	2	-	-	-	12	13	1	3	3	-	-	-	-	1	-	115	23	1	191	5	10
Materials Science and Computer Science	50	10	-	4	-	27	13	3	1	16	2	-	1	1	1	-	209	87	-	424	5	17
Mechanical Engineering	23	1	-	1	-	3	7	-	1	1	-	-	3	1	1	3	104	22	-	169	-	20
Nuclear Engineering	26	3	-	1	-	10	11	1	6	22	-	-	5	1	1	1	178	12	2	279	-	13
Ocean Engineering	12	1	-	1	-	4	2	1	-	-	-	-	-	-	1	-	62	20	1	105	-	9
	10	1	-	1	-	8	5	-	-	1	-	-	-	-	-	-	41	8	1	76	-	6
Total	173	28	-	8	-	77	62	10	15	59	2	3	13	7	5	872	207	5	1,546	15	95	
School of Humanities and Social Science																						
Educational Programs	6	-	-	-	-	2	4	-	-	-	-	-	1	-	-	-	1	-	-	14	2	3
Economics	16	1	-	-	-	2	5	2	-	-	-	-	-	-	-	-	8	23	-	57	1	7
Humanities	18	2	-	-	-	23	18	1	1	19	-	19	16	-	-	-	-	2	-	119	8	1
Linguistics and Philosophy	11	1	-	-	-	3	4	-	-	2	-	2	-	-	-	-	23	12	-	56	3	15
Political Science	15	3	-	-	-	2	3	-	1	-	-	3	-	-	-	-	12	10	-	49	2	4
Psychology	6	1	-	-	-	5	-	-	-	1	-	-	2	-	-	2	2	-	-	19	-	19
Total	72	8	-	-	-	37	34	3	2	20	-	25	18	-	2	46	47	-	314	16	49	
Alfred P. Sloan School of Management																						
Management	23	3	-	4	-	15	21	3	6	2	-	1	-	-	-	-	45	37	-	160	8	20

Table III Classification of Students since 1976

	1976-77				1977-78				1978-79				Course Number			
	2	3	4	G Total	2	3	4	G Total	2	3	4	G Total				
School of Architecture and Planning																
Architecture, IV	38	46	50	201	335	27	44	47	194	312	34	33	47	199	313	IV
Architecture, IV-B	2	2	2	-	6	1	1	2	-	4	-	2	1	-	3	IV-B
Urban Studies and Planning, XI	10	12	18	127	167	5	9	16	148	178	12	11	10	168	201	XI
Total	50	60	70	328	508	33	54	65	342	494	46	46	58	367	517	Total
School of Engineering																
Aeronautics and Astronautics, XVI	46	28	15	178	267	36	41	27	177	281	52	27	42	166	287	XVI
Aeronautics and Astronautics, XVI-B(Cooperative)	2	2	3	-	7	3	4	3	-	10	1	4	3	-	8	XVI-B
Aeronautics and Astronautics, XVI-C(Internship)	-	-	-	-	-	-	-	-	-	-	-	6	-	-	6	XVI-C
Chemical Engineering, X	99	96	44	181	420	106	102	82	195	485	111	114	101	198	524	X
Chemical Engineering, X-C(Internship)	3	1	7	-	11	1	4	2	-	7	-	2	4	-	6	X-C
Civil Engineering, I	52	67	57	218	394	38	67	61	238	404	31	53	69	266	419	I
Electrical Engineering and Computer Science, VI																
Program 1-Electrical Science and Engineering	203	141	127	496	1223	188	174	136	463	1256	219	140	182	485	1271	VI
Program 3-Computer Science and Engineering	76	93	87	-	-	84	99	112	-	-	59	76	110	-	-	-
Electrical Engineering and Computer Science, VI-A (Cooperative)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Program 1-Electrical Science and Engineering	-	66	48	55	169	-	45	49	49	182	-	43	48	65	207	VI-A
Program 3-Computer Science and Engineering	-	-	-	-	-	-	20	19	-	-	-	29	22	-	-	-
Electrical Engineering and Computer Science, VI-W (Woods Hole)	-	-	-	-	-	-	-	-	1	1	-	-	-	1	1	VI-W
Materials Science and Engineering, III	16	7	8	160	191	23	10	9	159	201	29	20	12	162	223	III
Materials Science and Engineering, III-A	2	-	1	-	3	2	4	-	-	6	3	3	4	-	10	III-A
Materials Science and Engineering, III-B (Cooperative)	3	10	2	-	15	6	13	6	1	26	6	17	14	-	37	III-B
Materials Science and Engineering, III-W (Woods Hole)	-	-	-	-	-	-	-	-	1	1	-	-	-	1	1	III-W
Mechanical Engineering, II	105	77	74	227	483	85	124	78	279	566	118	113	134	309	674	II
Mechanical Engineering, II-A	15	12	16	-	43	12	9	13	-	34	12	20	14	-	46	II-A
Mechanical Engineering, II-B(Internship)	5	5	7	-	17	2	13	13	-	28	-	11	-	-	11	II-B
Mechanical Engineering, II-T(Textile Technology)	-	-	-	2	2	-	-	-	3	3	-	-	-	4	4	II-T
Mechanical Engineering, II-W(Woods Hole)	-	-	-	-	-	-	-	-	1	1	-	-	-	1	1	II-W
Nuclear Engineering, XXII	13	19	2	190	224	18	14	16	172	220	16	16	7	174	213	XXII
Nuclear Engineering, XXII-A(Internship)	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2	XXII-A
Ocean Engineering, XIII	17	10	10	97	134	14	14	10	91	129	11	15	11	86	123	XIII
Ocean Engineering, XIII-C(Cooperative)	-	-	2	-	2	1	4	-	-	5	-	1	2	-	3	XIII-C
Ocean Engineering, XIII-W(Woods Hole)	-	-	-	11	11	-	-	-	9	9	-	-	-	5	5	XIII-W
Naval Construction and Engineering, XIII-A	-	-	-	62	62	-	-	-	55	55	-	-	-	47	47	XIII-A
Shipping and Shipbuilding Management, XIII-B	-	-	-	3	3	-	-	-	6	6	-	-	-	5	5	XIII-B
Center for Advanced Engineering Study, EN	-	-	-	42	42	-	-	-	54	54	-	-	-	49	49	EN
Total	657	634	510	1922	3723	619	761	636	1954	3970	668	712	779	2024	4183	Total

School of Humanities and Social Science

Economics, XIV	8	27	33	122	190	12	15	27	124	178	12	18	23	130	183	XIV
Humanities and Engineering, XXI-A	-	7	3	-	10	-	1	1	-	2	-	-	2	-	2	XXI-A
Humanities and Science, XXI-B	4	8	12	-	24	5	9	13	-	27	7	9	17	-	33	XXI-B
Linguistics and Philosophy, XXIV	2	7	-	54	63	2	5	4	48	59	2	2	2	48	54	XXIV
Political Science, XVII	7	9	10	101	127	3	5	8	108	124	3	8	8	112	131	XVII
Psychology, IX	-	-	-	29	29	-	-	-	26	26	-	-	-	26	26	IX
Total	21	58	58	306	443	22	35	53	306	416	24	37	52	316	429	Total

Alfred P. Sloan School of Management

Management, XV	21	45	40	347	453	20	36	33	345	434	36	32	46	335	449	XV
Management Fellows, XV-A	-	-	-	72	72	-	-	-	65	65	-	-	-	65	65	XV-A
Management-Operations Research, XV-B	-	-	-	14	14	-	-	-	11	11	-	-	-	23	23	XV-B
Total	21	45	40	433	539	20	36	33	421	510	36	32	46	423	537	Total

School of Science

Biology, VII	53	72	61	135	321	43	69	68	122	302	64	59	70	123	316	VII
Biology, VII-A	7	13	9	-	29	5	7	12	-	24	2	10	11	-	23	VII-A
Biology, VII-B	10	44	44	-	98	26	17	44	-	87	11	28	24	-	63	VII-B
Biology, VII-W(Woods Hole)	-	-	-	15	15	-	-	-	16	16	-	-	-	18	18	VII-W
Chemistry, V	59	53	43	177	332	43	59	53	169	324	52	42	56	179	329	V
Earth and Planetary Sciences, XII	16	25	23	83	147	12	22	30	95	159	18	17	22	83	140	XII
Earth and Planetary Sciences, XII-W(Woods Hole)	-	-	-	39	39	-	-	-	35	35	-	-	-	44	44	XII-W
Interdisciplinary Science Program, XXV	2	7	7	16	32	3	6	4	12	25	3	4	9	15	31	XXV
Mathematics, XVIII	47	68	78	127	320	41	57	71	115	284	35	45	56	116	252	XVIII
Meteorology, XIX	-	-	-	51	51	-	-	-	50	50	-	-	-	40	40	XIX
Meteorology, XIX-W(Woods Hole)	-	-	-	12	12	-	-	-	15	15	-	-	-	15	15	XIX-W
Nutrition and Food Science, XX	-	-	-	188	188	-	-	-	199	199	-	-	-	184	184	XX
Physics, VIII	103	88	101	255	547	68	106	93	271	538	80	84	95	287	546	VIII
Total	297	370	366	1098	2131	241	343	375	1099	2058	265	289	343	1104	2001	Total

Health Sciences and Technology, HST

Undesignated	158	-	-	42	42	-	-	-	43	43	-	-	-	53	53	HST
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First Year	1053	1053	1081	1081	1066	95	1066	1066	1066	1066	1066	1066	1066	1066	1066	First Year
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Grand Total	1053	1204 ¹	1167 ¹	1044 ¹	4129	8597	1081	1075 ²	1229 ²	1162	4165	8712	1066	1134	1116 ³	1278 ³	4287	8881	Grand Total
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(not included in above figures)

Non-Institute Students from Harvard	5	2	15	251	272	4	11	11	287	313	2	15	18	310	345	NIH
Non-Institute Students from Wellesley	4	63	76	84	227	67	45	88	1	201	37	53	87	-	177	NIW

¹These totals include 7 students in third year, 3 in fourth year on Foreign Study; 1 student in second year, 2 in third year on Domestic Study.
²These totals include 8 students in third year, 1 in fourth year on Foreign Study; 1 student in second year, 1 in third year and 1 in fourth year on Domestic Study.
³These totals include 4 students in third year and 2 in fourth year on Foreign Study; 1 student in fourth year on Domestic Study.

Table III-A Women Students by Schools, Courses and Years, 1978-79¹

Course	2	3	4	Graduate		Total
				Regular	Special	
School of Architecture and Planning						
Architecture,IV	10	3	12	60	8	93
Architecture,IV-B	-	-	-	-	-	-
Urban Studies and Planning,XI	6	3	4	67	5	85
Total	16	6	16	127	13	178
School of Engineering						
Aeronautics and Astronautics,XVI	4	3	-	7	-	14
Chemical Engineering,X	15	23	22	27	-	87
Chemical Engineering,X-C	-	2	1	-	-	3
Civil Engineering,I	11	13	13	15	3	55
Electrical Engineering and Computer Science,VI						
Program 1-Electrical Science and Engineering	20	7	3	38	5	90
Program 3-Computer Science and Engineering	5	4	8			
Electrical Engineering and Computer Science,VI-A(Cooperative)						
Program 1-Electrical Science and Engineering	-	4	2	7	-	19
Program 3-Computer Science and Engineering	-	3	3			
Materials Science and Engineering,III	9	4	4	24	1	42
Materials Science and Engineering,III-A	1	2	3	-	-	6
Materials Science and Engineering,III-B(Cooperative)	2	5	8	-	-	15
Mechanical Engineering,II	17	11	12	16	1	57
Mechanical Engineering,II-A	-	4	2	-	-	6
Mechanical Engineering,II-B (Internship)	-	1	-	-	-	1
Nuclear Engineering,XXII	2	-	1	9	-	12
Ocean Engineering,XIII	-	-	2	2	1	5
Ocean Engineering,XIII-C(Cooperative)	-	-	2	-	-	2
Shipping and Shipbuilding Management,XIII-B	-	-	-	1	-	1
Total	86	86	86	146	11	415
School of Humanities and Social Science						
Economics,XIV	2	1	1	16	1	21
Humanities and Engineering,XXI-A	-	-	1	-	-	1
Humanities and Science,XXI-B	1	1	8	-	-	10
Linguistics and Philosophy,XXIV	1	-	1	18	2	22
Political Science,XVII	2	-	1	24	2	29
Psychology,IX	-	-	-	9	-	9
Total	6	2	12	67	5	92
Alfred P. Sloan School of Management						
Management,XV	8	12	10	68	13	111
Management-Fellows,XV-A	-	-	-	5	2	7
Management-Operations Research,XV-B	-	-	-	6	-	6
Total	8	12	10	79	15	124
School of Science						
Biology,VII	16	19	18	34	12	99
Biology,VII-A	1	1	6	-	-	8
Biology,VII-B	4	15	9	-	-	28
Biology,VII-W(Woods Hole)	-	-	-	5	-	5
Chemistry,V	12	12	12	34	-	70
Earth and Planetary Sciences,XII	6	3	9	15	-	33
Earth and Planetary Sciences,XII-W(Woods Hole)	-	-	-	13	-	13
Interdisciplinary Science Program,XXV	-	1	3	3	-	7
Mathematics,XVIII	5	8	11	13	-	37
Meteorology,XIX	-	-	-	2	1	3
Meteorology,XIX-W(Woods Hole)	-	-	-	3	-	3
Nutrition and Food Science,XX	-	-	-	52	3	55
Physics,VIII	11	5	8	14	1	39
Total	55	64	76	188	17	400
Health Sciences and Technology,HST	-	-	-	1	7	8
Undesignated	18					18
First Year	231					231
Grand Total	231	189	170	200	68	1466

¹Also included in Table III

Total undergraduate women 790, 16 special undergraduate women are included.

Table III-B Special Students by Schools, Courses and Years, 1978-79¹

Course	2	3	4	6	Total
School of Architecture and Planning					
Architecture,IV	1	-	-	10	11
Urban Studies and Planning,XI	-	-	-	22	22
Total	1	-	-	32	33
School of Engineering					
Aeronautics and Astronautics,XVI	-	-	-	17	17
Chemical Engineering,X	-	-	-	2	2
Civil Engineering,I	-	1	-	23	24
Electrical Engineering and Computer Science,VI, VI-1,VI-3,VI-A	6	4	1	57	68
Materials Science and Engineering,III	1	-	-	5	6
Mechanical Engineering,II	2	-	-	10	12
Nuclear Engineering,XXII	-	-	-	2	2
Ocean Engineering,XIII	-	-	-	6	6
Center for Advanced Engineering Study,EN	-	-	-	49	49
Total	9	5	1	171	186
School of Humanities and Social Science					
Economics,XIV	1	-	2	4	7
Humanities and Science,XXI-B	3	1	3	-	7
Linguistics and Philosophy,XXIV	-	-	1	2	3
Political Science,XVII	-	-	1	10	11
Psychology,IX	-	-	-	1	1
Total	4	1	7	17	29
Alfred P. Sloan School of Management					
Management,XV,XV-A	3	-	-	35	38
School of Science					
Biology,VII,VII-A,VII-B	4	-	-	16	20
Chemistry,V	-	-	-	3	3
Earth and Planetary Sciences,XII	-	-	-	-	-
Interdisciplinary Science Program,XXV	-	-	-	1	1
Mathematics,XVIII	3	1	4	5	13
Meteorology,XIX	-	-	-	1	1
Nutrition and Food Science,XX	-	-	-	10	10
Physics,VIII	2	2	-	5	9
Total	9	3	4	41	57
Health Sciences and Technology,HST	-	-	-	47	47
Undesignated	8				8
Grand Total	34	9	12	343	398

¹Included also in Table III

Table IV Continued, Former, and New Students

	1974-75	1975-76	1976-77	1977-78	1978-79
Continued Students					
Undergraduate and graduate students registered at the end of the last academic year (including special students).	5,513	5,747	5,980	6,055	6,122
Non-continued 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).	249	227	272	271	311
Undergraduate students who enrolled for the first time since secondary school (excluding special students).	1,033	1,156	1,042	1,073	1,055
Undergraduate students who enrolled for the first time at the Institute and who transferred from another collegiate institution (excluding special students).	99	130	134	124	120
Graduate students who enrolled for the first time at the Institute (excluding special students).	849	935	958	968	1,025
Special undergraduate and graduate students with no previous Institute registration.	307	287	211	221	248
	8,050	8,482	8,597	8,712	8,881

Table V Regular Students from Other Colleges and Graduates of M.I.T.
Classified by Schools and Courses 1978-79

	Entered with no previous degree	Entered with Bachelor's degree from other colleges	Entered Graduate School with Bachelor's degree from M.I.T.
School of Architecture and Planning			
Architecture (IV,IV-B)	14	161	28
Urban Studies and Planning (XI)	4	130	16
Total	18	291	44
School of Engineering			
Aeronautics and Astronautics (XVI,XVI-B)	13	117	32
Chemical Engineering (X,X-C)	26	154	42
Civil Engineering (I)	17	197	46
Electrical Engineering and Computer Science (VI,VI-1,VI-3,VI-A,VI-W)	94	260	234
Materials Science and Engineering (III,III-A,III-B,III-W)	1	128	30
Mechanical Engineering (II,II-A,II-B,II-T,II-W)	40	242	62
Nuclear Engineering (XXII)	4	146	26
Ocean Engineering (XIII,XIII-A,XIII-B,XIII-C,XIII-W)	8	122	15
Total	203	1,366	487
School of Humanities and Social Science			
Economics (XIV)	7	121	5
Humanities and Engineering or Science (XXI-A,XXI-B)	1	-	-
Linguistics and Philosophy (XXIV)	-	43	3
Political Science (XVII)	1	93	9
Psychology (IX)	-	21	4
Total	9	278	21
Alfred P. Sloan School of Management			
Management (XV,XV-A,XV-B)	3	333	55
School of Science			
Biology (VII,VII-A,VII-B,VII-W)	13	110	15
Chemistry (V)	13	174	2
Earth and Planetary Sciences (XII,XII-W)	5	106	21
Interdisciplinary Science Program (XXV)	1	10	4
Mathematics (XVIII)	12	96	15
Meteorology (XIX,XIX-W)	-	51	3
Nutrition and Food Science (XX)	-	135	39
Physics (VIII)	35	217	65
Total	79	899	164
Health Sciences and Technology (HST)	-	4	2
Undesignated	3		
First Year	3		
Grand Total	318	3,171	773

Table VI List of Colleges and Universities with Number of Graduates
Entering the Institute as Regular Students¹

Air Force Institute of Technology	1	Grinnell College	3
Alabama, University of	1	Gustavus Adolphus College	1
Alfred University	2	Hampshire College	2
American University	1	Harvard University	21
Amherst College	4	Harvey Mudd College	1
Antioch College	1	Harverford College	3
Arizona, University of	1	Hawaii, University of	3
Atlanta University	1	Hobart and William Smith Colleges	1
Austin College	1	Hofstra University	1
Babson College	1	Holy Cross, College of the	2
Bard College	1	Howard University	6
Barnard College	2	Illinois, University of, Chicago Circle	2
Bates College	2	Illinois, University of, Urbana-Champaign	2
Boston College	3	Illinois Institute of Technology	1
Boston University	7	Indiana University, Bloomington	1
Bowdoin College	4	Iowa, University of	1
Brandeis University	7	Iowa State University of Science and Technology	3
Brigham Young University	2	Ithaca College	1
Brooklyn College	1	John Carroll University	1
Brown University	12	Johns Hopkins University	4
Bryn Mawr College	1	Kent State University	1
Bucknell University	1	Kentucky, University of	1
California, University of, Berkeley	41	Lambuth College	1
California, University of, Davis	2	Lawrence Institute of Technology, Michigan	1
California, University of, Irvine	2	Lawrence University	1
California, University of, Los Angeles	6	Lehigh University	3
California, University of, Riverside	2	Lewis and Clark College	1
California, University of, San Diego	3	Louisville, University of	2
California, University of, Santa Barbara	2	Lowell, University of	4
California, University of, Santa Cruz	3	Loyola University of Los Angeles	1
California Institute of Technology	7	Manhattan College	2
California Polytechnic Institute	1	Marlboro College	1
California State University, Los Angeles	1	Marquette University	1
Carleton College, Mississippi	1	Marshall University	1
Carnegie-Mellon University	4	Maryland, University of, Baltimore County	1
Case Western Reserve University	4	Maryland, University of, College Park	7
Central Michigan University	1	Massachusetts, University of, Amherst	10
Chicago, University of	3	Massachusetts, University of, Boston	1
Christian Brothers College	1	Massachusetts Institute of Technology	248
Cincinnati, University of	2	Merrimack College	4
City College, The	3	Miami, University of, Florida	1
Clark University	1	Michigan, University of, Ann Arbor	15
Clarkson College of Technology	2	Michigan, University of, Dearborn	1
Cleveland State University	1	Michigan State University	6
Coe College	1	Michigan Technological University	1
Colby College	1	Middlebury College	4
Colgate University	2	Mills College	1
Colorado, University of	3	Minnesota, University of	2
Colorado School of Mines	2	Mississippi, University of	2
Colorado State University	3	Missouri, University of, Columbia	1
Columbia Union College	1	Missouri, University of, Rolla	2
Columbia University	11	Mount Holyoke College	3
Columbus College	1	Naval Postgraduate School	1
Corncordia College	1	Nebraska, University of	1
Connecticut, University of	5	Nevada, University of	1
Cooper Union, The	3	New Hampshire, University of	3
Cornell University	19	New Jersey Institute of Technology	1
Dartmouth College	11	New Mexico State University	1
Delaware, University of	2	New York, City University of	1
Dickinson College	1	New York, City University of, Graduate School and University Center	1
Drake University	2	New York, State University of, Albany	3
Drexel University	2	New York, State University of, Buffalo	2
Duke University	5	New York, State University of, Postdam	1
Eastern Nazarene College	1	New York, State University of, Stonybrook	7
Elmira College	1	New York, State University of, College of Environmental Science and Forestry	1
Florida, University of	5	New York University	1
Florida Atlantic University	1	Newark College of Engineering	1
Florida Institute of Technology	3	North Carolina, University of, Chapel Hill	2
Florida State University	1	North Carolina State University, Raleigh	5
Fordham University	1	North Dakota State University	1
Franklin and Marshall College	1	Northeastern University	9
General Motors Institute	5	Northern Colorado, University of	1
Georgetown University	3		
Georgia Institute of Technology	6		
Georgia State University	2		
Goddard College	1		
Golden Gate College	1		

Northern Illinois University	2	West Virginia University	5
Northwestern University	2	Westminster College, Missouri	1
Notre Dame, University of	11	Wheaton College, Massachusetts	1
Oberlin College	7	Wichita State University	1
Ohio State University	5	William and Mary, College of	1
Ohio University	1	Williams College	1
Oklahoma, University of	1	Wisconsin, University of, Madison	8
Oklahoma State University	2	Wisconsin, University of, Parkside	1
Old Dominion University	1	Worcester Polytechnic Institute	6
Oregon, University of	1	Worcester State College	1
Oregon State University	2	Yale University	15
Pace College	1	U.S. Territories and Dependencies	
Pacific, University of the	1	Puerto Rico, University of, Mayaguez	3
Pennsylvania, University of	7		
Pennsylvania State University, The	9		1,017
Pittsburgh, University of	1		
Polytechnic Institute of New York	2	Alberta, University of (Canada)	2
Pomona College	4	Al-Jami'ah Al-Amiriyah Fi Bayrut (Lebanon)	3
Pratt Institute	1	Aristotelion Panepistimion Thessalonikis (Greece)	2
Princeton University	23	Asian Institute of Technology (Thailand)	1
Principia College	1	Aston, University of Birmingham (England)	1
Purdue University	14	Auckland, University of (New Zealand)	1
Queens College		Australian National University (Australia)	1
Radcliffe College	2	Birmingham, University of (England)	1
Reed College	2	Bogazici Universitesi (Turkey)	1
Rensselaer Polytechnic Institute	14	Bouwcentrum (Netherlands)	1
Rhode Island, University of	2	Bristol, University of (England)	1
Rhode Island School of Design	1	British Columbia, University of (Canada)	4
Rice University	5	Cairo University (Egypt)	2
Rochester, University of,	5	Calcutta, University of (India)	2
Rose-Hulman Institute of Technology	1	Calgary, University of (Canada)	1
Rutgers, The State University	8	Cambridge University (England)	4
San Jose State University	1	Cape Town, University of (South Africa)	2
Seattle University	1	Chung Cheng Institute of Technology (Republic of China)	4
Simmons College	1	Chung-Yuan College of Science and Engineering (Republic of China)	1
Smith College	4	Daneshgah Sanat-e Arya-Mehr (Iran)	1
South Florida, University of	1	Daneshgah Tehran (Iran)	1
Southeastern Massachusetts University	5	Ecole Centrale de Lyon (France)	1
Southern California, University of	1	Ecole Centrale des Arts et Manufactures (France)	1
Southern Illinois, University of	1	Ecole Nationale d'Ingenieurs de Constructions Aeronautiques (France)	1
Southern Methodist University	1	Ecole Nationale des Ponts et Chaussees (France)	4
Southwestern at Memphis	1	Ecole Nationale Polytechnique (Algeria)	1
Spelman College	1	Ecole Nationale Supérieure d'Arts et Metiers (France)	2
Stanford University	15	Ecole Nationale Supérieure de Chimie de Paris (France)	2
Swarthmore College	7	Ecole Nationale Supérieure des Beau Arts (France)	1
Syracuse University	1	Ecole Nationale Supérieure des Telecommunications (France)	1
Temple University	1	Ecole Polytechnique (France)	1
Tennessee, University of, Knoxville	5	Ecole Polytechnique Fédérale de Lausanne (Switzerland)	1
Tennessee Technological University	1	Ecole Supérieure d'Electricité (France)	1
Texas, University of, Austin	4	Ecole Supérieure d'Informatique, Electronique, Automatique (France)	1
Texas A & M University	3	Engineering College (India)	1
Toledo, University of	1	Escola Naval Portuguesa (Portugal)	1
Tufts University	14	Escuela de Ingenieria Naval (Chile)	1
Tulane University	6	Escuela Naval del Peru (Peru)	1
Union College, New York	1	Escuela Técnica Superior de Ingenieros Aeronauticos (Spain)	1
U.S. Air Force Academy	3	Escuela Técnica Superior de Ingenieros Industriales (Spain)	1
U.S. Coast Guard Academy	7	Escuela Técnica Superior de Ingenieros Navales (Spain)	2
United States International University	1	Ethnikon Metsovian Polytechnion Athenai (Greece)	6
U.S. Military Academy	7	Gama'at Khartoum (Sudan)	2
U.S. Naval Academy	3	Goteborgs Universitet (Sweden)	1
Utah, University of	1	Gujarat University (India)	1
Vanderbilt University	2	Ha'Technion-Machon Technologi le Israel (Israel)	6
Vassar College	5	Ibadan, University of (Nigeria)	1
Vermont, University of	4	Imperial College of Science and Technology (England)	1
Villanova University	2	Indian Institute of Management (India)	1
Virginia, University of	3		
Virginia Commonwealth University	1		
Virginia Polytechnic Institute and State University	2		
Washington University, Missouri	7		
Washington, University of	4		
Washington State University	1		
Wayne State University	1		
Webb Institute of Naval Architecture	2		
Wellesley College	2		
Wentworth Institute	1		
Wesley Theological Seminar	1		
Wesleyan University, Connecticut	2		
West Florida, University of	1		

Indian Institute of Medical Sciences(India)	1	Universidad Catolica Madre y Maestra, Santiago(Dominican Republic)	1
Indian Institute of Technology,Kanpur(India)	3	Universidad catolica de Chile(Chile)	1
Indian Institute of Technology,New Delhi(India)	2	Universidad catolica de Valparaiso(Chile)	1
Istanbul Teknik Universitesi(Turkey)	2	Universidad de Buenos Aires(Argentina)	3
Institut Industriel du Nord(France)	1	Universidad de Chile(Chile)	3
Instituto politecnico nacional(Mexico)	1	Universidad de Guatemala(Guatemala)	1
Instituto tecnologico de Aeronautica(Brazil)	1	Universidad de Los Andes(Columbia)	1
Jami'at Al-Riyad(Saudi Arabia)	3	Universidad Metropolitana(Venezuela)	1
Kabul Pohantoon(Afghanistan)	1	Universidad nacional autonoma de Mexico (Mexico)	2
Keio Gijuku Daigaku(Japan)	2	Universidad nacional de Rosario(Argentina)	1
Kerala,University of(India)	1	Universidad Simon Bolivar(Venezuela)	2
Kyoto Daigaku(Japan)	1	Universidade de Sao Paulo(Brazil)	2
Lagos,University of(Nigeria)	1	Universita degli Studi di Bologna(Italy)	4
Laval University(Canada)	1	Universita degli Studi di Milano(Italy)	1
London,University of(England)	3	Universita degli Studi di Napoli(Italy)	2
London School of Economics and Political Science(England)	1	Universita degli Studi di Pavia(Italy)	1
Malaya,University of(Malaysia)	1	Universita degli Studi di Roma(Italy)	1
Manchester,University of,Institute of Science and Technology(England)	1	Universitas Indonesia(Indonesia)	1
McGill University(Canada)	6	Universitat Fridericiana Karlsruhe (W.Germany)	2
McMaster University(Canada)	2	Universitat Tel-Aviv(Israel)	3
Meerut University(India)	1	Universite d'Alger(Algeria)	2
Moscow State University(U.S.S.R)	1	Universite de Geneve(Switzerland)	1
Nanyang Technical College(Republic of China)	1	Universite de l'Etat a Liege(Belgium)	1
National Cheng Kung University(Republic of China)	1	Universite de Montreal(Canada)	5
National Chengchi University(Republic of China)	1	Universite Paris,VI(France)	1
National Taiwan University(Republic of China)	7	Universite Paris VII(France)	1
National Tsing Hua University(Republic of China)	1	Universite de Paris VIII(France)	2
New Brunswick,University of(Canada)	1	Universite de Paris-Dauphine(Paris IX) (France)	1
Newcastle upon Tyne,University of(England)	2	Universite libre de Bruxelles(Belgium)	1
Osaka Daigaku(Japan)	1	Universitet Druzby Norodov im Patrisa Lumumby (U.S.S.R.)	1
Osaka Gaikokugo Daigaku(Japan)	1	Universitetet i Oslo(Norway)	1
Oxford,University of(England)	4	University College(England)	1
Politecnico di Milano(Italy)	2	Univerzitet u Beogradu(Yugoslavia)	1
Pontificia Universidade catolica de Campinas (Brazil)	1	Univerzitet u Sarajevu(Yugoslavia)	1
Pontificia Universidade catolica do Rio de Janeiro(Brazil)	1	Uniwersytet Warszawski(Poland)	1
Queen's University at Kingston(Canada)	1	Victoria University of Manchester(England)	1
Ranchi,University of(India)	1	Von Karman Institute for Fluid Dynamics (Belgium)	1
Rheinische Friedrich-Wilhelms-Universitat (W.Germany)	1	Waseda Daigaku(Japan)	2
Rheinisch-Westfalische Technische Hochschule (W.Germany)	1	Waterloo,University of(Canada)	1
Saint Catherine's College(England)	1	Witwatersrand,University of the(South Africa)	1
Salford,University of(England)	1	York University(Canada)	1
Scholi Naftikon Dokimon(Greece)	3	Yukselis Muhendislik ve Mimarlik Yuksek Okulu(Turkey)	1
School of Architecture,Ahmedabad(India)	1		
Seoul Dae Hag Gyo(Korea)	9	Total Foreign	256
Shibaura Kogyo Daigaku(Japan)	1		
Singapore,University of(Singapore)	1	Grand Total	1,273
South Africa,University of(Africa)	1		
Staatliche Ingenieurschule(W.Germany)	1		
Sussex,University of(England)	1		
Taipei Institute of Technology(Republic of China)	1		
Tamkang College of Arts and Sciences(Republic of China)	1		
Technische Hogeschool Delft(The Netherlands)	1		
Technische Universitat Carolo-Wilhelmina zu Braunschweig(W.Germany)	1		
Technische Universitat Clausthal(W.Germany)	1		
Tokyo,National University of Arts and Music (Japan)	1		
Tokyo Daigaku(Japan)	9		
Tokyo Kogyo Daigaku(Japan)	1		
Toronto,University of(Canada)	7		

¹Graduates of 239 Colleges and Universities in the United States and 149 Foreign Colleges and Universities entered the Institute.

Table VII Geographic Distribution of Students, 1978-79

	Under-grad.	Grad.		Under-grad.	Grad.		Under-grad.	Grad.
United States			U.S.Territories and Dependencies			Jamaica	3	1
Alabama	18	11	Puerto Rico	24	13	Japan	11	78
Alaska	9	2	Virgin Islands	1	1	Jordan	-	5
Arizona	33	9	U.S.Citizens Foreign Address	64	84	Kenya	-	2
Arkansas	8	4	Total U.S.	4,227	3,021	Korea	31	34
California	190	189	Foreign Countries *			Kuwait	-	1
Colorado	34	28	Afghanistan	-	1	Lebanon	2	16
Connecticut	166	67	Algeria	2	11	Libya	-	1
Delaware	15	12	Argentina	-	11	Malaysia	15	17
District of Columbia	20	19	Australia	-	4	Mauritania	-	1
Florida	108	37	Austria	-	3	Mexico	1	31
Georgia	32	20	Bahama Islands	1	-	Monaco	1	-
Hawaii	21	8	Bangladesh	4	3	Netherlands	6	4
Idaho	8	5	Belgium	-	11	Netherlands Antilles	1	-
Illinois	164	69	Bermuda	1	-	New Zealand	-	3
Indiana	24	20	Bolivia	2	-	Nicaragua	-	2
Iowa	24	12	Brazil	-	41	Nigeria	3	22
Kansas	28	9	Burundi	-	1	Norway	1	6
Kentucky	11	11	Canada	46	101	Pakistan	13	15
Louisiana	23	9	Chile	-	16	Panama	1	-
Maine	33	9	China, Peoples Republic of	1	2	Paraguay	-	2
Maryland	118	51	China, Republic of	28	113	Peru	4	5
Massachusetts	721	1,310	Columbia	4	8	Philippines	3	8
Michigan	113	67	Cuba	1	-	Poland	-	3
Minnesota	44	17	Cyprus	-	2	Portugal	-	11
Mississippi	9	5	Czechoslovakia	2	-	Rumania	1	3
Missouri	58	21	Denmark	-	3	Saudi Arabia	1	12
Montana	9	2	Dominican Republic	-	1	Singapore	3	7
Nebraska	15	7	Ecuador	1	3	South Africa	1	13
Nevada	8	5	Egypt	1	17	Spain	2	33
New Hampshire	34	25	El Salvador	-	2	Sri Lanka	4	2
New Jersey	284	118	Ethiopia	-	2	Sudan	-	3
New Mexico	11	6	Finland	-	4	Sweden	4	8
New York	788	298	France	2	38	Switzerland	-	9
North Carolina	52	23	Germany	6	25	Syria	-	1
North Dakota	4	1	Ghana	11	9	Tanzania	-	2
Ohio	140	78	Greece	12	60	Thailand	7	6
Oklahoma	16	9	Guatemala	-	2	Trinidad	7	2
Oregon	37	14	Guyana	1	-	Tunisia	-	1
Pennsylvania	236	108	Honduras	-	1	Turkey	8	18
Rhode Island	30	19	Hong Kong	25	58	Uganda	1	1
South Carolina	14	10	Hungary	-	1	United Kingdom	20	44
South Dakota	4	3	Iceland	-	2	Uruguay	3	4
Tennessee	22	10	India	13	70	Venezuela	4	30
Texas	124	42	Indonesia	3	4	Vietnam	7	4
Utah	7	6	Iran	12	84	Yugoslavia	4	7
Vermont	20	13	Iraq	1	4	Zaire, Republic of	-	1
Virginia	115	45	Ireland	-	2	Zambia	1	-
Washington	62	34	Israel	5	33	Stateless	5	12
West Virginia	5	2	Italy	3	20	Total Foreign	367	1,266
Wisconsin	66	23	Ivory Coast	-	2	Grand Total	4,594	4,287
Wyoming	3	1						

* Country of Citizenship

Table VIII Number of Degrees Awarded in September 1978, February 1979, and June 1979

	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	-	-	-	-	6	7	19	3	2	18	-	-	-	-	-	-	9
Undesignated	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Art and Design	-	6	30	-	-	-	-	-	-	-	-	-	-	-	-	-	6
Visual Studies	-	-	-	2	6	-	-	-	-	-	-	-	-	-	-	-	2
Urban Studies and Planning	4	5	9	-	-	8	8	26	-	-	-	3	1	8	-	15	
Total	4	11	40	-	2	6	14	15	45	3	2	18	-	-	-	24	
School of Engineering																	
Aeronautics and Astronautics	-	5	35	18	7	17	-	-	-	2	1	-	4	3	2	22	
Ceramics	-	7	15	74	11	14	16	-	-	-	3	-	-	4	-	18	
Chemical Engineering	1	2	9	-	-	-	-	-	-	-	-	-	-	-	-	1	
Undesignated	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
Chemical Engineering Practice	4	10	51	15	31	36	-	-	-	2	1	2	6	5	1	22	
Civil Engineering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	49	
Undesignated	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	3	
Computer Science and Engineering	15	15	72	-	-	-	-	-	-	-	-	-	-	-	-	15	
Electrical Engineering	12	25	144	-	-	-	-	-	-	2	7	14	9	16	2	12	
Electrical Engineering and Computer Science	-	-	-	30	40	54	-	-	-	2	11	14	9	16	2	48	
Environmental Engineer	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	
Materials Engineering	-	-	-	1	2	4	-	-	-	-	-	-	-	-	-	4	
Materials Science and Engineering	2	6	14	-	-	-	-	-	-	-	2	1	1	1	4	5	
Undesignated	1	1	3	-	-	-	-	-	-	-	-	-	-	-	-	1	
Materials Science	9	10	115	23	16	37	-	-	-	2	1	2	10	5	2	34	
Mechanical Engineering	2	3	13	-	-	-	-	-	-	-	-	-	-	-	-	2	
Undesignated	-	-	-	4	2	2	-	-	-	-	-	-	-	-	-	3	
Metallurgy	-	-	-	4	2	2	-	-	-	-	-	-	-	-	-	4	
Naval Architecture and Marine Engineering	-	-	7	2	7	12	-	-	-	-	-	-	-	-	-	2	
Nuclear Engineering	1	1	7	18	6	11	-	-	-	4	2	4	1	4	4	26	
Ocean Engineering	-	3	2	1	6	9	-	-	-	2	3	13	2	2	3	5	
Polymers	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	
Shipping and Shipbuilding Management	-	-	-	-	3	5	-	-	-	-	-	-	-	-	-	3	
Total	54	95	549	128	149	223	-	-	-	11	20	30	23	36	41	224	

School of Humanities and Social Science	2	3	19	1	1	9	7	12	12	10	32
Economics	-	-	-	-	-	-	-	-	-	-	-
Humanities and Engineering	1	2	11	-	-	-	-	-	-	1	11
Humanities and Science	-	-	-	-	-	-	-	-	-	2	1
Linguistics	-	-	-	-	-	-	-	-	-	1	1
Philosophy	-	2	6	1	9	5	4	6	2	5	17
Political Science	-	-	-	-	-	-	-	-	-	1	1
Psychology	-	-	-	-	-	-	-	-	-	-	-
Total	3	7	39	2	9	6	16	13	17	21	29

Alfred P. Sloan School of Management	2	8	25	12	9	187	6	6	7	20	23	219
Management	-	-	-	-	-	-	-	-	-	-	-	-

School of Science	2	3	19	1	1	9	7	12	12	10	32
Biochemical Engineering	-	-	-	4	1	-	-	-	-	-	-
Biochemistry	-	-	-	1	-	-	-	-	-	4	1
Biology	-	-	-	-	-	-	-	-	-	1	9
Undesignated	-	-	-	-	-	-	-	-	-	23	4
Chemistry	2	9	49	3	4	-	5	9	13	10	18
Earth and Planetary Sciences	1	3	19	-	4	-	6	4	3	8	7
Food Science and Technology	-	-	-	3	4	5	-	-	-	3	4
Interdisciplinary Science(S.B.Undesignated)	-	-	-	3	1	6	-	-	-	3	1
Life Sciences	2	11	59	-	-	-	-	-	-	2	11
Mathematics	3	8	49	1	4	4	3	4	9	7	16
Meteorology	-	-	-	1	5	1	1	2	-	2	5
Neural and Endocrine Regulation	-	-	-	2	-	-	-	-	-	1	4
Nutrition and Food Science	-	-	-	-	-	-	8	7	10	9	8
Nutritional Biochemistry and Metabolism	-	-	-	-	1	1	-	-	-	-	1
Oceanography	-	-	-	-	1	2	-	-	-	-	1
Physics	12	5	77	6	5	7	11	13	20	3	32
Toxicology	-	-	-	1	1	3	-	-	-	1	1
Total	20	45	285	25	23	37	35	46	61	5	1

Operations Research	-	-	-	3	1	2	-	-	-	-	-	3
Technology and Policy	-	-	-	1	7	6	-	-	-	-	-	1
Without Course Specification	-	-	-	13	7	17	-	-	-	-	-	13

Awarded jointly with Woods Hole Oceanographic Institution	2	3	19	1	1	9	7	12	12	10	32
Biology	-	-	-	-	-	-	1	1	-	-	1
Earth and Planetary Sciences	-	-	-	-	-	-	1	2	1	-	1
Electrical Engineering and Computer Science	-	-	-	-	-	1	-	-	-	-	1
Meteorology	-	-	-	-	-	-	1	1	-	1	1
Ocean Engineering	-	-	-	-	-	1	2	1	-	-	2

Grand Total	83	166	938	184	207	484	14	15	45	3	2
							18	12	20	33	87
							106	136	13	19	20
							396	535	1,674		

Table IX Number of Degrees of Bachelor of Science Awarded

All statistics are arranged by schools as of the current year. During the years 1868-1949 the general divisions were Architecture, Engineering, and Science. In 1950 the School of Humanities and Social Studies was established, and in 1951 the School of Industrial Management (after 1963 the Alfred P. Sloan School of Management) was added.

	Total by decade										Grand Total	Calendar year since 1975 (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-	1975	1976	1977	1978	1979*
School of Architecture and Planning¹																		
Architecture	-	12	24	162	188	233	223	23	-	-	-	-	-	-	-	-	-	865
Undesignated	-	-	-	-	-	-	-	23	-	-	-	-	-	-	-	-	-	20
Architectural Engineering ²	-	-	-	-	-	108	64	-	-	-	2	18	4	2	1	-	-	172
Art and Design	-	-	-	-	-	-	-	-	-	26	-	403	37	46	49	42	-	429
Urban Studies	-	-	-	-	-	-	-	-	-	-	-	146	21	25	11	13	14	146
Undesignated	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	2
Total	-	12	24	162	188	233	331	87	-	28	569	62	73	61	56	51	1,634	
School of Engineering																		
Aeronautics and Astronautics ¹¹	-	-	-	-	-	-	68	287	526	395	556	229	21	13	14	25	40	2,061
Undesignated	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Building Engineering and Construction	-	-	-	-	-	32	99	114	131	-	-	396	36	39	52	83	89	3,874
Chemical Engineering	-	-	-	91	123	372	571	434	740	726	421	72	10	7	11	9	11	3,775
Undesignated	-	-	-	-	-	-	99	90	95	108	3	-	-	-	-	-	-	393
Chemical Engineering Practice	-	-	-	-	-	-	-	284	272	457	252	436	49	59	54	65	61	3,703
Civil Engineering	12	84	86	256	407	504	653	284	272	457	7	25	2	2	1	3	3	355
Undesignated	-	-	-	-	-	-	-	-	-	-	-	355	10	84	80	94	87	3,703
Computer Science and Engineering	-	-	-	-	-	-	-	-	-	-	-	1,665	216	137	138	133	169	9,285
Electrical Engineering	-	-	72	335	349	468	1,000	719	1,218	1,518	1,941	1	-	-	-	-	-	1
Undesignated	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	301
Electrochemical Engineering ³	-	-	-	-	28	84	133	56	-	-	-	-	-	-	-	-	-	817
General Engineering	-	-	-	-	6	226	222	230	133	-	-	-	-	-	-	-	-	867
Materials Science and Engineering ⁴	-	-	-	-	-	-	-	52	194	311	186	124	10	19	12	10	20	867
Undesignated	-	-	-	-	-	-	-	-	-	-	1	25	2	1	3	4	26	26
Mechanical Engineering	5	40	147	329	502	623	797	602	1,164	1,049	563	562	52	69	73	84	123	6,383
Undesignated	-	-	-	-	-	-	-	-	-	-	12	119	10	10	13	12	16	131
Military Engineering	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	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	47	5	7	1	7	7	1,007
Nuclear Engineering	-	-	-	-	-	-	-	-	-	-	-	22	-	-	3	12	7	22
Ocean Engineering	-	-	-	-	-	-	-	-	-	-	-	47	14	9	10	2	5	47
Undesignated	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
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	4,127	437	453	465	545	644	30,907

School of Humanities and Social Science																			
Economics	-	-	-	-	-	-	-	-	-	-	-	129	238	367	24	22	34	25	22
Economics, Politics and Engineering or Science	-	-	-	-	-	-	-	61	152	100	-	313	-	-	-	-	14	14	-
Humanities and Engineering or Science ⁵	-	-	-	-	-	-	-	-	49	412	294	755	25	23	14	14	5	5	2
Philosophy	-	-	-	-	-	-	-	-	-	31	-	31	-	-	3	7	13	8	8
Political Science ⁹	-	-	-	-	-	-	-	-	-	114	120	234	9	7	13	8	8	8	8
Total	-	-	-	-	-	-	-	61	201	755	683	1,700	58	55	66	52	46	46	46
Alfred P. Sloan School of Management ⁶																			
Business and Engineering Administration Management ¹⁰	-	-	-	-	-	-	142	872	641	909	732	-	3,296	-	-	-	51	40	33
Total	-	-	-	-	-	-	142	872	641	909	904	565	506	1,243	59	52	51	40	33
School of Science																			
Biology/ ⁷ Undesignated	-	3	11	25	27	49	57	129	74	116	16	-	507	-	-	-	-	-	-
Chemistry	2	27	80	154	151	111	141	166	232	207	307	446	2,024	52	61	40	57	58	58
Earth and Planetary Sciences ⁸	-	-	-	8	6	3	36	22	32	141	109	203	560	23	28	19	30	22	22
Undesignated	-	-	-	-	-	-	-	-	-	-	7	20	27	-	-	-	-	-	-
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-Undesignated	-	-	-	-	-	-	-	-	-	-	-	75	75	8	9	5	5	9	9
Life Sciences ⁷	-	-	-	-	-	-	-	-	-	-	291	797	1,088	102	110	97	106	70	70
Mathematics	-	-	-	-	-	-	19	48	72	220	831	820	2,010	107	86	90	74	57	57
Mathematics	-	-	-	-	-	-	-	-	-	56	38	-	94	-	-	-	-	-	-
Meteorology	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physics	-	5	6	24	19	21	49	170	306	617	1,079	856	3,152	85	106	84	92	82	82
Total	4	46	114	260	223	210	319	608	865	1,463	2,651	3,524	10,287	424	436	361	388	330	330
Grand Total	29	226	507	1,579	2,257	2,963	5,410	4,515	6,626	7,535	8,011	9,409	49,067	1,040	1,069	1,004	1,081	1,104	1,104

* Includes only February and June degrees
¹Two received the degree in Naval Architecture, Course XIII-B, in 1916 and three in 1917
²See also Table XI
³Prior to 1923 degrees were awarded in Architecture
⁴Prior to 1909 this course was designated as Option 3 (Electrochemistry) or Physics
⁵Prior to 1938 these degrees were included in Mining Engineering and Metallurgy; changed from Metallurgy to Metallurgy and Materials Science, January 1968; changed to Materials Science and Engineering 1975
⁶Prior to 1958 these degrees were included in General Engineering and General Science or General Course
⁷Changed to Alfred P. Sloan School of Management 1963
⁸Changed to Life Sciences beginning January 1962
⁹Changed from Geology and Geophysics to Earth Sciences in February 1961, changed from Earth Sciences to Earth and Planetary Sciences in February 1970
¹⁰Prior to September 1965, these degrees were included in Economics, Politics and Engineering or Science
¹¹Prior to 1959, Business and Engineering Administration, changed from Industrial Management to Management in February 1967

Table X Number of Degrees of Master of Science Awarded

	Total by decade										Grand Total	Calendar year since 1975 (included in decade total)				
	1886-90	1891-1900	1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-		1975	1976	1977	1978	1979*
School of Architecture and Planning¹																
Architecture	-	8	45	31	-	-	-	-	-	-	-	-	-	-	-	
Architectural Engineering ²	-	-	-	-	9	10	-	-	-	-	-	-	-	-	-	
Visual Studies	-	-	-	-	-	-	-	-	-	8	-	-	-	-	8	
Total	-	8	45	31	9	10	-	-	-	8	111	-	-	-	8	
School of Engineering																
Aeronautics and Astronautics ¹¹	-	-	-	17	59	76	307	375	645	361	1,840	31	37	36	42	24
Building Engineering and Construction	-	-	-	-	-	-	21	66	21	-	108	-	-	-	-	-
Ceramics	-	-	-	-	-	3	3	13	20	29	68	1	4	3	7	2
Chemical Engineering	-	3	2	18	69	152	275	467	398	234	1,618	15	24	34	36	30
Chemical Engineering Practice	-	-	-	-	245	284	241	256	102	261	1,389	40	33	31	31	26
Civil Engineering	-	1	4	27	53	179	194	350	548	629	1,985	70	104	75	73	67
Electrical Engineering and Computer Science (including VI-A) ¹²	-	-	7	43	462	474	546	1,164	1,529	1,027	5,252	95	126	144	116	94
Electrochemical Engineering	-	-	-	4	16	8	-	-	-	-	28	-	-	-	-	-
Fuel and Gas Engineering	-	-	-	-	15	11	-	-	-	-	26	-	-	-	-	-
Materials Engineering	-	-	-	-	-	-	-	-	-	33	33	11	4	2	8	6
Materials Science	-	-	-	-	-	-	-	-	-	30	30	4	4	10	4	5
Mechanical Engineering	-	1	8	22	100	175	357	525	690	618	2,496	66	67	71	83	53
Metallurgy	-	-	-	-	8	36	92	230	205	91	662	6	3	7	12	4
Mining Engineering	-	-	-	-	8	16	-	-	-	-	33	-	-	-	-	-
Naval Architecture and Marine Engineering	-	-	2	1	5	20	60	165	281	208	742	26	26	29	24	19
Naval Construction and Engineering	-	-	39	48	101	89	206	67	282	303	652	39	29	48	51	17
Nuclear Engineering ³	-	-	-	-	-	-	-	-	3	140	143	24	19	15	17	15
Ocean Engineering	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
Petroleum Engineering	-	-	-	-	-	5	-	-	-	9	9	1	4	-	2	2
Polymers	-	-	-	-	-	-	-	-	-	-	14	-	-	-	-	-
Railroad Engineering	-	-	-	-	-	14	-	-	-	-	14	-	-	-	-	-
Sanitary Engineering	-	-	2	8	3	10	53	99	16	-	191	-	-	-	-	-
Shipping and Shipbuilding Management	-	-	-	-	-	-	-	4	15	54	73	7	18	3	7	8
Textile Technology	-	-	-	-	-	1	31	34	20	10	96	2	-	-	-	-
Total	-	5	64	197	1,144	1,553	2,386	3,815	4,775	4,037	17,976	438	502	508	513	372

School of Humanities and Social Science																
Economics ⁷	-	-	-	-	-	-	-	-	19	20	39	1	2	3	3	1
Economics and Engineering or Science ¹⁰	-	-	-	-	-	-	-	19	10	-	57	-	-	-	-	-
Linguistics	-	-	-	-	-	-	-	-	1	7	8	3	-	-	-	-
Philosophy	-	-	-	-	-	-	-	-	2	10	10	2	1	-	1	-
Political Science ⁷	-	-	-	-	-	-	-	-	25	93	118	12	11	18	11	14
Psychology ⁴	-	-	-	-	-	-	-	-	7	9	16	-	1	2	1	-
Total	-	-	-	-	-	-	-	12	16	137	248	18	15	23	16	15
Alfred P. Sloan School of Management ⁵																
Management ⁸	-	-	-	-	4	60	122	581	1,274	1,657	3,698	184	161	217	201	196
School of Science																
Biochemical Engineering	-	-	-	-	-	-	-	-	17	25	42	1	4	4	6	1
Biochemistry	-	-	-	-	-	-	-	3	6	5	14	1	3	-	1	-
Biology	1	1	10	1	19	25	29	29	12	41	139	5	2	6	3	-
Biophysics	-	-	-	-	-	-	-	2	3	3	8	-	-	1	1	-
Chemistry	2	3	7	22	32	51	53	46	97	65	378	11	9	7	5	4
Earth and Planetary Sciences	-	-	-	-	-	-	-	-	7	76	83	8	10	13	5	4
Food Science and Technology	-	-	-	-	-	-	-	-	57	48	105	2	3	8	7	9
Food Technology	-	-	-	-	-	-	-	44	3	-	59	-	-	-	-	-
General Science	1	2	5	21	15	17	48	71	-	-	179	-	-	-	-	-
Geology and Geophysics ⁹	-	-	-	-	-	-	-	-	-	-	26	-	7	8	4	7
Interdisciplinary Science	-	-	-	2	9	25	45	96	73	58	308	6	9	10	4	8
Mathematics	-	-	-	-	-	-	-	-	87	74	413	7	6	13	7	6
Mathematics ⁶	-	-	-	-	35	99	118	118	87	74	413	7	6	13	7	6
Neural and Endocrine Regulation	-	-	-	-	-	-	-	-	-	4	4	-	-	1	3	-
Nutrition	-	-	-	-	-	-	-	-	23	-	23	-	-	-	-	-
Nutritional Biochemistry and Metabolism	-	-	-	-	-	-	-	7	25	79	111	10	16	13	14	2
Oceanography	-	-	-	-	-	-	-	-	28	20	48	3	-	-	-	3
Physics	3	2	2	16	40	50	121	138	125	497	15	9	13	14	12	12
Toxicology	-	-	-	-	-	-	-	-	-	13	13	-	-	5	4	4
Total	2	8	12	41	79	185	301	514	647	662	2,451	69	78	102	78	60
Operations Research	-	-	-	-	-	-	-	-	2	67	69	8	9	5	7	3
Technology and Policy	-	-	-	-	-	-	-	-	-	23	23	-	-	1	9	13
Without Course Specification	-	-	-	5	308	263	123	357	299	329	1,684	37	28	27	43	24
Grand Total	2	21	121	274	1,544	2,083	2,948	5,286	7,061	6,920	26,260	754	793	883	867	691

* Includes only February and June degrees

1. See Table XI

2. Prior to 1923 degrees were awarded in Architecture

3. Prior to 1959 included in Chemical Engineering

4. Prior to September 1964 included in Economics, Politics and Engineering or Science

5. Considered Engineering until 1950

6. Considered Engineering until 1956

7. Prior to September 1965 these degrees were included in Economics, Politics and Engineering or Science

8. Prior to February 1967 Industrial Management

9. Changed to Earth and Planetary Sciences beginning February 1970

10. Includes six degrees in Political Science awarded 1965

11. Prior to 1960 Aeronautical Engineering

12. Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975

Table XI Number of Degrees of Bachelor and Master in Architecture and Bachelor and Master in City Planning Awarded

	Total by decade										Calendar year since 1975 (included in decade total)				
	1921-30	1931-40	1941-50	1951-60	1961-70	1971-	Grand Total	1975	1976	1977	1978	1979*			
Bachelor in Architecture ²	-	146	126	257	188	5	722	-	-	-	-	-			
Bachelor in City Planning ¹	-	14	13	4	-	-	31	-	-	-	-	-			
Master in Architecture ³	63	81	78	191	214	21	648	-	-	-	-	-			
Master in City Planning	-	18	82	114	152	277	643	39	32	30	29	44			
Master of Architecture	-	-	-	-	23	241	264	27	38	36	30	26			
Master of Architecture in Advanced Studies	-	-	-	-	-	164	164	18	19	24	22	20			
Grand Total	63	259	299	566	577	708	2,472	84	89	90	81	90			

*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 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 decade					Grand Total	Calendar year since 1975 (included in decade total)					
	1949-60	1961-1970	1971-	1975	1976		1977	1978	1979*			
Building Engineer ³	5	2	-	7	-	7	-	-	-	-	-	-
Chemical Engineer	17	31	57	105	-	105	5	8	6	4	3	3
Civil Engineer	21	78	61	160	4	160	4	6	2	1	1	3
Electrical Engineer	132	444	350	926	41	926	32	41	36	39	18	18
Engineer in Aeronautics and Astronautics ¹	35	58	23	116	4	116	4	3	-	2	1	-
Environmental Engineer	-	-	11	11	2	11	2	2	3	1	-	-
Marine Mechanical Engineer	7	2	1	10	-	10	-	-	-	-	-	-
Materials Engineer	-	7	8	15	1	15	1	1	1	4	-	-
Mechanical Engineer	102	166	93	361	10	361	10	6	6	6	3	3
Metallurgical Engineer	24	18	7	49	-	49	-	-	-	1	-	-
Meteorologist ²	2	-	-	2	-	2	-	-	-	-	-	-
Naval Architect	11	21	17	49	8	49	8	3	-	-	-	-
Naval Engineer	334	246	20	600	1	600	1	-	-	-	-	-
Nuclear Engineer	-	37	64	101	4	101	4	6	17	12	6	6
Ocean Engineer	-	4	179	183	14	183	14	24	28	25	16	16
Sanitary Engineer ³	9	3	-	12	-	12	-	-	-	-	-	-
Total	699	1,117	891	2,707	85	2,707	85	100	99	95	50	50
Awarded jointly with Woods Hole												
Oceanographic Institution	-	-	1	1	-	1	-	-	-	-	-	1
Electrical Engineer	-	-	14	14	4	14	4	-	-	-	1	2
Ocean Engineer	-	-	-	-	-	-	-	-	-	-	-	-
Grand Total	699	1,117	906	2,722	89	2,722	89	100	99	96	53	53

* Includes only February and June degrees

¹ Prior to 1960 Aeronautical Engineer

² Degree discontinued after 1955

³ Degree discontinued after 1964

Table XIII Number of Degrees of Doctor of Philosophy Awarded

	Total by decade										Calendar year since 1975 (included in decade total)				
	1907-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-	Grand Total	1975	1976	1977	1978	1979*	
School of Architecture and Planning															
Architecture	-	-	-	-	-	-	-	3	3	1	-	-	1	1	
Urban Studies and Planning ⁶	-	-	-	-	-	-	24	59	83	6	6	9	7	9	
Total	-	-	-	-	-	-	24	62	86	7	6	9	8	10	
School of Engineering															
Aeronautics and Astronautics ⁷	-	-	-	-	-	6	57	87	150	12	11	6	8	7	
Chemical Engineering	-	-	-	-	-	-	31	40	71	3	2	8	3	4	
Civil Engineering	-	-	-	-	-	1	72	126	199	16	12	10	21	11	
Electrical Engineering and Computer Science ⁹	-	-	-	-	1	9	248	318	576	44	27	27	44	25	
Materials Science and Engineering ³	-	-	-	-	-	6	103	112	221	9	7	17	15	2	
Mechanical Engineering	-	-	-	-	-	4	95	127	226	16	16	10	13	15	
Nuclear Engineering	-	-	-	-	-	5	90	93	188	9	17	20	8	8	
Ocean Engineering ⁸	-	-	-	-	-	-	15	38	53	-	5	6	9	5	
Sanitary Engineering	-	-	-	-	-	2	3	-	5	-	-	-	-	-	
Total	-	-	-	-	1	33	714	941	1,689	109	97	104	121	77	
School of Humanities and Social Science															
Economics ¹	-	-	-	-	19	96	195	194	504	18	25	25	25	19	
Group Psychology	-	-	-	-	8	1	-	-	9	-	-	-	-	-	
Linguistics	-	-	-	-	-	-	35	56	91	7	9	2	6	1	
Philosophy	-	-	-	-	-	-	8	22	30	3	2	3	2	1	
Political Science	-	-	-	-	-	-	71	103	174	12	12	18	12	8	
Psychology	-	-	-	-	-	3+	24	42	69	7	7	7	5	1	
Total	-	-	-	-	27	100	333	417	877	47	55	55	50	30	

Alfred P. Sloan School of Management
Management²

	8	29	91	258	419	846	1,339	1,309	4,299	120	161	141	137	107
School of Science														
Biology	-	1	10	17	21	38	105	149	341	14	15	19	19	13
Chemistry	7	19	59	146	180	342	427	359	1,539	32	43	33	25	22
Earth and Planetary Sciences ⁴	1	7	10	22	20	71	84	87	302	13	12	6	17	7
Mathematics	-	-	6	25	35	70	211	205	552	18	23	28	23	13
Meteorology	-	-	-	-	-	14	45	32	91	2	4	2	2	2
Nutrition and Food Science	-	-	-	-	4	28	66	127	225	9	17	17	18	17
Oceanography ⁵	-	-	-	-	-	-	11	-	11	-	-	-	-	-
Physics	-	2	6	48	159	283	390	350	1,238	32	47	36	33	33
Total	8	29	91	258	419	846	1,339	1,309	4,299	120	161	141	137	107
Awarded jointly with Woods Hole Oceanographic Institution														
Biology	-	-	-	-	-	-	-	10	10	2	3	1	3	1
Earth and Planetary Sciences	-	-	-	-	-	-	4	34	38	6	6	6	3	3
Electrical Engineering and Computer Science	-	-	-	-	-	-	-	1	1	-	-	1	-	-
Meteorology	-	-	-	-	-	-	1	14	15	3	1	2	1	1
Ocean Engineering	-	-	-	-	-	-	-	6	6	1	1	2	2	-
Total	-	-	-	-	-	-	5	65	70	12	11	12	9	5
Grand Total	8	29	91	258	447	979	2,504	2,904	7,220	314	338	332	345	242

* Includes only February and June degrees

¹ Previously included in Industrial Economics

² Changed from Industrial Economics to Economics 1966

³ Changed from Industrial Management to Management 1967

⁴ Includes Ceramics, Metallurgy and Materials Science changed to Materials Science and Engineering 1975

⁵ Changed from Geology and Geophysics to Earth and Planetary Sciences 1970

⁶ Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology

⁷ Changed from City and Regional Planning to Urban Studies and Planning September 1969

⁸ Prior to 1960 Aeronautical Engineering

⁹ Changed from Naval Architecture and Marine Engineering to Ocean Engineering September 1971

¹⁰ Changed from Electrical Engineering and Computer Science 1975

Table XIV Number of Degrees of Doctor of Science Awarded

	Total by decade										Calendar year since 1975 (included in decade total)				
	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-	Grand Total	1975	1976	1977	1978	1979*		
School of Engineering															
Aeronautics and Astronautics ¹	2	4	5	18	31	76	45	181	4	7	5	3	5		
Chemical Engineering	-	23	78	114	117	151	69	552	7	9	6	4	4		
Civil Engineering	-	2	12	23	46	75	38	196	3	3	5	3	-		
Electrical Engineering and Computer Science ⁵	3	12	30	34	141	124	59	403	8	5	4	3	5		
Electrochemical Engineering	-	1	1	-	-	-	-	2	-	-	-	-	-		
Materials Science and Engineering ⁶	-	14	32	86	194	201	89	616	8	15	6	12	9		
Mechanical Engineering	-	4	13	35	125	145	75	397	9	11	5	9	7		
Mineral Engineering	1	-	4	-	-	-	-	5	-	-	-	-	-		
Nuclear Engineering	-	-	-	-	9	55	48	112	2	5	8	6	4		
Ocean Engineering ⁴	-	1	-	-	2	6	11	20	4	-	-	1	1		
Petroleum Engineering	-	-	1	-	-	-	-	1	-	-	-	-	-		
Sanitary Engineering	-	-	2	3	18	2	-	25	-	-	-	-	-		
Total	6	61	178	313	683	835	434	2,510	45	55	39	41	35		
School of Science															
Chemistry	-	2	5	4	3	1	2	17	-	1	-	-	-		
Earth and Planetary Sciences ²	1	2	4	5	2	3	7	24	2	1	-	2	-		
Mathematics	-	2	3	-	1	1	2	9	-	-	-	-	-		
Meteorology	-	-	6	25	17	6	9	63	2	1	3	1	1		
Nutrition and Food Science	-	-	-	3	10	17	20	50	-	1	3	2	1		
Oceanography ³	-	-	-	-	-	1	-	1	-	-	-	-	-		
Physics	-	5	18	14	7	7	15	66	2	2	3	3	1		
Total	1	11	36	51	40	36	55	230	6	6	9	8	3		
Awarded Jointly with Woods Hole Oceanographic Institution															
Earth and Planetary Sciences	-	-	-	-	-	-	1	1	-	-	1	-	-		
Meteorology	-	-	-	-	-	-	6	6	-	-	-	-	-		
Grand Total	7	72	214	364	723	871	496	2,747	51	61	50	49	39		

*Includes only February and June degrees prior to 1960

¹Aeronautical Engineering
²changed from Geology and Geophysics to Earth and Planetary Sciences 1970
³changed from Geology and Geophysics to Earth and Planetary Sciences or Meteorology beginning 1967-68 included in Earth and Planetary Sciences or Meteorology 1970
⁴changed from Naval Architecture and Marine Engineering to Ocean Engineering 1970
⁵changed from Electrical Engineering and Computer Science to Electrical Engineering and Computer Science 1975
⁶changed from Metallurgy and Materials Science to Materials Science and Engineering 1975

Table XV Summary of Degrees Awarded
(1868-1979)

Bachelor in Architecture (discontinued 1972)	722
Bachelor in City Planning (discontinued 1954)	31
Bachelor of Science	49,067
Master in Architecture (discontinued 1972)	648
Master in City Planning	633
Master in Public Health (discontinued 1944)	104
Master of Architecture	264
Master of Architecture in Advanced Studies	164
Master of Science	26,260
Advanced Engineering	2,707
Advanced Engineering awarded jointly with Woods Hole Oceanographic Institution	15
Doctor of Engineering (discontinued 1918)*	4
Doctor of Philosophy	7,150
Doctor of Philosophy awarded jointly with Woods Hole Oceanographic Institution	70
Doctor of Public Health (discontinued 1944)*	9
Doctor of Science	2,740
Doctor of Science awarded jointly with Woods Hole Oceanographic Institution	7
	<hr/>
	90,595

* See 1959 Report of the Registrar for details

Office of the President and the Chancellor

The annual reports that appear in this section are submitted by the heads of administrative departments and operations which report directly to the Office of the President and the Chancellor. The Department of Athletics has reported heretofore through the Office of the Dean for Student Affairs. During the review and reorganization of student services in the past year, the Department reported, and continues to report, to the Vice President in the Office of the President and the Chancellor. The Council for the Arts reports to the President through Professor Roy Lamson, Special Assistant to the President for the Arts. The Director of Information Processing Services and the Director of the Undergraduate Research Opportunities Program report directly to the Chancellor. The Institute Information Services and the MIT Press report to the Vice President in the Office of the President and the Chancellor.

Department of Athletics

A report on the past year in M.I.T. athletics must highlight the ground breaking for a much needed indoor athletic facility, with an ice rink events center on the ground level and a field house on the second level. The new facility features a unique design to maximize available land resources in meeting the varied sports and recreational interests within the M.I.T. community, and provides a center for major convocations on the campus. The decision to complete the design and begin construction of the new facility follows closely the construction of the Steinbrenner Stadium. It will complete the first phase in a development program to expand and upgrade existing indoor athletic facilities in support of the role accorded to athletics and recreation in student life at the Institute.

A second development of major interest to students was the finalization of a plan for a series of improvements on Briggs Field to increase use of the playing fields for intramural and club sports, as well as for intercollegiate sports. The improvements were made possible through a gift from the Class of 1974. Class officers worked closely this past spring with the officers of the Intramural Council, the Department of Athletics, and Physical Plant in a plan which accomplished the following:

- conversion of an underutilized hammer throw area in the southwest corner of Briggs Field to a multi-purpose surface which will enable the area to be used seasonally for touch football and softball, as well as for the hammer throw, in which a number of M.I.T. students have excelled nationally in recent years;
- construction of six softball backstops which will serve to better define the playing fields and will permit improved field maintenance; and
- designation of the field nearest to the Kresge parking lot as the "Class of 1974 Field," to be equipped with an expanded backstop and improved facilities suitable for intramural playoffs and other special events in the intramural sports program.

The improvements in Briggs Field coincide with the completion of the Steinbrenner Stadium and the construction of the Ice Rink-Events Center-Field House; they will provide for greater use of the playing fields that are a major component in the facilities that accommodate the unique opportunities for sports and recreation available to M.I.T. students.

Finally, it should be noted that one step remains in providing for maximum use and economical maintenance of the playing fields: the installation of a synthetic turf and night lighting on an area measuring approximately 250 by 400 feet located between Steinbrenner Stadium and the du Pont Tennis Courts. The area would be multiply used about 16 hours a day, seven days a week during the rainy months of March through May and September through November.

The area is used presently during the spring and fall outdoor seasons for physical education classes, general recreation, and as a practice and competition site for intramural, club, and intercollegiate sports. On weekends, intramural games are scheduled during the daylight hours beginning at 8 am (75 intramural soccer teams last fall). The result of such heavy use, even during periods of normal rainfall, too often is a quagmire which has been impossible to maintain with natural turf. It should be noted that the existing drainage system of the Steinbrenner Stadium could be utilized to drain a well-graded installation of synthetic turf on the adjacent area.

Limiting team practices and competitions to this area during inclement weather, in combination with use of the training facilities in the new field house, would ensure the availability of all-weather training and game sites and would minimize the misuse of the turf fields. This would provide for an economical maintenance of the turf which covers approximately 80 percent of the playing fields. Obviously, night lighting would further enhance utilization of the area.

Of a number of program innovations during the past year, one deserves a special mention. I quote from a column in *The Tech* by Gordon Haff, Class of 1979, Sports Editor, "One of the major events on the sports scene during the past year was the formation of a football club."

The Department opposed initial efforts by a group of undergraduates headed by Bruce Wrobel, Class of 1979, to seek official sponsorship of Club Football (permitting graduate students, as well as undergraduates, to be eligible for intercollegiate competition). Nevertheless, an ad hoc committee of students and members of the Athletics Board was appointed to study the proposal and its impact within the context of the existing sports program. Following the committee's study and report, the Department acted favorably on the committee's recommendation to conduct a one-year experiment with Club Football subject to the following conditions:

- The cost of Club Football shall not impact any of the present student athletic programs and shall be borne within the budget of the Office of the Dean for Student Affairs.
- The Medical Department shall provide the kind of medical coverage which it deems necessary. Further, the costs are to be considered the expense of the Club Football Team.

Despite a winless record, a squad of 45 students who started and completed the season were most enthusiastic about continuing Club Football. The team was competitive in all six games. The closing game was held in the Steinbrenner Stadium as the feature event of a "Homecoming Weekend," promoted entirely by student leadership within the fraternities and Institute dormitories. Complete with marching band and cheerleaders, the closely contested game with Siena College was a great success. There was general agreement that the event produced a weekend of desirable social activity and a cohesiveness among students not witnessed at M.I.T. in recent years.

At its December meeting, the Athletics Board recommended the continuation of the Club Football experiment through the coming year, and the Department has agreed. The future of the program will depend upon student interest as evidenced by the degree of participation and commitment to the special disciplines of a competitive and successful football program.

PHYSICAL EDUCATION

The basis for the participation of a large segment of our M.I.T. students in some form of sports or recreation is the quality of instruction provided in a wide range of courses offered in our physical education curriculum. Many of our students have avoided athletics due to unhappy experiences in secondary school programs. These same students have found great satisfaction

Department of Athletics

in life-long activities where professional instruction in small classes has revealed interests and abilities which they previously had not explored.

This past year there were 5,939 registrations in 57 different activity courses offered in the physical education curriculum, including eight courses offered only during Independent Activities Period: Precision Archery, Basketball Officiating, Labanotation, Ice Hockey Fundamentals, Box Lacrosse, Advanced Squash, New Games, and Master Swimming Techniques. The registration statistics for 1978-79 include 1,741 non-credit registrations. Seven Wellesley students were among this latter group.

Tables I and II show total registration statistics for the past year, and a five-year summary of registrations including an analysis of the non-credit registrations.

TABLE I
Registration Statistics for 1978-79

Dance		545	Gymnastics		106
Beginning Ballet	112		Gymnastics	43	
Intermediate Ballet	89		Trampoline	63	
Modern Dance	49				
Partner Dance	243		Softball		105
Tap	52				
Swimming		477	Touch Football		88
Beginning	256		Karate		84
Intermediate	58		Lacrosse		65
Advanced Techniques	39		Judo		62
Advanced Life Saving	15		Rock Climbing		57
Red Cross W.S.I.	15				
Diving	38		Basketball Fundamentals		57
Scuba	56				
Tennis		434	Self Defense		48
Beginning	255		Yoga		40
Advanced Beginning	20		First Aid		33
Intermediate	159		Bicycling		32
Self Designed Fitness		459	Ultimate Frisbee		28
Development		394	T'ai Chi		26
Sailing		336	Field Hockey		12
Ice Skating		228	Soccer Officiating		8
Beginning	188		Softball Officiating		6
Figure	18				
Hockey	22				
Fencing		223			
Rifle		196			5,249
Pistol		191	Independent Activities Period		690
Volleyball		184	TOTAL		5,939
Archery		175			
Squash		166			
Golf		142			
Beginning	115				
Intermediate	27				
Badminton		129			
Sculling		113			

TABLE II

Five-Year Summary -- Analysis, Physical Education Registration

	<u>78-79</u>	<u>77-78</u>	<u>76-77</u>	<u>75-76</u>	<u>74-75</u>
(a) Total Registrations	5,939	6,232	6,462	6,354	6,882
Change Over Previous Year	-293	-150	+108	-528	+846
% Change Over Previous Year	-4.7%	-2.5%	+1.7%	-7.6%	+14%
<hr/>					
(b) Non-Credit Registrations	1,741	1,195	2,492	2,053	2,653
Change Over Previous Year	+546	-1,297	+439	-614	+586
% Change Over Previous Year	+45%	-52%	+21%	-23%	+28%
<hr/>					
(c) Analysis of Non-Credit Registrations					
<u>Students</u>					
1st Year	77	1	65	58	63
2nd Year	190	24	308	313	293
3rd Year	186	52	413	282	341
4th Year	260	50	336	388	415
Graduates	739	770	905	734	1,015
Staff	289	298	465	279	526
	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
	1,741	1,195	2,492	2,054	2,653
<hr/>					
(d) Total Registrations Less Non-Credit Registrations					
Total Registrations	5,939	6,232	6,462	6,354	6,882
Non-Credit	1,741	1,195	2,492	2,053	2,653
	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
	4,198	5,037	3,970	4,301	4,229

INTERCOLLEGIATE ATHLETICS

The deepest commitment to sports participation by M.I.T. undergraduates is in the area of intercollegiate athletics, and the past year was no exception. Slightly more than 1,000 men and women competed regularly in 32 sports (21 of which included varsity and subvarsity schedules) in 636 contests in Cambridge or on the campus sites of our New England opponents.

As would be expected in a program where athletic scholarships are non-existent, peaks and valleys in terms of team and individual performance are characteristic of M.I.T. athletics. A number of noteworthy achievements during the past year include the following:

- The men's sailing team completed its best season in the past decade with Captain Leonard Dolhert, Class of 1979, winning the New England Singlehanded Championship; he also led our sailors to the New England Team Racing Championship and to a strong third place finish in the New England Dinghy Championship, thereby qualifying the M.I.T. sailors in all three national championships of the North America Intercollegiate Yacht Racing Association.
- The men's and women's fencing teams were outstanding in winning first and second places, respectively, in the New England Championships. Nationally, John Rodrigues, Class of 1979, placed ninth in the epee, and Michelle Prettyman, Class of 1979, won the gold medal in the New England women's foil championship.
- In men's and women's rowing, the men's varsity eight qualified for the finals in the championships of the Eastern Association of Rowing Colleges, and the women's crew placed second in the varsity fours' race at the Head of the Charles Regatta.
- The soccer and lacrosse teams enjoyed outstanding success, with key wins in soccer over Harvard 3-1 and Brandeis 3-0, the latter a strong contender for the NCAA Division III National Championship. The lacrosse team won eight of its last nine games to complete a season of eight wins against four defeats.
- In women's gymnastics, Leslie Harris, Class of 1981, won the all round championship of the Massachusetts Association of Intercollegiate Athletics for Women.
- The men's and women's swimming teams completed winning seasons of 9-2 and 8-1 respectively, with Preston Vorlicek, Class of 1979, winning All American recognition for the third consecutive year.
- All American honors in track and field were won by Stephen Sifferlen, Class of 1979, following his second place finish in the hammer throw in the NCAA Division III National Championships.

Among other noteworthy achievements were: a fifth successive winning season for the golf team, the pistol team's first place finish in the Greater Boston Pistol League, ski team captain Thomas Stevens' 1979 gold medal in the Division II jumping event of the New England Intercollegiate Skiing Association, and the outstanding performance of Kevin Burns, Class of 1980, M.I.T.'s number one squash player who defeated his number one opponent at both Harvard and West Point en route to a season of 14 wins against nine defeats.

Intercollegiate Letter Awards for 1978-79

<u>Undergraduate Men</u>		<u>Undergraduate Women</u>	
Varsity Letters	259	Varsity Letters	93
J-V Letters	149	J-V Letters	55
Frosh Numerals	63	Frosh Numerals	14

WOMEN'S ATHLETICS

Women's athletics is coordinated by Professor Jane Betts, Assistant Director of Athletics.

Women's sports collectively experienced a positive year of intercollegiate athletic competition. More women participated in varsity and sub-varsity teams than ever before at M.I.T. This may be attributed to the increased number of athletics across the country. All coaches and support staff (trainers) were in at least their second year of coaching M.I.T. teams which provided continuity and depth in the program. Women's sports are administered within the rules and regulations of the Association of Intercollegiate Athletics for Women (AIAW), and its state (MAIAW) and regional (Eastern AIAW) affiliates.

Varsity Programs

The varsity program for women included 10 sports. Participation numbers, season results, and significant events and accomplishments are as follows:

	<u>Participants</u>	<u>Results</u>
Fall Tennis	15	3-6
Fall Sailing	21	1-1st 2-2nds 1-3rd 6-4ths 2-8ths
Volleyball	17	3-11
Field Hockey	19	4-6
Basketball	25	8-9
Fencing	17	12-5
Gymnastics	10	9-5
Swimming	28	8-1
Spring Sailing	21	1-2nd 2-3rds 1-4th 5-5ths
Crew	37	6-2
Softball	22	4-6
Spring Tennis	15	1-3

The basketball team finished second in the Bates Invitational Tournament. Captain Diane Ozelius, Class of 1979, was named the Most Valuable Player in the Tournament. Karen Samuelson, Class of 1981, and Ms. Ozelius were named to the tournament all star team.

The fencing team was second in the New England Fencing Championship. Captain Michelle Prettyman won gold medal honors in the New Englands and competed in the National Women's Intercollegiate Fencing Championships at San Jose State College, San Jose, California.

Ms. Harris was all around champion at the MAIAW Gymnastics Chamionships. She qualified and competed in the EAIAW Championships at the University of Maryland.

The 1979 swimming season was the most outstanding for the women's team to date. Freshman Karen Klinecicz qualified for and competed in the AIAW Championships at the University of Reno, Reno, Nevada.

Second place in the varsity fours' race was captured by varsity oarswomen in the annual Head of the Charles Regatta. The varsity eight won the petite finals in the Eastern Sprints.

Sub-varsity teams competed in basketball, crew, fencing, softball and volleyball. Although 1979 was only the second season for varsity softball, the team interest and enthusiasm was significant enough to establish a sub-varsity program.

The total participation in the women's varsity and sub-varsity programs was 247 athletes.

Club Programs

Women competed on established club teams in water polo, rugby, and cross country. New interest was demonstrated at the club level in the following sports: soccer, lacrosse, and track and field.

Activities

GBCAA Mixed Doubles Tennis Championship. M.I.T. hosted the first GBCAA mixed doubles tennis championship on the Briggs Field courts. The tournament was a new approach to inter-collegiate athletics and was quite successful.

Women's Athletic Council. The Women's Athletic Council (WAC) was fairly inactive this year. This was perhaps largely due to the fact that the student athletes have chosen to concentrate their time and effort specifically on their sport rather than an organization that may have outlived its usefulness. The members of the WAC requested that the Director of Women's Athletics coordinate four meetings of the group each year. This will replace monthly meetings previously held by the WAC. Nancy Robinson is the WAC chairman for 1979-80.

MAIAW Softball Championships. M.I.T. hosted the four-team Division III softball championship on the Briggs Field Softball diamond. Although the M.I.T. team was not selected to compete, the women on the M.I.T. staff administered the championship as a contribution to the MAIAW.

In her report on women's athletics this year, Professor Betts concluded, "It is with modest pride that I submit this report on M.I.T. Women's Athletics for 1978-79. The women's program of intercollegiate athletics is respected by many for its purpose of providing meaningful experience in sports for student athletes willing to make the necessary commitment. The number of women student athletes increases yearly. No programs have been omitted due to insufficient interest, rather sub-varsity and club teams have been added to the program.

"Our coaches have done a commendable job in all sports. Our support personnel (trainers, equipment room personnel, business manager) have kept our teams in sound condition physically, well equipped, attractively uniformed, and on time to events away from home.

"Each year I become more aware that the M.I.T. Women's Intercollegiate Athletic Program reflects the efforts and attitudes of the members of the Athletic Department. Few here are satisfied with less than the best. It is a professional privilege for me to be associated with high quality people that make up the M.I.T. Athletic Department."

INTRAMURAL ATHLETICS

As of last year, the Intramural Program totaled 24 sports. The newest sport, ultimate frisbee, attracted 23 teams within the M.I.T. community and is typical of the growth in many of the non-traditional sports sponsored at the level of intramural competition. However, the most popular sports continue to be softball, soccer, basketball, touch football, volleyball, and ice hockey. In total, intramurals attract about 80 percent of our undergraduates and a significant number of graduate students and young faculty. In spite of space problems, and acceptable officiating in the team sports, participation continues to grow at a rate of about four percent per year.

Intramural Participation Statistics 1978-79

<u>Sport</u>	<u>Number of Teams</u>	<u>Approximate Number of Participants</u>
Badminton	43	215
Basketball	160	1,280
Bowling	109	327
Chess	10	60
Cross Country	22	183
Cycling	3	23
Fencing	14	85
Football	84	1,260
Frisbee	23	184
Hockey	63	630
Pool	24	120
Rifle	38	161
Sailing	10	40
Soccer	75	1,350
Softball	171	2,394
Squash	45	225
Swimming	15	91
Table Tennis	79	553
Tennis	--	322
Track (Indoor)	7	81
Track (Outdoor)	18	161
Volleyball	128	1,024
Water Polo	38	380
Weightlifting	6	51
Wrestling	13	92
	<u>1,198</u>	<u>11,292</u>

CLUB ATHLETICS

Club sports are a strong supplement to the varsity intercollegiate program for undergraduates. They are especially attractive to graduate students and young members of the faculty who are unable to make regular commitments in a highly organized and competitive program. This is not to imply that all clubs are entirely "soft pedal." The men's and women's rugby teams play regular schedules within the jurisdiction of the New England Rugby Union, and such clubs as graduate soccer, squash, and crew compete in organized greater Boston competitions.

CLUBS ACTIVE IN 1978-79

Archery	10	Pistol - Rifle	45
Badminton	22	Rugby - Men's	28
Bicycling	8	Rugby - Women's	22
Crew - Graduate	12	Scuba	30
Cricket	24	Soccer - Graduate	22
Dance Workshop	18	Squash - Women's	11
Folk Dance	60	Squash - MSRA	22
Round Dance	30	Table Tennis	16
Fencing - Graduate	18	Volleyball - Men's	15
Figure Skating	12	Water Polo - Spring	12
Football	45	Weightlifting	10
Judo	14	White Water	24
Karate - 2 clubs	46		

RECREATION FOR STUDENTS AND THE M.I.T. COMMUNITY

A major objective in the M.I.T. Athletics Program is to introduce all students to life-long sports and recreational interests in which they may develop a desire for regular participation in the years following graduation. The Department extends the same objective to members of the faculty, staff, alumni, and their families.

Toward the attainment of this objective, instruction is available in courses in the physical education curriculum, in shore schools at the Sailing Pavilion, sculling classes at the Crew House, summer tennis classes, and instruction in swimming and ice skating for children of faculty and staff.

The most visible evidence of the success of this program is the annual sale of the athletic card, required for the use of the Institute's athletic facilities. This past year a total of 9,255 were purchased within the M.I.T. community, entitling card holders to the use of standard equipment, towel service, and access to the facilities. The total figure includes 6,669 students, indicating that in excess of 80 percent of all registered students were participating in some form of athletics or recreation. In addition, 1,597 sailing cards were purchased.

Department of Athletics

Athletic Card Sales for 1978-79

Students		6,669
Faculty	347	
Academic Staff	1,490	
Exempt Staff	70	
Support Staff	214	
Service Staff	<u>48</u>	2,169
Alumni		<u>417</u>
		9,255
Sailing Cards:		
Students	809	
Faculty/Staff	200	
Alumni	63	
Specials	173	
Physical Education	<u>352</u>	1,597

CAMBRIDGE AND GREATER BOSTON RELATIONS

A list of special events sponsored by agencies in the Cambridge and greater Boston communities and conducted within our athletics facilities during the past year speaks to our regular policy of extending the use of the Institute's facilities to our neighbors at times not conflicting with our primary commitment to M.I.T. students.

In close liaison with the office of Walter Milne, Special Assistant to the President for Urban Affairs, a partial listing of a variety of events accommodated this past year included: summer sailing and rowing instruction for Cambridge and Boston youth, the New England Wheelchair Games, the Toddler Swim Program conducted by the M.I.T. Child Care Center, the annual Massachusetts State Science Fair, and the Cambridge Mayor's Annual Dinner-Dance.

Other events on a continuing basis during periods of off-peak use by M.I.T. groups include: use of Alumni Swimming Pool by the "New Horizons" program for girls ages 12-14 sponsored by Women's Enterprises of Boston; the use of our indoor and outdoor track and field facilities by the Roxbury Track Club and by the track teams of the Cambridge Rindge and Latin School for practice and competitions.

Finally, our M.I.T. students are assisted in sponsoring Cambridge young people on a one student-one guest relationship during "open" hours at the swimming pool, ice skating rink, and indoor basketball facilities.

MAJOR ATHLETIC AWARDS FOR 1978-79

The Class of 1948 Award to the Senior Athlete of the Year was presented to Preston L. Vorlicek, Class of 1979. The Admiral Edward L. Cochrane Award to the senior who has best combined the qualities of leadership, humility, and scholarship in intercollegiate athletics was awarded to Bruce J. Wrobel, Class of 1979. The Malcolm G. Kispert Award to the senior scholar-athlete of the year was presented to Leonard E. Dolhert, Class of 1979. The Betsy Schumacker Award for excellence in athletic competition by a woman student was won by Diane L. Medved, Class of 1980.

The Straight T Award for national or regional recognition in intercollegiate athletics at M.I.T. was presented to the following: John D. Blascovich, Class of 1982, Luis G. Boza, Class of 1979, Cynthia E. Cole, Class of 1979, Elizabeth A. Fisher, Class of 1980, Diane Medved, Douglas A. Parigian, Class of 1981, Michelle L. Prettyman, Class of 1979, Elliot P. Rossen, Class of 1979, Thomas D. Stevens,

Class of 1979, Raymond G. Swartz, Debra Utiko, Joan M. Whitten, and Arj Wichiencharoen, all of the Class of 1980.

The Burton R. Anderson, Jr. Award to the Manager of the Year was presented to John M. Canning, Class of 1982 and Kevin B. Riehl, Class of 1980. The Varsity Club Award to the Frosh Athlete of the Year was won by Karen M. Klinecicz, Class of 1982. The Harold J. Pettegrove Award for outstanding contributions to intramural athletics was awarded to Jason J. Tong, Class of 1980.

ROSS H. SMITH

Council for the Arts

The academic year 1978-79, the Council's sixth operating year, was characterized by considerable planning for continued development of the arts at M.I.T. Under the guidance of Professor Roy Lamson, Special Assistant to the President for the Arts, a staff of four -- Peter Spackman, Executive Director; Elsa G. Sonnabend, Associate Director; Deborah Hoover, Assistant Director; and Rebecca Burke, Secretary -- worked with Council members and with M.I.T. administration, faculty, and students to strengthen the Council's programs, to pursue the arts-related goals of the Institute's Leadership Campaign, and to develop further plans for major new facilities to house M.I.T.'s strong and growing arts and media programs.

Committees

Under the leadership of President Jerome B. Wiesner and Council Chairman Luis A. Ferré, the Council's Executive Committee met three times to plan for future activity as well as conduct the Council's general business. The Council's committee structure was reviewed, streamlined, and made more flexible in order to facilitate Council interaction with the developing plans for new facilities. Two new committees were established: the Arts Facilities Sponsoring Committee, under the chairmanship of Vernon R. Alden, with Vera List and Kay Stratton acting as co-chairmen; and the Ad Hoc Committee on the Future, under the chairmanship of Professor Lamson.

The Arts Facilities Sponsoring Committee, a national committee charged with helping senior officers of M.I.T. locate capital funds in a long-range program to build new arts facilities at the Institute, had one general and four regional meetings during the year to establish goals and formulate fund-raising plans. At the general meeting in New York, the Committee reviewed long-term planning for four funding phases -- for the visual arts, media arts and technology, music, and drama. The regional meetings in New York, Washington, DC, Boston, and Chicago began planning on an intensive basis for events, publicity, and solicitation in support of the program in the months after the Council's annual meeting in October 1979. With several commitments in hand for phase one of the program, the Committee looked forward to an active and productive year ahead.

In support of the Committee's work, a good deal of planning activity was coordinated by the Council staff with other M.I.T. offices, particularly the Office of Resource Development and the Planning Office. Application was made to the Challenge Grant Program of the National Endowment for the Arts for a major grant to help with the proposed arts and media technology facilities. The Council also applied to the Endowment's Design Arts Program for assistance in planning, design, preparation of promotional materials, and technical research. Notification of the Endowment's action will be received early next fall. With a faculty program group headed by William L. Porter, Dean of the School of Architecture and Planning, the Council staff helped coordinate program planning toward a series of integrated facilities that are foreseen as providing a unique mixture of the arts and media technologies. This integrated facilities plan would provide improved spaces and specialized resources for teaching, research, and creative work in the existing disciplinary programs of film/video, computer graphics, electronic music, photography, environmental art, and print and computer graphics, supplemented by Institute-wide educational programs in exhibitions and video resources.

Council for the Arts

The Ad Hoc Committee on the Future met for intensive sessions on six occasions, including two all-day sessions, to examine several aspects of the Council's role at M.I.T. and to make recommendations for Executive Committee action. The Committee sought the advice and experience of a number of M.I.T. officers, meeting with Peter Richardson, Director of Admissions; Professor N. John Habraken, Head of the Department of Architecture; Dean Harold Hanham, of the School of Humanities and Social Science; Vincent A. Fulmer, Secretary of the Institute; Dr. Paul Earls, Fellow, Center for Advanced Visual Studies; Kathy Halbreich, Director of Exhibitions of the Committee on the Visual Arts; and Professors Richard Leacock and Nicholas Negroponte of the Department of Architecture. The last two meetings heard Professor Walter Rosenblith, Provost, and President Jerome B. Wiesner. The report, together with 13 recommendations, was presented at the spring meeting of the Executive Committee and will be a point for more detailed discussion at the next Executive Meeting. An attitude survey entitled "The Arts by Numbers? A Study of M.I.T. Undergraduates' Attitudes Toward the Arts" was conducted by four students in Professor Thomas J. Allen's Managerial Psychology Laboratory.

The Grants Committee, under the chairmanship of Lewis P. Cabot, met to consider three rounds of applications for Council assistance in the fall, winter, and spring. Grants totaling \$24,371 were awarded to 17 recipients representing a wide variety of arts activities at M.I.T. Included among these grants were the following: an informal lecture series sponsored by the Committee on the Visual Arts entitled "Confrontations with Contemporary Art;" assistance in bringing the Lasalle Quartet to M.I.T.; support for a visiting writers' program; equipment purchase for the Visible Language Workshop and the Student Art Association; a seminar series on "The Conservation of Materials" sponsored by the M.I.T. Historical Collections; and assistance in producing a broadcast quality video recording of Henry Brant's "Spatial Concerto" performed by the M.I.T. Symphony Orchestra. The Grants Committee also has revised and refined its practices and procedures, and thereby has redirected the grants program for the coming year. A new application outline and policy statement were drafted for public announcement, and a memorandum on operational procedures was completed for use by the committee.

The Acquisitions Committee, chaired by Ida Rubin, met on several occasions to discuss art acquisitions policies. At a joint meeting with the M.I.T. Committee on the Visual Arts (C.V.A.), it was agreed that the need for planning was heightened by the prospect of new facilities for the arts and media technologies, including a new conservation laboratory. A subcommittee was appointed to study the various ramifications and needs of the M.I.T. Permanent Collection. This committee, consisting of three members of the C.V.A. and three Council members, is to begin its work in the fall.

The Development Committee, chaired by Gregory Smith, met at intervals throughout the year. A policy was established to relate major capital fund-raising plans to the Council's ongoing efforts to increase funds for its operating and grants programs. A program of annual giving to the Council was launched, and resulted in 55 gifts, a modest increase over previous years. The Committee and its members worked in New York to help with arts-related solicitations in the M.I.T. Leadership Campaign, making over 75 calls on a variety of M.I.T. alumni and others interested in these aspects of the Institute's educational program.

Nine new members were nominated by the Nominations Committee and were appointed to the Council by President Wiesner for three-year terms. They are: Ambassador Virgilio Barco, Class of 1943, Washington, DC; Maria A. Bentel, Class of 1951, New York; S. James Goldstein, Class of 1946, New Jersey; Dr. James A. Hester, Jr., Class of 1965, Boston; Yulla Lipchitz, New York; Dr. Arthur K. Solomon, Boston; Marianne L. Teuber, Boston; Nancy A. Vappi, Boston; and Edith Wyle, Los Angeles. During the year, resignations were received from Cornelius Van S. Roosevelt and William H. Lane. We were saddened by the death of Thomas K. Meloy, a longtime, loyal supporter of M.I.T. and the Council. Total Council membership at year's end was 88.

Annual Meeting

The Council's seventh annual meeting was held on November 6, 1978. After being greeted by the President, Council members heard a report of the year's highlights by Chairman Ferré and witnessed a presentation by Professors Leacock and Steven Gregory of the Department of Architecture on the new stimuli afforded the visual arts by the coming of videodisc and digital television technologies. At the luncheon, Council members met with faculty and students in the

arts, and heard Mrs. Margaret McDermott present the fifth McDermott Award to Mrs. Julius Stratton. The McDermott Award, which carries a cash prize of \$1,000, is presented annually by the Council for "major contributions to the arts as a means of human fulfillment."

After lunch, Council members attended mini-seminars of their choice with one of 13 members of the M.I.T. faculty in the wide variety of arts disciplines currently active at M.I.T. Fields included: computer music, architecture, film/video, graphics and design, holography, writing, materials research in archaeology and ethnology, and the M.I.T. outdoor sculpture collection.

The Annual Meeting concluded with dinner at the President's House, followed by a showing of several films by Charles Eames. Mr. Eames, who died suddenly last summer, had been a long-time friend of the Institute and its various initiatives in the arts. President Wiesner and Professor Judith Wechsler paid a brief tribute to him and his effect on the Institute before the film showing. This was a private preview of a three-week public showing of Eames films that was sponsored by the Council as a celebration of the man and his work.

Publications: Fund-Raising Activities

In cooperation with the Eames Office in Venice, California and in conjunction with the M.I.T. Eames film festival, the Council printed with the film schedule an illustrative chronology of the work of Charles and Ray Eames, from 1940 through 1978. A complete listing of their films was also included.

A variety of fund-raising materials was prepared, including a revised Council brochure, a collection of local and national newspaper clippings concerning the arts and media called "M.I.T. Arts in the News," and an illustrated notebook documenting the visual arts and media programs to be housed at the new facilities. The monthly M.I.T. Arts Calendar also was continued.

In addition to numerous fund-raising luncheons in New York, the Council held a reception in March for Boston Council members following the first performance in the United States of Andor Kovach's one-act opera, *The Rendez-Vous*, and Dramashop's one-act play by Peter Shaffer, *Black Comedy*.

Production assistance and guidance were provided to a special filming project which highlights the broad spectrum of arts activities at M.I.T. Guidance and support also were provided to several programs and departments in writing proposals and securing funds.

Staff Transitions

Susan Knight left to marry Council member Lewis P. Cabot early in the year. She was replaced by Deborah Hoover as Assistant Director, who came from the Design Arts Program of the National Endowment for the Arts, and Elsa G. Sonnabend as Associate Director, who had been with Thomas A. Buffum Associates and a fund raiser for Lesley and Vassar colleges.

PETER SPACKMAN

Institute Information Services

During the past several years, the concept of the Institute Information Services (I.I.S.) has been useful in the improvement of the channels of communication among information-related offices. For the past six years, representatives of I.I.S. and other staff members across the Institute, whose responsibilities involve receiving and disseminating information, have met together in the Information Group to brief each other on current developments and to discuss common interests and tasks. This informal but continuous encouragement of more open and cooperative sharing of information across departmental lines will be especially helpful in this current period as the Institute continues to move toward making administrative services more economical and cost-effective.

The activities of the I.I.S. departments during the past year are reported below by Robert M. Byers, Director of the News Office, and Kathryn W. Lombardi, Manager of Campus Information Services.

CONSTANTINE B. SIMONIDES

NEWS OFFICE

M.I.T.'s representation in the nation's news during 1978-79 continued at approximately the same levels achieved during the previous year. At year's end, widespread news attention was given to the election of the first woman, Professor Sheila E. Widnall, as chairman of the faculty. Other subjects that brought the Institute to national attention, to cite just a few, included: advances in fusion energy research with ALCATOR C; selection of graduate student Byron Lichtenberg as a space shuttle payload specialist; the role of sodium nitrite, a meat preservative in producing cancer among rats; the possibilities of remanufacturing to extend the life of home appliances; the Centerbeam exhibition on The Mall in Washington, DC; dedication of Steinbrenner Stadium; X-ray astronomy discoveries with experiments aboard the SAS-3 and HEAO-2 satellites, and discoveries about the environments of Venus with the Pioneer probe and of Jupiter with the Voyager probes; the Institute's first football team; the beginning of a search for a new president to succeed President Jerome B. Wiesner when he retires at the end of the coming 1979-80 academic year; studies at the Francis Bitter National Magnet Laboratory on how smoking impairs the ability of the lungs to clear dust, and other studies on magnetite found in bacteria; studies on the effectiveness of radical mastectomies in breast cancer; housing studies; and the beginning development of a method of using the sounds babies make when they cry for diagnostic purposes.

All told, the News Office issued 220 news releases during the year. Nearly 50 of those dealt with the substance of scientific and engineering research. Another 75 related to areas of art, music, theatre, and dance, fields that continue to expand.

Tech Talk was published 39 times -- one four-page issue, 33 eight-page issues, and five 12-page issues -- for a total of 328 pages. In addition, three supplements were included with *Tech Talk* this year -- the eight-page Report of the President and the Chancellor in October, the eight-page listing of Committees of the Institute in November, and the four-page Interim Report of the Ad Hoc Committee on M.I.T. and the Intelligence Agencies in April. In 1978-79, the Positions Available section of *Tech Talk*, supplied by the Office of Personnel Services, used 41 pages, compared to 37 pages the previous year and 28 pages the year before that. Week-to-week space used for Positions Available ranged from 60 column inches on January 17 to 152 column inches on August 30.

The "MIT79" section of *Technology Review* was sent to the parents of undergraduate students six times during the year in place of the *M.I.T. Observer* collection of news clippings, which has now been discontinued. During 1979-80, responsibility for this activity will be transferred to the Office of the Dean for Student Affairs in collaboration with *Technology Review*.

Nine issues of *Reports on Research* were published during the year, each with three to four articles. Reorganization of *Reports on Research* mailing lists has been successfully completed. The publication is now being sent to members of the Industrial Liaison Program through a list maintained by I.L.P., to members of the Educational Council through a list maintained by the Office of the Vice President for Research, and to press and friends of the Institute through a list maintained by the News Office.

Staff and staff assignments were unchanged for the year. On the biweekly staff, Donna Dudzik became Secretary during the year, succeeding Helen Pollari who left to become a graduate student in the M.I.T. Department of Mechanical Engineering.

ROBERT M. BYERS

CAMPUS INFORMATION SERVICES

During the past year, there was continued high demand for the services of all of the offices within the Campus Information Services. In addition, in response to growing need for more assistance in the coordination of on-campus conferences, we established a separate position to provide this service. In the following pages are the reports of each of the organizations within the Campus Information Services: Conference Coordination, Design Services, the Information Center, and the M.I.T. Bulletin Office.

Conference Coordination

This past year, the Campus Information Services established a new, Institute-wide service to help coordinate the many conferences that are held on campus. In past years, the Director of the Information Center had provided information and advice to conference sponsors on the available resources and services at M.I.T., but the logistical coordination was left to the sponsor to assume or delegate. This system was not efficient because each new conference meant starting from "point zero" in terms of informing the specific sponsor or coordinator of the services and procedures for running a conference.

In 1978, therefore, we established a new, full-time position -- the Assistant for Special Events -- and appointed Barbara Weinblatt to be responsible for the logistical coordination of on-campus conferences and special events, with particular emphasis on attracting and supporting major conference activity on campus during the summer months. In addition, this position involves responsibility for working with relevant M.I.T. staff to determine policy on procedural matters relating to conference coordination and to develop a general system of conference coordination at the Institute.

A major objective of this service is to make better use of our facilities and services during the summer months and thus generate income which can be used to help offset room and board charges during the academic year. Another objective is to coordinate conferences well enough so that there is not a major disruption of services to the M.I.T. community during the period of the conference itself.

Persons wishing to have a conference at M.I.T. first discuss their needs with the Director of the Information Center who takes the request to the Facilities Use Committee for approval. If the request is approved, the Assistant for Special Events consults with the conference sponsor to determine the general scope, schedule, and basic needs of the conference. Together they develop the plans, budget, and timetable for the M.I.T. services which support a conference. The Assistant for Special Events interprets the specific needs of the conference into the information needed by the M.I.T. Dining Services, Housing Office, Design Services, Campus Patrol, Telecommunications, Physical Plant, and so forth. Monitoring and approving expenditures against the conference budget is an equally important responsibility.

During the 1978-79 academic year, the following conferences were coordinated by this office:

The National Academy of Sciences held a two-day symposium on Urban Waterfront Land Use at M.I.T. in March. The conference focused on the port development of New York, Baltimore, Boston, San Francisco, Pensacola, and Jacksonville, and discussed such issues as the impact of changes in transportation technology on the use of land in harbor areas.

In April, the Department of Mechanical Engineering sponsored the First Annual Conference on Computer Graphics in Computer Aided Design/Computer Aided Manufacturing systems. The conference, which drew over 550 professionals to M.I.T., discussed the current state of knowledge in the field of computer graphics in CAD/CAM, assessed major problem areas for future development, and provided technical information for prospective as well as current users of CAD/CAM systems.

In June, the Acoustical Society of America held its annual week-long conference for 1,200 participants. The conference included plenary sessions highlighting the major advances of the past 50 years in the field of acoustics as well as identifying the possible critical problems that remain to be solved in future years. The conference program also included over 55 technical sessions where papers were presented in sessions on architectural, physical, underwater, psychological, physiological, engineering, and musical acoustics, and also on noise and speech communication.

Also in June a conference was held on progress in the development and application of radio interferometry as a tool for geophysical research. This conference on Radio Interferometry Techniques for Geodesy, sponsored by the National Aeronautics and Space Administration and the American Geophysical Union, was attended by approximately 140 scientists from the United States and abroad.

In addition, a major activity during the year was the formulation of logistical plans for the World Council of Churches' conference on Faith, Science, and the Future, to be held on the M.I.T. campus in July 1979. Over 450 delegates, 150 staff persons, 450 accredited visitors, and 200 press people were expected for this 14-day conference.

While this Institute-wide service has been developed over the past four years within Campus Information Services, there are a number of other sources of support on campus for special-purpose conferences or seminars. These include, for example: the Seminar Office of the Center for Advanced Engineering Study (which supports continuing education seminars or programs offered by faculty in the School of Engineering), the Industrial Liaison Office (which runs seminars on topics of interest to companies which are members of the Industrial Liaison Program), and the Sloan School (which runs conferences involving Sloan faculty, interested alumni, and the outside business community).

During the coming year, we hope to develop a better means for communicating or sharing information about all conferences scheduled to be held on campus, in order to help avoid redundancy in program content as well as to prevent conflicts or overload in the use of Institute facilities and services.

Design Services

In 1978-79 the Office of Design Services, under the direction of Jacqueline Casey, undertook 399 graphic design and publishing projects consisting of 658 parts. Of these publications, 30 were in support of the M.I.T. Leadership Campaign, 64 were publications for the Alumni Association, and the rest were assignments from many individual offices and departments within the Institute. The Office continues to provide design and production assistance to the growing number of conferences coordinated by Barbara Weinblatt.

Among the many projects this year was the redesign, by Ralph Coburn, of the program for the M.I.T. Commencement exercises, held outdoors in the Killian Court for the first time in over 50 years.

During the year the work of Ms. Casey, Mr. Coburn, Betsy Hacker, and Nancy Pokross was broadly represented in major design exhibits, books, and journals. These include the Swiss Graphis Annual (Ms. Hacker), Graphis Posters (Ms. Casey), American Institute of Graphic Arts (Ms. Casey), Society of Publication Designers (Ms. Pokross), University and College Designers Association (Mr. Coburn, Ms. Pokross), Print Case Books (Mr. Coburn), Council for the Advancement in Support of Education (CASE) (Ms. Casey, Mr. Coburn, Ms. Pokross), and the Art Directors Club of Boston 1978 (Ms. Casey, Mr. Coburn, Ms. Hacker), and 1979 Exhibits (Ms. Casey, Mr. Coburn, Ms. Pokross).

Ms. Casey was represented in the Silver Anniversary Issue of *Idea Magazine* printed in Japan. This special issue featured "Important US Graphic Designers in the Last 25 Years." Her work was on exhibit at Lincoln Laboratory and American Posters 1973-1978 at the American Institute of Graphic Arts (AIGA). She was elected a member of the board of the AIGA. She served as a juror in the Communications Arts Annual Exhibition and continues as a panelist reviewing government graphics for the National Endowment for the Arts in Washington. She will be included in the *Dictionary of International Biography*, Volume XVI, and the fifth edition of the *World Who's Who of Women*.

Mr. Coburn serves as a juror for senior projects at the Art Institute of Boston as well as the Massachusetts College of Art. He appeared on a television interview at the Institute of Contemporary Art. He and several other prominent artists and art historians were involved in a discussion concerning the history of Boston Expressionism. He is included in the seventh edition of *Men of Achievement*.

Nancy Pokross lectured at meetings of the Massachusetts Society of Fund Raisers, the Art Institute of Boston, and Women in Communications, and she was a critic for CASE and a panel member for the Art Directors Club of Boston. She was awarded three distinctive merit awards for her designs for *Technology Review* covers from the Society of Publication Designers.

The work of Ms. Casey, Mr. Coburn (Special Award), and Ms. Pokross was included in the 1978 Art Directors Club of Boston. There were 14 pieces exhibited at the 1979 Show: Ms. Casey six (one Silver Medal), Mr. Coburn two, and Ms. Pokross six.

Ms. Casey, Mr. Coburn, and Ms. Pokross represented 13 percent of the award-winning 100 pieces included in the 1979 CASE Exhibit. Of these: Ms. Casey exhibited five, Mr. Coburn two, and Ms. Pokross six. All received exceptional achievements, citations, and merit awards.

Information Center

The Information Center, now housed for over a year in its extremely workable new quarters, has continued in the traditional role of providing advisory services on Institute programs, activities, services and communications, in addition to supporting international faculty, staff, and short-term visitors.

Adjacent to the main office, in the Building 7 Lobby, is a new lounge area which further enhances the services of the Center. The lounge, a gift of the Class of 1978, consists of plantings of greenery in five large wooden planters, a quadrangle of benches, and a kiosk bearing directions to the Information Center, the Admissions Office, and the Alumni Center. The gift was made to M.I.T. through the Alumni Association and the Lobby 7 Committee, and was designed by a group under the direction of Harry P. Portnoy, the campus architect. The newly designed Visitors Lounge, across from the Information Center, has been a welcome setting in which visitors can find a quiet space where they may wait for the Institute tour, watch cable TV, or simply read material about M.I.T.

It was with regret that the Center discontinued its evening operations. While this provided a certain flexibility for the community, the need for the service was not sufficient to justify the expense.

There is continuing high demand for publications and reports distributed through the Center. The following is a general distribution list: Bulletin issues (18,817); Reports (16,075); M.I.T. maps and guides (28,762); other publications (27,653).

The Center continues its practice of hiring students as tour guides and office assistants. The Center employed 27 students during the past year. During the summer, Marcia Grabow and Nanelle Scott, both of the Class of 1979, were valuable members of our summer staff. The tours continue to be a popular and vital part of the Center's operations. Visitors from all over the world have an image of M.I.T. as an excellent university and a leader in the fields of engineering and science. Although our tour guides give a good overview of the Institute, pointing out distinctive programs in Architecture and Urban Planning, Management, Humanities, and the Social Sciences, some visitors are still disappointed at not being able to view laboratory demonstrations. The following is a list of visitors who saw the Institute through an M.I.T. tour from July 1978 through June 1979:

Prospective Students	2,197
International Students	752
General Visitors	<u>2,327</u>
TOTAL	5,276
Visitors on General Tours	4,622
Visitors on Special Tours	<u>654</u>
TOTAL	5,276

Commencement this year was an exciting and memorable event, held outdoors in the Killian Court, a setting which had not been used for Commencement since the exercises were held in the lower DuPont Court in 1927. The Court made a beautiful setting for 1,400 students to receive their degrees as 6,000 spectators looked on. A soft rain did not dampen spirits, and the sun broke through in time for the reception which was held in the DuPont and Lowell courts immediately following the ceremony. A total of 58 children, from infant to school age, participated in the Commencement Day child care program.

The Center's work includes assistance to the international faculty and staff for appointments and visa applications, under the administration of Virginia D. Lyons. The past year has been a busy one for international staff, faculty, and visitors. Record numbers of international staff and faculty were appointed at the Institute, bringing the total to 772 people from 70 countries. This represented a 10 percent increase over last year's figure. The number of short-term visitors also increased significantly, and the Center arranged 487 appointments for 632 visitors during the 1978 calendar year.

There also has been increased interest by international faculty and staff in obtaining permanent resident status in the US. There were a total of 55 immigrant applications supported by M.I.T. on behalf of international faculty and research staff for the period of January 1, 1978 to the present. These applications included the following:

	<u>1/1/77-12/31/78</u>	<u>1/1/78-6/13/79</u>
<u>Individual Labor Certifications</u>		
Filed	18	16
Approved	14	11
Denied	2	0
<u>Preference Petitions</u>		
Filed	14	16
Approved	19	16
Denied	3	0
<u>Adjustment of Status Applications</u>		
Filed	17	15
Approved	21	7
Denied	0	0

The increased number of faculty and staff that we serve and the complexity of many applications have made it important to prepare information for the Institute community to explain the regulations and laws involved and to give them step-by-step procedures to follow for each type of application. This year, Ms. Lyons prepared new information, revised old guidelines, and re-wrote a new, larger section on visas for the new Personnel Manual. In addition, the Manager of Campus Information Services and the Assistant for International Visitors were involved this year with colleagues at Harvard and the Association of American Universities in proposing changes in the Department of Labor and Immigration Service regulations on the permanent employment of foreign nationals. We expect to see the results of these efforts this summer in the form of proposed changes in the *Federal Register*. It is hoped that the changes will be in force by the end of 1979.

The short-term international visitors have been ably taken care of by Terri Priest, who is making most of these arrangements. She is coordinating the appointments with the Harvard Marshal's Office and the Boston Center for International Visitors.

This year, with the normalization of relations with the People's Republic of China, we have seen the beginning of exchanges of scholars with the PRC. The Institute currently has seven Chinese visiting scholars on campus, with the expectation of several more such visitors during the summer and fall. In addition, there were at least eight Chinese delegations that visited the Institute for one or several days during the academic year.

The Center also made arrangements for the first Cuban delegation to visit the United States in some time. The Minister of Higher Education and a party of nine visited the Institute in November for one day.

In addition to her work with the international community, Ms. Lyons arranges representation of M.I.T. at inaugural events of other universities. There were 17 inaugurations, including those for the new presidents of the California Institute of Technology and of Mount Holyoke College, at which M.I.T. was represented.

This report would not be complete without a special salute to the Center's support staff -- Deborah Abelman, Kathleen Barrett, Donald Ferland, and Terri Priest -- whose efficiency, reliability, and good cheer have much to do with the continued high level of service which the Center seeks to maintain.

M.I.T. Bulletin

In 1978-79, the M.I.T. Bulletin Office produced the three Institute catalogues, the small and large versions of both the *Report of the Treasurer* and the *Report of the President and the Chancellor*, and the *Student Directory*.

The contents of the Bulletin series of publications have been changed to conform to Postal Service requirements for second-class mailing privileges. The Bulletin now consists of the following publications: *Courses and Degree Programs*, the *General Catalogue*, the *Summer Session Catalogue*, and the *Final I.A.P. Guide*. The I.A.P. publication, which was approved as a "catalogue" by the Postal Service, is still produced in the I.A.P. Office.

In last year's report, we noted the discussions which were held to review the content and distribution of our catalogues. The study group decided to try an experiment to assess the effectiveness of the *General Catalogue* and the *Freshman Handbook* as recruiting pieces.

This year, each book was sent to a random sample of 500 applicants early enough in the admissions process so that the books were truly recruiting pieces. The Admissions Office analyzed the data from the random sample and found that the *General Catalogue* was better as a first-order information source. More of the students who received the *Catalogue* filed a final application than did those who received the *Handbook*. However, if students did file a final application and were accepted, they were more likely to come to M.I.T. if they were in the sample group which had received the *Handbook*.

This sample mailing indicated that both books are useful, though in different ways. Perhaps in the future, the *Handbook* could be sent to all accepted students before they must let

Information Processing Services

Admissions know if they plan to come to M.I.T. Or, the *Handbook* could at least be sent to accepted students outside of the Northeast who would be less likely to visit the campus. (Currently the *Handbook* is sent to students only after they accept admission.)

This year, the Bulletin's staff is exploring the possibility of having the *Student Directory* typeset by computer composition, rather than printing from a reduced computer printout of the student name and number copy. This change is being considered as a way of improving the readability and general look of the publication.

This year, Susan Shansky, the Bulletin's Editorial/Production Assistant, edited the preliminary catalogue accompanying the exhibition *Aspects of Art and Science*, which took place at the Margaret Hutchinson Compton Gallery in October 1978. In April, she assisted in preparing the introductory overview of M.I.T. for the Institute's accreditation by the New England Association of Schools and Colleges. And, as in past years, Ms. Shansky edited the Special Summer Session Program brochures produced by the Office of Design Services.

Janet Snover, the Bulletin's Editor/Production Manager, met with representatives of several M.I.T. offices which produce publications. She reviewed current production procedures and suggested ways to improve the quality and cost effectiveness of the publications. She continued to serve as president of the New England College Publications Association, a group of approximately 100 publications professionals from a wide variety of colleges and universities.

KATHRYN W. LOMBARDI

Information Processing Services

During the past year, Information Processing Services has seen: the number of time sharing users on our 370/168 increase threefold through the implementation of CMS (Conversational Monitor System) under VM (Virtual Memory); 1,100 projects converted from OS/MVT/ASP to VM/CMS/VS1; the purchase, sale, and lease-back of our 370/148 to support administrative computing; the complete "phase-out" of Harvard's bulk usage of our 168; the installation of a PRIME 400 at the Sloan School of Management; the establishment of a remote access network which expands the availability of our student records and financial aid data bases; the final report of the Ad Hoc Committee on Computational Needs completed, published, and accepted by the Institute; the installation of the ADABAS data base management software and completion of the initial phase of our new Alumni System; a significant increase of usage on a broad scope of the Multics System; an increase in the support of external networking via TYMNET, Telenet, and EDUNET (through EDUCOM); and a closer integration of hardware, software, and technical support between administrative, academic, and research computing services.

Administrative Computing Services

Production services in administrative data processing showed about an 11 percent increase over last year, with 11,800 jobs processed.

At the same time, we experienced a 167 percent increase in the number of modification tasks which has left us with an outstanding balance of 115 on June 30. This increase has put a significant burden on our analytical and programming resources. However, in spite of this, we were still able to make significant progress on the conversion of our 1401 and DOS Systems to VS1. As of this time, we have 95 percent of our DOS control language converted and 11 administrative systems are now running under the new operating system environment.

The major new system turned over to our Operations Group was the expansion of the Registrar's Student Data Base to include student financial aid information. At the same time, 10 additional terminals were added, covering the offices of Student Financial Aid, Student Affairs, Medical, Student Loan, Graduate School, and Housing and Food Services. At present, the Registrar, Financial Aid, and Student Loan are the only offices inputting data, whereas the others use the system for inquiry purposes only.

In January, we purchased, sold, and then leased-back our 370/148 System, signing a commitment for five years. This arrangement reduced our expenses more than \$100,000 per year compared to what we were paying in rent, and assures adequate computer capacity in the future; we will be able not only to add work on the 148 and possibly further expand our student information network, but also to establish an environment which is software-compatible with the 370/168 so that we can develop a networking connection between the two machines.

Business Systems Development

Data base management systems and the demand of client offices for easier access to their information have had the greatest impact on our new systems development activity. Current new systems under design using this new technology include those for the Alumni Association, Budget Office, Admissions Office, Accounts Payable/Purchasing, and a biographical data base for the Medical Department.

Most experience to date has been in the Alumni area where, in utilizing the ADABAS software system, we have completed and installed the first (inquiry) stage of the design.

This is the first major administrative application to run on the 370/168 System under VS1 in an isolated and controlled environment. To provide this controlled environment, the Systems Programming Group installed a separate administrative virtual machine. This design allows us to provide a responsive, interactive configuration during the day and revert to a batch-oriented environment on other shifts. This dedicated virtual machine, although configured and operating on the Building 39 facility, is scheduled and managed by the Administrative Computing Services' Operations Group. To date this has been quite a successful experiment. We will be transferring other administrative applications into that same environment.

In order to establish better communication with client offices and, at the same time, to provide a mechanism for the review and peer-evaluation of new systems, a Development Review Committee has been formed. This committee is composed of 17 people representing 13 different Institute departments and offices. Although this may seem like a large complement of people, it is not expected that each individual or operation will be interested in each system that is reviewed. On the average, 8 to 10 attendees are involved in each review. Agenda items include the four basic development and installation phases of new systems, i.e., 1) functional requirements, 2) design specifications, 3) implementation plan, and 4) post-installation review.

Academic and Research Computing

Certainly the major accomplishment during this past year has been the conversion of 2,000 registered users running under 1,100 projects from OS/MVT/ASP/TSO to VM/VS1/CMS on our IBM 370/168 System. In conjunction with this conversion, we produced reams of new user documentation, including two primers, one for CMS (Conversational Monitor System) and one for VS1. These two documents have been considered the best available in the industry and have been requested by other universities across the country.

Our services to other sites on campus continue. At the Sloan School of Management we were able to install a new PRIME 400 System for users of the east campus area and to phase out the PRIME 300 on schedule. A communication link also has been established between the 370/168 and the DEC VAX 11/780 at the Joint Computer Facility in the Departments of Mechanical and Civil Engineering.

Both of the above-mentioned installations are examples of decentralized academic and research computing facilities which are consistent with the plan set forth in the final report of the Ad Hoc Committee studying computational needs. In fact, these two facilities conform very closely to the two models described in the report. In the case of the M.E./C.E. facility, I.P.S. has no direct involvement in the delivery of services, whereas at the east campus site, I.P.S./A.R.C.S. acts as the facility's manager, providing hardware, software, and user services' support.

If the Institute should elect to pursue the program recommended in the Committee's report, 10 centers, five of which will have free-standing computers, will be established on the campus. In

Information Processing Services

addition, a network would be constructed with the potential of linking all computer facilities on the campus. In any event, our experience at Sloan and at M.E./C.E. will be extremely valuable in implementing such a plan.

On the Multics System, the off-shift rates that were instituted last year and increased hardware and software reliability continue to attract new users. In the past year, we have seen an increase of 68 percent in the number of registered users on this system and an increase of 41 percent in total usage. This service is, as in the past, delivered in close collaboration with the software development staff of Honeywell Information Systems, Incorporated. Negotiations are currently under way with HISI for hardware enhancements and a follow-on three-year contract.

Our experience in providing TROLL services through M.I.T.'s Center for Computational Research in Economics and Management Science has been very rewarding. The number of projects has increased almost 100 percent (from 72 to 136) during the past year. Other involvement with C.C.R.E.M.S. includes the joint development of a mathematical programming system known as SESAME which when completed will replace a very expensive software package now contracted from outside. In addition, SESAME should be superior in many respects to any systems available elsewhere.

Systems Programming

Systems Programming activity during this past year was for the most part dedicated to the conversion of our 370/168 operating environment from OS/MVT/ASP/TSO to VM/CMS/VS1. This task required close coordination with the Academic and Research Computing Services group as well as the Administrative Services group to ensure not only the smooth transition of the 2,000 users of MVT and TSO, but also the establishment of the VS1 virtual machine for our new data base and batch administrative usage. In addition, the plan included the ultimate goal of identical VM operating system environments, both on the 168 and 148, affording the opportunity to off-load and distribute the administrative application.

In the Multics area, two major efforts were undertaken. First, under a cooperative program with Honeywell Information Systems, we implemented a new electronic mail system. Second, we developed a working version of a revised Relational Data Base Management System (RDMS) and have one application now running under it in a production mode. We anticipate that general user conversion will begin by year-end.

WESTON J. BURNER
JOSEPH R. STEINBERG

MIT Press

For the MIT Press, 1978-79 was a year of growth and accomplishment. The Press published 103 books: 68 new hardbound and 35 paperback reprints. The list comprised 17 hardcover trade titles, 4 new textbooks, and a majority of scholarly, professional, and reference titles. For the first time, international sales were over \$1 million and total book sales were \$3.55 million, continuing the pattern of controlled growth of the past few years. Frank Urbanowski toured the People's Republic of China as part of a delegation of scholarly and scientific publishers, and reported great interest there in MIT Press books. The pace of acquisitions and list development accelerated; new series were launched; and a number of copublication agreements were made with distinguished organizations and institutions. The Press received awards for publishing and design, including the prestigious Alice Davis Hitchcock Award from the Society of Architectural Historians and Art Libraries of North America award for the best art book of the year. An in-house mini-computer EDP system was installed for order processing and accounting, and plans and space renovation were completed for Computergraphics, the in-house computer composition system which will be installed next year. Mr. Urbanowski was appointed to simultaneous terms on the governing boards of the Association of American University Presses and the Association of American

Publishers. Mr. Urbanowski is the first university press director to serve as Chairman of the AAP Technical, Scientific, and Medical Division.

Table A

<u>Sales</u>	<u>FY76</u>	<u>FY77</u>	<u>FY 78</u>	<u>FY79</u>
Net Sales, Domestic	\$1,995,000	2,067,000	2,719,000	2,494,808
Net Sales, Foreign	600,000	638,000	867,000	1,046,229
Total Sales	\$2,595,000	2,705,000	3,586,000	3,541,037

Table B

<u>Fiscal Year</u>	<u>Orig. Hard</u>	<u>Dist. Hard</u>	<u>Import Hard</u>	<u>Orig. Paper</u>	<u>MITP Paper</u>	<u>Oth.Pub. Paper</u>	<u>Dist. Paper</u>	<u>Import Paper</u>	<u>Total = Hard</u>	<u>Total = Paper</u>	<u>= Total</u>
1976	30	3	6	-	24	-	-	-	39	+	24 = 63
1977	39	13	4	11	13	-	4	-	35	+	28 = 84
1978	51	13	4	2	30	3	6	1	68	+	42 = 110
1979	58	7	6	6	23	2	1	-	71	+	32 = 103
1980*	66	7	8	2	20	-	2	1	81	+	25 = 106

* projected

The publication of over 100 books this year brought the Press very close to its 2,000th book, an event heralded by a special exhibition at the Margaret Hutchinson Compton Gallery at M.I.T. BOOKS 2000 used graphic displays and materials from award-winning MIT Press books to present a past, present, and future view of the MIT Press and the scholarly publishing process.

The scholarly publishing process was the subject of a report released this year by the National Enquiry into Scholarly Communication, which was sponsored by the Council of Learned Societies. Most of the recommendations made by the Enquiry -- intelligent use of technology to increase the cost-effectiveness of operations, collaboration in the management of warehousing and fulfillment, and vigorous efforts to promote sales of scholarly books abroad -- are areas in which the MIT Press already has made significant progress. The progress and accomplishments of the past few years will provide a secure base for continued growth. Despite the constricting economic environment, the prospects for sales of scholarly and professional books remain high. M.I.T.'s academic strengths and research interests characterize much of the MIT Press list, and these are the areas of greatest buoyancy in the publishing market today.

The publishing event of the spring season was undoubtedly *Moments of Vision: The Stroboscopic Revolution in Photography* by Harold E. Edgerton and James R. Killian, Jr. The occasion was celebrated during the Technology Week festivities by an autographing party at the Tech Coop. Photographs excerpted from the book have been featured in articles in *Smithsonian*, *Camera 35*, *Sterns*, and *The New York Times*.

President Jerome B. Wiesner joined the MIT Press list this year as coeditor with Norman C. Dahl of *World Change and World Security*, the fifth volume in the MIT Bicentennial Studies Series. *The Environmental Protection Hustle*, by Bernard Frieden was the subject of reviews, interviews, and controversial exchanges across the country. Professor Frieden appeared on "The Today Show" and on radio and television programs in Los Angeles and San Francisco. Lloyd C. Etheredge, author of *A World of Men: Private Sources of American Foreign Policy*, was interviewed by both Associated Press and United Press International and was a guest on national public radio. Professor Etheredge and his book were the subjects of feature articles in *The Washington Post*, *The New York Times*, and *The Los Angeles Times*. *A World of Men* was reviewed in *Foreign Affairs* and *American Political Science Review*.

Receptions were given throughout the year to celebrate the publication of books by M.I.T. authors, including David Epstein's *Beyond Orpheus: Studies in Musical Structure*, Stephan L. Chorover's *From Genesis to Genocide: The Meaning of Human Nature and the Power of Behavior Control*, and Paul A. Samuelson's *Collected Scientific Papers*, Volume 4. Receptions also were held with the M.I.T. Political Science Department to honor Professors Walter Dean Burnham and Martha Wagner Weinberg, coeditors of *American Politics and Public Policy*, which was dedicated to the memory of Professor Jeffrey L. Pressman; and with the School of Architecture and Planning to celebrate new and upcoming publications, such as *On Streets* edited by Stanford Anderson, *Urbanization Primer* by Horacio Caminos and Reinhard Goethert, *Art and Architecture in the Service of Politics* edited by Henry A. Millon and Linda Nochlin, *Teach Yourself to Build* by Edward Allen and Gale Beth Goldberg, as well as classic backlist titles by department faculty. All faculty authors were honored at a special showing of the *BOOKS 2000* exhibition, which featured a display of MIT Press books by M.I.T. authors.

Serving on the MIT Press Editorial Board for 1978-79 were Jagdish N. Bhagwati, Professor of Economics; Joan Bresnan, Linguistics; Fernando Corbató, Electrical Engineering and Computer Science; Harold J. Hanham, Dean, School of Humanities and Social Science; Leo Marx, Program in Science, Technology, and Society; Henry A. Millon, History and Architecture; Ernest J. Moniz, Physics; Ascher Shapiro, Mechanical Engineering; and Robert A. Weinberg, Biology. Associate Provost Hartley Rogers, Jr., served as chairman of the Board. Arnoldo C. Hax, Management Science; Walter S. Owen, Materials Science and Engineering; Professor Rogers; and Myron Weiner, Political Science, served on the MIT Press Management Board with W. Bradford Wiley, chairman of John Wiley and Sons, and Jack Schulman, emeritus director of Cambridge University Press. The Management Board is chaired by Vice President Constantine B. Simonides.

BOOK ACQUISITION

The results of last year's expansion in the acquisitions department and of intensified efforts to establish series as the focal point for list development are becoming evident. Copublication arrangements with distinguished professional and scholarly organizations also received major emphasis this year.

Table C

	<u>FY77</u>	<u>FY78</u>	<u>FY79</u>
Physical Science and Mathematics	4	14	7
Life Science	14	14	9
Engineering	22	20	13
Management Science and Economics	4	14	3
Social Science	20	20	18
Humanities and Linguistics	12	13	24
Art, Architecture and Urban Studies	27	13	24

In the engineering and technology list (Frank Satlow, editor), series publication has developed around two major approaches: the innovative, theoretical leading edge of research and the interdisciplinary applications of engineering and technology to pressing social issues. The Series

in Computer Science and the Energy Laboratory Series each published new books this year, including *Research Directions in Software Technology* edited by Peter Wegner and *Electric Power in the United States: Models and Policy Analysis* by Martin L. Baughman, Paul Joskow, and Dilip P. Kamat. The MIT Press Series in Transportation Studies edited by Marvin L. Manheim published *The Urban Transportation System: Politics and Policy Innovation* by Alan A. Altshuler et al., *Planning and Politics: The Metro Toronto Transportation Plan Review* by Juri Pill, and *Fundamentals of Transportation System Analysis, Volume 1*, by Marvin L. Manheim.

Several new series were inaugurated this year. Five books were published in the Series in Artificial Intelligence edited by Patrick Henry Winston and Mike Brady, including the two-volume *Artificial Intelligence: An M.I.T. Perspective* edited by Professor Winston and Richard Henry Brown; *NETL: A System for Representing and Using Real World Knowledge* by Scott E. Fahlman; *The Interpretation of Visual Motion* by Shimon Ullman; and *A Theory of Syntactic Recognition for Natural Languages* by Mitchell P. Marcus. The first book in the Institute for Energy Analysis and the MIT Press Perspectives in Energy Series made a timely appearance: The publication of *Economic and Environmental Impacts of a US Nuclear Moratorium 1985-2010*, second edition, coincided with the Three Mile Island emergency. The second book in the series, *Energy and Economic Growth in the United States* by Edward L. Allen, will appear in the fall. The MIT Press Series in Signal Processing, Optimization, and Control edited by Alan S. Willsky was launched with the publication of two books this year: *Digital Signal Processing and Control and Estimation Theory* by Professor Willsky and *Location on Networks: Theory and Algorithms* by Gabriel Y. Handler and Pitu B. Mirchandani. *Stability and Robustness of Multivariant Feedback Systems* by Michael Safonov and *Representation and Control of Linear Infinite Dimensional Systems* by Sanjoy Mitter will be published next year. The Press acquired distribution rights to Wright-Allen Press titles, which now form the backlist of the new MIT Press/Wright-Allen Series in System Dynamics edited by Jay W. Forrester.

In science and mathematics (Larry Cohen, editor), the Press added two volumes to its Mathematicians of Our Time series: *Probability, Number Theory, and Statistical Physics: The Selected Papers of Mark Kac* edited by K. Baclawski and M. D. Donsker, and the first volume of the *Collected Papers of Percy Alexander MacMahon* edited by George Andrew. Volume 2 of the *Collected Works of Norbert Wiener* edited by P. Masani, Volume 4 of the *Collected Papers of Oscar Zariski* edited by J. Lipman and B. Teissier, and a three-volume collection of the works of Richard Brauer edited by W. Wong and P. Fong, will be published next year. One of the year's major textbooks is *Infinitesimal Calculus* by James M. Henle and Eugene M. Kleinberg, an undergraduate-level text with a unique approach to teaching calculus theory. Work has begun on a revised edition of the *Encyclopedic Dictionary of Mathematics*, to be published in 1983. The first English-language edition of the *Encyclopedic Dictionary of Mathematics* is in its fourth printing, having established itself as a major standard reference work. List development plans in science and mathematics include monograph series in mathematics and physics; a series in science, technology, and society in cooperation with M.I.T.'s Program in Science, Technology, and Society; and a series of books in the philosophy of science. Popular science titles on the fall list include the second edition of Victor F. Weisskopf's classic *Knowledge and Wonder: The Natural World as Man Knows It*; *Astronomy of the Ancients*, a collection edited by Kenneth Brecher and Michael Feirtag, based on a seminar series at M.I.T.; and *Monsters in the Sky* by Paolo Maffei author of *Beyond the Moon* (MIT Press, 1978).

In the life sciences, the Press continued to publish the papers of the Neurosciences Research Program. The most recent volume, *The Neurosciences: Fourth Study Program*, will appear in the spring. New series have been initiated in toxicology, edited by Gerald Wogan; epidemiology, edited by O. S. Miettinen; and social and humanistic dimensions of medicine, edited by Stanley J. Reiser.

The MIT Press architecture list (Roger Conover, editor) has grown to a position of preeminence in one of the most specialized and competitive areas of scholarly publishing. Added to the distinguished backlist this year were *White Towers* by Paul Hirshorn and Steven Izenour, *H. H. Richardson and his Office: Selected Drawings* by James F. O'Gorman, *Collage City* by Fred Koetter and Colin Rowe, *The Federal Presence* by Lois A. Craig and the staff of the National Endowment for the Arts' Federal Architecture Project, and *Visionary Drawings of Architecture and Planning* by George R. Collins.

In the fall, MIT Press inaugurated a distinguished new series of books in collaboration with the Architectural History Foundation, New York. The first book in the series, *On Domestic Architecture, the Sixth Book*, a reduced facsimile of the original 16th-century manuscript by Sebastiano Serlio, was the recipient of the Art Publication Award of the Art Libraries Society of North America and the Alice Davis Hitchcock Award of the Society of Architectural Historians. The MIT Press also has launched a new series of books in architecture with the Institute for Architecture and Urban Studies (IAUS), New York. In addition to books such as *On Streets* edited by Stanford Anderson and the upcoming *Giuseppe Terragni: Transformations, Decompositions, Critiques* by Peter Eisenman, the Press has for several years published the IAUS's award-winning journal of architecture, *Oppositions*. A series of Oppositions Books will continue in the tradition of the journal and will be initiated in the spring with the publication of *The Architecture of the City* by Aldo Rossi. The 1980 list will also include books published in cooperation with the Boston Athenaeum and the National Trust for Historic Preservation as well as *Studies in Italian Art and Architecture, 15th through 18th Centuries*. This book, edited by Professor Millon, is being published in cooperation with the American Academy in Rome as the first book in the Studies in Art History Series.

In humanities and social sciences (Barbara H. Ankeny, editor), the MIT Press Current Studies in Linguistics Series, edited by S. Jay Keyser, has been revitalized; its seventh volume, *Panini as a Variationist* by Paul Kiparsky, will be published this fall. Professor Keyser is also the editor of the most recent volume in the Linguistic Inquiry Monographs, *Recent Transformational Studies in European Languages*. Two important linguistic texts were published this year, *Principles and Methods for Historical Linguistics* by Robert J. Jeffers and Ilse Lehiste, for advanced level and graduate students, and *Linguistics: An Introduction to Language and Communication*, an introductory text by Adrian Akmajian, Richard A. Demers, and Robert M. Harnish. Upcoming for the fall is *Dyslexia: Theory and Research* by Frank R. Vellutino.

The focus of the Press's political science list continues to be its American Politics and Public Policy series edited by Martha Wagner Weinberg and Benjamin Page. Two new volumes in the series were published this year: *American Politics and Public Policy* edited by Professors Burnham and Weinberg and *Reforming Special Education* by Richard A. Weatherley. The sixth book in the series, *Regulatory Bureaucracy: The Federal Trade Commission and Antitrust Policy* by Robert A. Katzman, is on the fall list.

The Press published several major works in philosophy of science: a revised edition of the classic *Remarks on the Foundations of Mathematics* by Ludwig Wittgenstein, *The Critical Theory of Jurgen Habermas* by Thomas McCarthy, and *The Visionary Eye* by J. Bronowski, a companion volume to the earlier *A Sense of the Future*, now in its eighth printing. On the fall philosophy list is *Comrade and Lover: Rosa Luxemburg's Letters to Leo Jogiches*, edited and translated by Elzbieta Chodakowska-Ettinger.

In the Press's list in visual communication (Muriel Cooper, special projects), the Exhibition Catalogues in Art and Architecture series has been launched and includes the work of Gyorgy Kepes, Richard Smith, and Cyril Stanley Smith. The MIT Press has undertaken an exciting long-term project -- a full-scale illustrated documentary history of *The Arts at Black Mountain College 1933-1956* by Mary Emma Harris. The result of ten years' research, this unparalleled collection of visual, textual, and oral source materials promises to be as valuable a publication and resource as the MIT Press's award-winning *Bauhaus* and the forthcoming *Bauhaus in America*.

In the Press's newest list, business and economics (Rene Olivieri, editor) the series again serves as a focal point for list development. The M.I.T.-Harvard Joint Center for Urban Studies series has been revitalized with four new books this year: *The Environmental Protection Hustle* by Bernard Frieden, *The Prospective City* edited by Arthur P. Solomon, *The Urban Transportation System: Politics and Policy Innovation* by Professors Altshuler et al. (published jointly with the MIT Press Series in Transportation Studies), and *Seasonal Cycles in the Housing Market* by Kenneth T. Rosen.

Two new series have been launched with interdisciplinary public policy interests: *Regulation of Economic Activity* edited by Richard Schmalensee and *Health and Public Policy* edited by Jeffrey E. Harris. The Press has begun an informal series of works of prominent economists, opening with a four-volume collection of the scientific papers of Paul A. Samuelson, completed last fall. A similar collection of the papers of Franco Modigliani will be published.

Other areas of publishing interest are international economics, finance and accounting, labor studies, and economic history. The list also will include advanced-level textbooks such as *The Pure Theory of International Trade* by Jagdish Bhagwati and T. N. Srinivasan, which will be published in 1981.

BOOK PRODUCTION

Members of the Editorial Department, under the direction of Helen Osborne, continue to edit and put into book form many thousands of pages of text covering an unusually broad range of subjects. They make a major contribution to the high quality of our list. Ms. Osborne mentions as outstanding projects for this year the Edgerton/Killian *Moments of Vision*, David Epstein's *Beyond Orpheus*, and *The Computer Age*, edited by Michael Dertouzos and Joel Moses, which is on the fall 1979 list.

The Production Department, under Dick Woelflein, contracted \$1,484,445 in composition, printing, and manufacturing work with outside suppliers this year. A total of 140 books were reprinted, including *The Image of the City* by Kevin Lynch, now in its fifteenth printing.

In addition to designing books for the 1979 list, the MIT Press Design Department, managed by Sylvia Steiner, provided design services for the Journals and Promotion departments. The MIT Press received design awards from the Association of American University Presses for *Structure in Nature is a Strategy for Design* by Peter Pearce, *The Federal Presence* by Lois Craig, and two journals, *Cell* and *Oppositions*. *Structure in Nature* and *Alvar Aalto/Sketches* edited by Goran Schildt and translated by Stuart Wrede also received awards from the Boston Art Director's Club Design 25. The New England Bookshow presented design honors to *Structure in Nature* and to *Coptic Art and Archaeology* by Alexander Badawy. Nine book jackets and covers received design awards from various design shows.

The Press's book production departments have a challenge before them in the coming year with the integration of Computergraphics, the Press's new in-house computer composition system. A new book production protocol is being developed to ease the transition as well as an array of standard design formats to ensure the attractive but timely publication of MIT Press books. Office space has been renovated to house the facility, and the Penta system has been selected over the comparable Atex because of the greater versatility of its mathematics program and character sets and its tabular and page make-up capabilities. Mildene Bradley, Manager of Computergraphics, expects contract negotiations to be completed shortly, with installation set for early in the new year.

BOOK MARKETING AND DISTRIBUTION

Under the direction of Thomas McCorkle, Marketing Manager, 427,353 copies of MIT Press books were sold this year. Among our best-selling new hardcover titles were *The Visionary Eye* by J. Bronowski, *The Environmental Protection Hustle* by Bernard Frieden, *The Architecture of Frank Lloyd Wright*, second edition, by William Allin Storrer, *Good News, Bad News* by Edwin Diamond, and *Science, Sin, and Scholarship: The Politics of Reverend Moon and the Unification Church* edited by Irving L. Horowitz. Leading paperback sales were reprints of three highly successful hardcovers: *Bauhaus* by Hans Maria Wingler, *The Visionary Eye* by J. Bronowski, and *The Psychology of Reading* by Eleanor J. Gibson and Harry Levin.

Table D

<u>Customer Type</u>	<u>FY79</u>	<u>FY78</u>	<u>FY77</u>	<u>FY76</u>
Government	\$ 29,000*	32,000	25,000	28,000
College Bookstore	563,000	581,000	467,000	479,000
Retail Bookstore	671,000	671,000	482,000	542,000
Wholesale and Jobber	668,000	600,000	369,000	380,000
Public Library	7,000*	18,000	18,000	27,000
College & University Library	110,000	169,000	162,000	158,000
Business	-- *	81,000	61,000	53,000
Institute	-- *	8,000	6,000	9,000
Direct Mail	222,000	390,000	370,000	195,000
Other	<u>256,000*</u>	<u>76,000</u>	<u>42,000</u>	<u>34,000</u>
TOTAL	\$2,532,000	2,626,000	2,002,000	1,905,000

* Totals are not comparable to FY78 totals because of reclassification involved in changeover to new computer system.

International sales surpassed the \$1 million mark for the first time, with the greatest growth in Asia and South America. The MIT Press became a founding member of Unilibros, a university press consortium, and the first year's result was a 50 percent increase in sales to Latin America. Sales to Japan are currently being made on a limited direct basis rather than through an agency. The Press is considering cooperative marketing arrangements for East Asia and possibly Canada. On Mr. Urbanowski's tour to the major cities and universities of the People's Republic of China, he met with the China National Publications Import Corporation and the China Publications Administration Bureau, the agencies responsible for importation and publication of books in the People's Republic. Although the People's Republic has yet to recognize the International Copyright Convention, Mr. Urbanowski believes the prospects for significant sales to China in the next few years are very good.

Table E

	<u>FY79</u>	<u>FY78</u>	<u>FY77</u>
Australasia	\$ 40,000	40,000	25,000
Canada	117,000	105,000	85,000
East Asia, Latin America	341,000	292,000	158,000
UK, Europe, Africa, Middle East	<u>550,000</u>	<u>430,000</u>	<u>370,000</u>
TOTAL	\$1,048,100	867,000	638,000

Twenty-four sales of translation rights to MIT Press books were concluded this year for a total income of \$29,000, including Bahasa Malaysian rights to Noam Chomsky's *Aspects of the Theory of Syntax* and Serbo-Croatian rights to *A Sense of the Future* by J. Bronowski and *The Character of Physical Law* by Richard Feynman.

Thirteen MIT Press books were selected by bookclubs this year for a total income of \$13,200. The major selections were by the Psychology Today Book Club, which offered Stephan Chorover's *From Genesis to Genocide: The Meaning of Human Nature and the Power of Behavior Control* as an alternate selection; the Library of Urban Affairs chose *The Conservation of European Cities* by Donald Appleyard as one-half of a dual main selection to be offered to club members in the fall of 1979.

Table F

	<u>FY79</u>	<u>FY78</u>	<u>FY77</u>
Translation rights	\$29,000	30,000	20,000
Bookclub rights	13,200	12,100	14,400
Permissions and serial rights	<u>18,300*</u>	<u>5,500</u>	<u>3,100</u>
TOTAL	\$60,500	47,600	37,500

* Includes \$10,000 for sale of paperback rights.

MIT Press books were promoted during the year through direct mail, space advertising, and publicity activities. Under the direction of Brooke Stevens, Promotion Manager, 400,000 promotion pieces were mailed directly to individual and institutional customers. These included new book and text brochures, seasonal announcement catalogues, a librarian's newsletter, and a special sale catalogue. Over 100 space ads were placed, some in the general reader's media such as *The New York Times*, *The New York Review of Books*, *The New Republic*, and *Commentary*, and the majority in specialized professional journals such as *American Photographer*, the *Journal of the Society of Architectural Historians*, *IEEE Spectrum*, *American Scientist*, *Technology Review*, and the *Sloan Management Review*. MIT Press books were displayed and promoted at 81 professional meetings during the year, including the meetings of the American Booksellers Association, the Association for the Advancement of Science, the American Mathematical Society, the Linguistic Society of America, the American Political Science Association, the American Society for Neuroscience, the American Collegiate Schools of Architecture, and the New England Booksellers Association. MIT Press authors Lois Craig, Edwin Diamond, Roger Kaufman, and Irving Horowitz were featured speakers at the Boston Globe Book Fair.

Our new joint warehouse/fulfillment center, UNISERV, continues to benefit customer relations and cost effectiveness. During the year, under the direction of Controller Michael Leonard, the Press changed from an outside vendor for order processing, inventory and sales analysis, royalties, and customer files to a new in-house minicomputer-based system, Ultimacc. Fulfillment costs, which have remained steady for several years, now show promise of declining as a percentage of sales.

JOURNALS

The MIT Press Journals operation experienced dramatic growth over the past year. Manager Ann Reinke increased the number of journals from seven to eleven, and the subscription level rose to 20,000. Total receipts in 1978-79 were \$932,000. New journals include three architecture annuals: *Via*, from the University of Pennsylvania Department of Architecture, *Perspecta: Yale Papers in Architecture*, and the *Harvard Architecture Review* as well as the *Milbank Memorial Fund Quarterly/Health and Society*, now entering its 57th year of publication.

Continuing journals are *Linguistic Inquiry*, S. Jay Keyser, editor (quarterly); the *Journal of Interdisciplinary History*, Robert I. Rotberg and Theodore K. Rabb, editors (quarterly); *International Security*, Albert Carnesale and Michael Nacht, editors (quarterly); *Neurosciences Research Program Bulletin*, George Adelman, editor (quarterly); *Oppositions*, Peter Eisenman, Kenneth Frampton, Mario Gandelsonas, Anthony Vidler, and Kurt Forster, editors (quarterly); *October*, Rosalind Krauss and Annette Michelson, editors (quarterly); and *Cell*, Benjamin Lewin, editor (monthly). We plan to expand the journals operation at the rate of one to two journals a year for the next four to five years.

FRANK URBANOWSKI

Undergraduate Research Opportunities Program (UROP)

The Undergraduate Research Opportunities Program (UROP) will begin its eleventh year this coming fall. Ten years ago access by undergraduates to the Institute's research enterprises was significantly broadened by extending to undergraduates of all departmental majors and all ranges of experience an invitation to work in partnership with faculty on projects of mutual interest. After a decade, every academic department and large laboratory has now had an acquaintance with one or more UROP researchers. New faculty, new students and new programs show special eagerness to seek ways to use UROP as a vehicle for developing themselves.

This past year approximately 800 students applied for and received some form of direct research funding support through UROP. These awards were of two categories, materials/equipment/travel expenses incurred during the student's research pursuits, and spartan term-time and summer personal stipends (received through UROP by approximately 10 percent of the student body each year). By a policy of dollar-matching to funds contributed from faculty research grants, UROP increases the amount of financial support available to UROP students well beyond its own budget. In 1978-79, the total of monies awarded to students exceeded \$.75 million, two-thirds of which was contributed through UROP under this policy.

By far the majority of UROP students during term time elect to receive academic credit (approximately 40 percent of participants) or to participate only for the love of it (approximately 40 percent) despite the heavy financial pressures felt by many. Full-time research participation during the summer, however, is possible only with stipend support. The special intensity of summer is often the highlight educationally for the UROP student and the time of most significant research progress. In looking ahead, development of increased summer stipend support will be a priority concern for the UROP office.

Some special funding for student research originates from outside sources and is administered by UROP. For example, Clapp and Poliak awards for excellence in engineering design were awarded to five students. Another five students in as many departments won Eloranta Summer Fellowships to pursue summer research ventures requiring unusual arrangements; one student sought to compose computer music for opera and symphony, another undertook a study of Federal legislation for medical devices. Winning proposals also included a plan for field and wind tunnel studies of wind ripples on sand, development of a torque transducer for automobiles, and building of a three-dimensional display device. Awards for materials costs of UROP projects were made by the M.I.T. chapter of Sigma Xi, supporting student pursuits in mechanical engineering, biology, chemistry, and chemical engineering. Two new special awards for original work were given during an alumni dinner for members of Sigma Xi at which past and present award recipients were honored guests.

New this year were the Undergraduate Awards in Research Related to Mineral Resources, instituted by the M.I.T. Mining and Mineral Resources Research Institute under UROP aegis. Seven students received such grants for the spring term. These grants will be awarded again in the coming academic year, and a grants program for 1980 summer research projects is anticipated. The James McCormack awards supported three students working in areas related to technology and its application to social issues. Six students were supported this year by Uniroyal Foundation grants aimed at encouraging beginners working on their first UROP projects. The Class of 1970 award was granted to a student undertaking a study of student housing. Through the Wellesley-M.I.T. Exchange Program, summer awards were made to an M.I.T. student to undertake work with a Wellesley faculty member and to four Wellesley students who wished to participate in UROP at M.I.T.

Undergraduates are frequently invited to describe their UROP experiences or present their research work before M.I.T. audiences. UROP and departments sponsor symposia as a forum for students to present their work. There were five such events this past year. The highlight of the year grew out of UROP activities at the Alumni Officers Conference in October. Two undergraduates and their respective faculty supervisors made presentations on their UROP

collaborations; one of these concerned development of photovoltaic solar cells, the other, alteration in the curvature of the cornea. *Technology Review* carried an article about the UROP students' presentations, calling it "Dreaming the Possible Dream: UROP Helps It Come True." The success of these presentations led to invitations from alumni clubs to UROP for student researchers to come to the clubs as guest speakers. The Hudson Valley, Phoenix, and Oklahoma City clubs were visited by UROP students in the spring and presentations are planned at two other clubs during the next fall term.

UROP's relationship with M.I.T.'s departments and laboratories depends to a large degree on our faculty coordinators and administrative networks. Each year UROP has a series of informal coordinator meetings to discuss UROP-Institute-departmental policies. Our liaison within M.I.T. must be current and active; thus we keep lines open to and coordinate interests with such offices as the Public Policy Program (a joint venture of the Departments of Urban Studies and Planning, and Political Science), the Student Employment Office, the Engineering Internship Program, the Division of Health Sciences and Technology, Sea Grant, Council for the Arts, Industrial Liaison Program (I.L.P.), and many other offices and programs. To protect student interests, especially in the more vulnerable areas of bioengineering or at off-campus sites, we work closely with the Committee on the Use of Humans as Experimental Subjects, the Patent, Copyright, and Licensing Office, and M.I.T.'s Insurance and Legal Administration Officer. UROP and the Institute as a whole are, thus, strongly interrelated. Changes in departmental academic policies, faculty research programs, and Institute financial procedures could profoundly affect UROP's capability to effectively serve the aspirations of its undergraduate constituency and the needs of the faculty and the institution as a whole. Thus it is vital for the UROP staff to maintain the strong, mutually respectful relationships of our office with others across the Institute.

As we enter into a second decade of UROP, we must be mindful of the continuing importance of these relationships.

MARGARET MACVICAR

Vice President, Administration and Personnel

The reports which follow will review the highlights of the year in the administrative offices for which I am accountable. They report a year of achievement -- and some disappointments -- but by a substantial balance the year was a good one. The Admissions Office reached a new peak of applications and brought in a good class, including a record number of black freshmen -- in the first year following the *Bakke* decision. The Student Financial Aid Office continued to make an effective case for the financial need of our students, as evidenced by an increased allocation of Federal support. The lack of success in persuading graduate students to provide the data on their resources, the principal underpinning of an effective claim for Federal assistance, was a serious disappointment.

This was a year in which most of our collective bargaining contracts expired, and a new mode of negotiating was undertaken with the chief Institute operating officers in the area served by the majority of the members of a particular union leading the negotiating team. The Institute Manager of Industrial Relations coordinated the bargaining across the board and led the negotiations with Research Development and Technical Employees Unions. The negotiations resulted in three-year contracts expiring June 30, 1981, and calling for a seven percent wage increase in each of the three years.

The Benefits Office was faced with an array of issues caused by passage of the Age Discrimination in Employment Act (ADEA). The essential feature of ADEA was to prohibit involuntary retirement because of age before age 70. Tenured faculty were exempted by the Act from that provision until June 1, 1982. The Institute decided, however, not to take advantage of that exemption, being unwilling to treat tenured faculty differently from all others employed at M.I.T. Thus, effectively, ADEA raised M.I.T.'s mandatory retirement age to 70. For pension purposes, the Act permits a "normal retirement age" lower than 70 and the Institute has chosen to consider the "normal retirement age" as 65. There have been many problems of adjustment, some awaiting clarifying Federal regulations, such as the legality of reducing the life insurance in force between 65 and 70. The passage of ADEA stimulated a broad review of the Institute's staff retirement income and related benefits -- a review still under way by an ad hoc committee. The full implications of changing the retirement age to 70 are yet to be seen.

In this area, it is also noteworthy that during the year a decision was made to move to a unisex basis for determining staff pension annuities, effective for those retiring July 1, 1979. Unlike most universities which fund their staff pensions through the Teachers Insurance and Annuity Association, M.I.T. has its own qualified pension plan and, therefore, the freedom to take its own initiative to eliminate bias in the pension area.

Salary administration was in one sense more difficult and in another simpler this year. Inflationary pressures provided a strong upward push on salaries, which became more severe as the year progressed. Nevertheless, the Institute, as a major Federal contractor, was required to certify to its compliance with the Federal pay standards of not exceeding seven percent increases over the course of the year. Price guidelines were more ambiguous when applied to universities in a deficit position in which the principal price is tuition. Despite the evidence that many universities did not feel limited by the guidelines, the Institute sought to act with restraint in its tuition increase for 1979-80.

The year saw the completion of the study by the Office/Clerical Working Group on the "biweekly" grade structure. The recommendations were adopted by the Academic Council, effective in mid-July. They called for use of better defined position standards, to result gradually in a greater differentiation of levels of skill and responsibility. The structure recognizes three levels of secretarial work, for example, Secretary, Senior Secretary, and Administrative Secretary. An optional generic title, Staff Assistant, is authorized for use in lieu of Secretary at all levels. The Working Group also recommended use of the term Support Staff in lieu of Biweekly and Service Staff in lieu of Hourly.

Two important steps were taken in clarifying and communicating the Institute's personnel and other administrative policies. A new *Personnel Policy Manual* was published, representing many hours of hard work in raising questions and formulating policy answers which are now available for supervisor and employee use. A new edition of *Policies and Procedures*, a guide for faculty and staff members, was being readied at this writing for September publication.

The year's focus on affirmative action began with an assessment of the US Supreme Court's decision in the *Bakke* case. The pattern of M.I.T. admissions seemed consistent in its essentials with the judicially permissible admissions procedures set forth in the Court's majority opinion. Similarly, the decision in the *Weber* case on affirmative action in employment appeared to impose no constraint on the Institute's existing affirmative action program. However, the year saw a growing conviction that new measures were required if M.I.T. is to make further progress, especially in the recruitment of black faculty and staff. During the spring the Equal Opportunity Committee was reconstituted with new membership and a focus especially on increasing the numbers of black faculty.

One issue tangentially related to affirmative action arose during the year. The Department of Labor issued a complaint against the University of California at Berkeley seeking to compel the University to provide copies of confidential faculty evaluations as part of an affirmative action compliance review. As a result, the Institute feared that government custody of confidential evaluations would put them within reach of a Freedom of Information Act inquiry and in time chill the candor with which such evaluations are made. Through its attorneys, the Institute filed an amicus brief with the administrative law judge hearing the complaint. The recommended decision bars the provision of confidential evaluations, and if accepted by the Secretary of Labor, will go forth to allay our concerns.

In addition to the substantial substantive issues noted here and in the reports of the department heads, there were significant staff changes.

Cheryl R. Prejean spent a year at the Institute, on loan from the Department of Labor, as our Equal Opportunity Advisor, during the absence of Patricia A. Garrison. We profited greatly from Ms. Prejean's experience and insight; Ms. Garrison returned in June from her year's leave of absence as a Sloan Fellow to become Director of Personnel Services, replacing Claudia B. Liebesny, who took a leave of absence to study in the Sloan School for a year also as a Sloan Fellow.

With the retirement on June 30, 1978 of Robert J. Davis, Director of Personnel Relations, a decision was made to alter the personnel organization with Kerry B. Wilson as Wage and Salary Administrator, Richard P. Marvel as Benefits Officer, and James J. Fandel as Manager of Industrial Relations. These individuals will report directly, along with other personnel functions, to James J. Culliton, who was designated Director of Personnel in addition to his responsibilities as Assistant to the Vice President for Administration and Personnel. These were significant changes in providing more direct leadership and better coordination of personnel administration for the Institute.

As with other recent years, the year just past was one of continued pressure on administrative budgets. Department heads are squeezed between rising expectations for services and demands for creative administration on the one hand and constrained budgets on the other. To them, and to those in the administration who work under their leadership, I must express my admiration and appreciation for their skill and dedication in the conduct of the Institute's business.

JOHN M. WYNNE

Affirmative Action Program

During the past year M.I.T. was fortunate to have the services of Cheryl R. Prejean, a senior compliance officer from the Department of Labor's Office of Federal Contract Compliance Programs. On loan to M.I.T. as an Equal Opportunity Advisor, Ms. Prejean has enhanced our efforts to analyze equal employment opportunity (EEO) and affirmative action (AA) compliance activities at the Institute. We have appreciated Ms. Prejean's advice and assistance to the Institute in meeting its affirmative action goals and objectives.

While our efforts during the past year have included numerous activities, this report will emphasize two: 1) progress of the Institute Program for the Handicapped, and 2) reorganization of the EEO Committee.

A major focus on M.I.T.'s compliance with provisions of sections 503 and 504 of the Rehabilitation Act of 1973 led to extensive review and, where appropriate, updating of the Institute's Program for the Handicapped, originally formulated in June 1977. Using survey data submitted to the EEO Officer in May 1978, we completed the formulation of a self-evaluation plan for the handicapped. With this plan now in place, we hope to continue taking all appropriate steps to implement program-accessibility objectives for handicapped members of the M.I.T. community.

Another focus of EEO/AA activity has been on the reorganization of the Institute Equal Opportunity Committee. With a new chairman, Professor Michael Feld, and streamlined membership, the Committee hopes to increase the efficiency and effectiveness of its operation. The Committee will be aggressive in seeking answers to the shortfall during the past year in EEO/AA goal attainment for blacks and other minorities at M.I.T. While current employment statistics show that our efforts at improving the presence of faculty and staff women at M.I.T. have shown moderate success during the past years, the data also show that we have made no substantial improvement in the employment and retention of black Americans in most employment categories.

The following summary of employment statistics from the most recent data available illustrate this problem: As of April 1979, women comprised 36 percent (182) of the administrative staff, meeting the goal for that category. On the academic and research staff, women comprise 26 percent (226), surpassing the goal of 19 percent (108). Goals also were achieved in the exempt category, at 44 percent (154), and in the service staff category, 14 percent (153). The Institute fell short of its employment goals for women in only two categories, faculty (8 percent representation, with a goal of 10 percent) and other academic (24 percent representation, with a goal of 28 percent).

Even though our goals for black employment for the past year were modest, we did not achieve anticipated representation. As of April 1979, blacks comprised 2 percent (16) of the faculty and 2 percent (23) of other academic staff. Both categories have a goal of 3% (23). Blacks comprise 4 percent (21) of administrative staff, with a goal of 6 percent (29) and 2 percent (14) of sponsored research staff, with a goal of 5 percent (30). The data are similarly gloomy for other categories, that, black exempt and support staff representation is 6 percent, while service staff representation is 14 percent. Again, goals were not achieved.

The Director of Personnel Services is currently holding a series of meetings with the Personnel staff in an effort to develop creative methods to attract qualified black candidates and to retain blacks once they have joined the M.I.T. community.

We hope that the coming year will see major new efforts throughout the Institute to renew commitment to Affirmative Action and to show substantial gains in the employment and retention of blacks and other minorities. We will be looking for innovative ways to assist departments, laboratories, and centers in achieving their EEO/AA objectives.

ISAAC M. COLBERT

Office of Admissions

Despite our concern about impending population shifts, the number of quality undergraduate applicants has continued to increase. M.I.T. attracts some of the finest students from all over the world. All but three states, Nevada, Montana, and Idaho, will be represented in the 1979 entering class, which will include citizens from 26 countries. This year our yield of undergraduates is higher than at any time since the mid-60s. The entering class will be full to overflowing again in September. The demand for engineers by industry appears to be an important element in this situation, but other quality private universities are seeing a similarly strong demand.

The number of minority students in the class also has increased by about 15 percent, but our efforts to attract women have been less satisfactory. Despite extensive efforts on the part of the staff as well as women students and alumnae, the number of women who will enter has not increased. While we have increased preliminary applications from women, we have not been able to increase the number of final applications. This must be a high priority objective in the coming year if we are to be able to increase the number of women who enroll. A special pilot program in Michigan may provide new insight into our efforts to attract the interest of young women in junior high school.

The efforts of the M.I.T. Educational Council cannot be overestimated. As the number of women appointed to the Council climbs, their interest will make a positive contribution to that effort. There are now 1,250 counselors who reported on 4,800 interviews for the class of 1983. The Admissions Office is also indebted to the large number of faculty and staff who helped with the selection process by reading over 4,300 folders. Their contribution helps significantly in identifying the type of student who enters M.I.T. The preparation of the class can be measured by the fact that over 50% will enter with some form of advanced placement.

Graduate applications displayed patterns similar to previous years with the programs in Electrical Engineering and Management receiving the largest volume. The percentage of applicants offered admission varies widely from 15 to 70 with Psychology and Economics having the most applicants per opening. The percentage of those offered admission who enroll (yield) also varies widely from 30 to 80 with Nutrition and Food Science and Psychology attracting the most of those offered admission. A difference in available funding of graduate students also exists. To date little analysis has been done on how the demand for our graduate departments will develop in the coming decade but of one thing we can be certain, that the departments will be faced with widely varying situations.

Admissions Trends 1974-1979

	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>
<u>Entrants from Secondary Schools</u>						
Preliminary Applications	7,651	8,166	8,104	7,853	9,320	10,274
Final Applications	4,584	4,726	5,194	4,838	4,870	5,368
Admissions offered	1,936	2,106	2,277	1,939	1,865	1,813
Actual Registrations	1,036	1,154	1,044	1,073	1,059	1,059
Registrations as percent of admissions	53.5%	54.7%	47 %	55.3%	56.7%	58.4%
Number of secondary schools represented	808	918	866	859	877	893
Percent of students from 9 north-eastern states	52 %	50.8%	48 %	52 %	50.6%	49 %
<u>College Transfers</u>						
Total applications	791	879	941	1,079	1,074	1,143
Applications completed	338	499	536	591	535	486
Admissions offered	166	200	203	175	172	152
Actual registrations	123	155	162	141	123	124
Registrations as percent of admissions	74 %	77.5%	80 %	81 %	72 %	82 %
<u>Graduate Students</u>						
Total applications	6,213	6,447	7,511	7,740	7,454	7,849
Admissions offered	2,060	2,119	2,676	2,644	2,724	2,636
Actual registrations	1,058	1,015	1,441	1,369	1,461	1,362
Registrations as percent of admissions	51 %	48 %	54 %	52 %	54 %	52 %

OFFICE OF THE ADVISOR TO FOREIGN STUDENTS

The task of the Advisor to Foreign Students was affected by two international events this year. The realities of the revolution in Iran were keenly felt by many residents of that country engaged in studies at M.I.T. Funds for maintenance and tuition were withheld for much of the academic year by various sponsors in that country. Extraordinary efforts by M.I.T. and others were necessary to fill the gap. Moreover, the change of governments in Iran initiated a series of disturbances in this country among some Iranian students resulting in demands for tighter control of visiting students from the general public and the US government. Intense negotiations involving foreign student advisors, the National Association of Foreign Student Advisors (NAFSA) and the Immigration and Naturalization Service produced a tempered response.

Secondly, the failure on the part of the government of Nigeria to provide prompt dollar exchange for its citizens on study assignments in this country created serious financial difficulties for many institutions across this country and for the students involved. While the Nigerian Embassy has responded to producing, it may in the future be necessary to require prepayment in full from Nigerian citizens. Some universities already have.

Almost one-third of M.I.T. graduate students are citizens of countries other than the United States. The decision to increase the support services for graduate students in the Dean for Student Affairs Office has led to a plan to move the foreign student advising functions to the Dean's Office. The ever-present foreign students, their tireless advisor, Eugene R. Chamberlain, and his support group will be missed. Their leaving ends a close association of over 30 years that has enriched our experience.

PETER H. RICHARDSON

Office of Student Financial Aid

The Financial Aid year was again characterized by increases in the overall need for financial aid, and in the aggregate amount of grants made available to meet the need. The student payroll was increased, although the percentage of financially needy students working seemed to decline. The planned shift away from Technology Loan Fund assistance, in favor of student loans available from commercial sources, resulted in a significant decline in M.I.T. loans made to both undergraduates and graduate students.

Grant Program

There were a few developments of significance in the spectrum of scholarship and grant sources. Continued expansion of the Federal Basic Opportunity Grant Program yielded \$50,000 in additional grants. The Supplemental Opportunity Grants Program provided \$730,000 -- slightly less than in fiscal 1978. These programs directly displace M.I.T.'s own unrestricted funds used for undergraduate grants, and so serve to check the rate of increase in the demand for them. That category of funding moved upward from \$1,201,000 in fiscal 1978 to \$1,385,000 this past year.

Less effect was produced by additions to the scholarship and grant endowment during the year, as the result of the Leadership Campaign. Additions to principal totaled about \$500,000, an increment lower by \$200,000 than last year's.

A new "Matching Grant Program" inaugurated by the Commonwealth of Massachusetts provides grant dollars to needy Massachusetts natives enrolled in universities within the state. A total of \$55,665 was distributed for this purpose during the past year.

M.I.T. students continue to enjoy an increasing incidence of awards made directly by outside agencies. Aside from the Federal Basic Grants and the steadily-increasing R.O.T.C. programs, this component of the total financial aid program not only keeps pace with rising tuition, but seems to encompass a greater proportion of the student body each year. In fiscal 1979, 1,460 students received some kind of help from one or more of these agencies -- this is well over half of the total needy population.

Technology Loan Fund (T.L.F.)

The past year was the first in which the recommendations of the Loan Task Force were fully implemented. The essence of one of these provisions is to require a co-maker for all M.I.T. loans that are not otherwise guaranteed (as are those made under the Federal government's National Direct and Guaranteed Student Loan Programs). A second provision requires loan applicants to attempt to tap commercial sources of guaranteed loan before M.I.T. makes this type of loan from its T.L.F. The combined result has been a dramatic reduction in loan demand from the T.L.F., from \$2,314,000 in fiscal 1978 to \$1,133,000 this past year. A corollary increase in guaranteed loans from sources outside M.I.T. was observed -- from some \$2,000,000 to \$3,360,000.

Student Employment

Fiscal year 1979 was another growing year in the student employment area. During the year some 4,350 students were paid through the Student Hourly Payroll System (almost identical to fiscal 78's 4,347 students). Graduate and undergraduate students combined to earn more than \$6,054,505 through the payroll system, an increase of about \$714,392 (13.4 percent) over the previous year. Needy students constituted about one-third of the total number of students working, and earned a total of about \$1,686,223 through the College Work-Study Program.

Fiscal 1979 also saw the base minimum wage rate on campus increase from \$2.85 per hour to \$3.05 per hour. This growth has allowed students to earn more without taking more time away from their academic pursuits.

To say the least, on-campus and off-campus demand for student work is growing at a significant rate, particularly for the type of skilled student found at M.I.T.

College Work-Study Program (CWSP)

Our continuing effort to expand the use of this program in the Graduate School fell far short of our goals; indeed effective usage declined this year relative to last. As this is written, there is a real possibility that for the first time we shall be unable to spend the entire allocation, \$1,794,000, this year.

The principal reason was that, whereas in fiscal 1978 more than 80 percent of all graduate students probably eligible to be paid under this program completed the necessary forms to ascertain eligibility, in fiscal 1979 the percentage dropped to below 50. Thus, a good many graduate teaching assistants to whom CWSP funds could have been disbursed were not paid under that program for want of this documentation, solicited by the S.F.A.O. and the graduate departments on a voluntary basis. During the coming year, the S.F.A.O. will continue to search for imaginative ways to utilize this important grant program, including ways to secure greater cooperation by needy students who could be involved in the program. In fiscal 1981 we foresee the probability that the necessary documentation will become a requirement of our graduate students as an integral part of their yearly registration process.

Data Processing

An entirely revised data processing system for financial aid was implemented in February 1979. Based in the Registrar's student data file, the system features direct visual access to financial aid data by means of cathode-ray terminals located in the Student Financial Aid Office. Award actions are input to the system daily rather than biweekly. These features are expected to improve the effective delivery of financial aid services to students.

The integration of data describing graduate student awards -- fellowships and assistantships, as well as loans -- already inaugurated in the prior data processing configuration, will continue in the new system. When complete, this system will provide the S.F.A.O. for the first time with an accurate and comprehensive view of financial aid to graduate students. In addition, information on students' actual earnings is being incorporated for the first time into the S.F.A.O. data base, minimizing the need for several elaborate interface programs with the payroll system.

Staff Notes

Soon after the start of the fiscal year, Stanley Hudson (B.A., Springfield College; M.A., Columbia University; M.B.A., University of Chicago) joined the S.F.A.O. staff as an associate director. Then in November 1978, Frederick L. Massie (A.M. and A.B., Brown University) also joined the staff in the capacity of an associate director.

During the year, J. Samuel Jones, associate director, served as the president of the Massachusetts Association of Student Financial Aid Administrators. Under his leadership, the Association sponsored and worked for important legislation proposing a new state student assistance agency.

JACK H. FRAILEY

Career Planning and Placement Office

One measure of a year's activity in the Office is the number of interviews taken by students with visiting employers. Four times since World War II the number of interviews has topped 8,000. The past year was one of them, with an interview count of 8,527. The size of next year's senior class in engineering suggests that 1979-80 will be even busier, but so far no greater-than-8,000 year has been followed by another. The four peak years since the war do not conform to a pattern. In 1956-57 the high tide of interviews coincided with Sputnik. Research and development spending sharply increased while industrial production was at one of its cyclical highs. In 1960-61, President John Kennedy's first year in the White House, the reasons for the surge in interviews are less obvious; the economy was in a mild recession and research and development spending, while still growing, had slowed. In 1963-64, Lyndon Johnson's first year as President, both the growth of the economy and R&D spending were accelerating. Last year, 1978-79, was different again. R&D spending was once more on the rise after several years of negligible, if not negative, growth, and business in many areas of the economy was brisk, yet there was talk all year of impending recession.

Peaks in student interviewing have not always coincided with peaks in recruiting activity. This year, however, they did. A total of 430 separate organizations made recruiting visits to the Office (388 companies, 21 government agencies, 7 other employers, and 14 graduate schools). This compares with a total of 349 in 1977-78. There have been four previous peaks in recruiting activity since World War II when the number of organizations coming through the Office reached or exceeded 400: in 1951-52, in the three-year period 1955-58, in 1961-62, and again in the three-year period 1965-68.

Last year's scramble by employers gave a push to industrial starting salaries. In many disciplines the rising cost of living nullified the gain, but in electrical engineering, at all degree levels, starting salaries outstripped inflation. The median offer to bachelors in electrical engineering (Course VI-1) was \$19,380 and to the bachelors in computer science (VI-3) \$18,900. The median offer to masters was \$21,300 and to doctors \$28,880. High as these salaries may seem, however, they do not match in constant dollars the starting salaries of 10 years ago when offers reached an all-time high. Measured in 1960 dollars, bachelors' salaries are still some \$30 a month lower, masters' salaries are \$70 lower (equal to where they were in 1962-63), and doctors' salaries -- \$180 a month below their peak -- are roughly where they were in 1960.

Students visited the Office in large numbers to talk over their plans with the staff. They included students at all levels, from prospective students coming with their parents to explore the marketability of an M.I.T. degree to postdoctorals anxious about the chances of reaching a tenured position on the academic career ladder. Our resources for counseling students were greatly enhanced by the appointment of Jane E. Wells as assistant director, with particular responsibility for assisting students in architecture, urban studies, the social sciences, and the humanities. Some 800 students made counseling appointments with her or with the director. Others attended group meetings on such topics as the interview process, the merits of a master's in management, and the preparation of an architectural portfolio. Prompted by the students themselves, the Office cooperated with the Office of Freshman Advising, the Alumni Center, and the Undergraduate Association in organizing a Saturday symposium for the freshman class on careers and Course selection. Held on March 10, it attracted 175 students. This was a year when students seemed particularly mindful of career issues.

The high demand for technically trained graduates showed itself in the area of Alumni Career Services. Demand was particularly strong for electrical, mechanical, and chemical engineers, as well as for graduates in computer science. Many employers felt the need to come to the Office in person to announce their requirements. The increase in employer activity was matched by a drop in the number of alumni requesting placement assistance. Favorable as the market was for job seekers, however, 40 percent of registrants still took six months or more to find satisfactory employment.

Office of Child Care

Compared with 1977-78, this year's registrants were generally older, held higher degrees, and were at higher salary levels. Fifty-seven percent were over 40 and forty-one percent earned over \$30,000. Less were in manufacturing, and more in service organizations (consulting, government, teaching, etc.). A number were engaged in significant career changes, among them faculty members leaving academia and officers retiring from the military.

Members of the M.I.T. community (faculty, staff, and support staff) have been coming to the Office in increasing numbers. They are chiefly interested, as are many of the alumni, in general career exploration rather than the more immediate task of finding a job.

The year's work could not have been accomplished without the help of a devoted staff. They combine admirable efficiency with a rare responsiveness to the needs of student, alumnus, and employer. A debt is owed to them.

ROBERT K. WEATHERALL

Office of Child Care

The Child Care Office has continued to provide assistance to M.I.T. families in their search for services for their young children. An increasing number of requests came from prospective employees of the Institute. More and more people are making inquiries well in advance of actual need. This is particularly true of women having children, who don't want to seriously disrupt their careers.

A total of 276 children were placed in M.I.T.-related programs this year, an increase of 36% over last year. An additional 200 children were referred to other programs. The range of requests has broadened as well, with a substantial interest in summer camp programs.

Family Day Care

F.D.C., a home-based program designed primarily for infants and toddlers under 33 months old, accommodated 132 children, an increase of 61 percent over last year. Almost half of these children were under 12 months old. This has been the case for the last two years and we expect it will continue to be true for the next several years.

The Family Day Care Program was the source of income for 45 providers, 43 of whom were graduate student wives. Although such records are not kept, we do know that incomes ranged from a low of \$300 to a high of \$14,000, an important means of support for a group whose traditional sources have become less available.

Technology Children's Center, Inc.

T.C.C., a private, nonprofit corporation which provides pre-school programs on campus, reported capacity enrollment in all programs throughout the year. A total of 139 children were enrolled in three programs: 37 in the full-day program, 90 in the part-day program, and 12 in the full-day kindergarten.

The kindergarten program opened this past September with full enrollment. During second semester, several new children were added. It is unusual for a child care program to be fully enrolled on its first day of operation. It is a reflection on T.C.C.'s ability and willingness to respond to the needs of the community as those needs are expressed, that such was the case.

Also worthy of note is a change in the operating philosophy of the nursery school, which provides morning programs during the academic year and for six weeks during the summer. As of this year, parent participation in the classroom has been eliminated as a requirement. This means

that the nursery school will now be truly accessible to part-time employees. It is anticipated that the nursery school, at least at Eastgate, will extend its day until mid-afternoon, thereby increasing the number of potential users.

MARGARET SAND

Personnel Office

To achieve better coordination in the formulation and administration of personnel policy, the personnel organization was restructured to the end that all major sections of personnel, including benefits, labor relations, personnel development, personnel services, and wage and salary administration, now report to the Vice President, Administration and Personnel through a newly designated Director of Personnel.

A number of other changes in staffing also occurred during the year. Patricia A. Garrison, who had been on leave for a year as a Sloan Fellow, returned to the Institute as Director of Personnel Services; Claudia B. Liebesny left that post on a leave of absence to enter the Sloan Fellows Program this year. Lewis A. Redding left the Office of Personnel Services to attend graduate school at Cornell University, and Lawrence E. Milan was appointed in his place. Susan Warshauer and Vera J. Ballard were appointed in the Office of Personnel Development, while Isaac M. Colbert left that office to assume the position of M.I.T.'s Assistant Equal Opportunity Officer.

In the reports which follow, the several components which comprise the Personnel Office demonstrate their commitment to effective delivery of a wide range of services to the Institute community to provide present and prospective employees a better place to work.

JAMES J. CULLITON

BENEFITS ADMINISTRATION

More effective employee communications was the major goal of the year for the Benefits Office and was implemented through several projects: 1) printing and distribution of retirement plan booklets and summary annual reports, as well as the revision and distribution of information pertaining to other benefits; 2) revamping the format and content of the pre-retirement seminars; 3) initiation of an audiovisual program designed for departmental use, encompassing the major benefits programs, which is close to completion and will be available for use in the fall; and 4) the offering of tax deferred annuity seminars to members of the community on a regular basis.

With the passage of the Age Discrimination in Employment Act, the Benefits Office closely monitored developments relating to this important legislation. Existing benefit programs and policies were reviewed to ensure compliance under the Act, and recommendations were communicated as necessary.

Members of the Office staff met throughout the year with their counterparts at other colleges and universities and participated in the development of two major surveys to facilitate communication concerning benefits developments.

Last summer the Benefits Office moved to larger quarters on the fourth floor of the Ford building (E19). This move permits increased privacy for personal counseling and enabled the Office to assume and centralize the responsibilities for ERISA administration and compliance matters.

RICHARD P. MARVEL

LABOR RELATIONS

With the retirement of Robert J. Davis, the Institute's chief negotiator for the past 23 years, a new approach to collective bargaining was used to negotiate labor agreements. The Director of Physical Plant, the Director of Housing and Food Services, and the Personnel Manager for Lincoln Laboratory served as spokespersons for the Institute on negotiations for contracts expiring July 1, 1978. The Manager of Labor Relations served as the coordinator for those negotiations, substituted for the chief spokespersons as needed, and served as liaison with the central administration on negotiation issues.

Negotiations with the seven bargaining units began in May 1978. Contracts for the Service Employees units and the units of the Hotel, Restaurant, Institutional and Bartender's Union were signed in January 1979, and the Research, Development and Technical Employees' Union agreement was signed in February 1979. All agreements were for three years. Negotiations are in progress at the present time for a new agreement with the M.I.T. Campus Police Association. The Manager of Labor Relations will serve as the Institute spokesperson during this negotiation.

JAMES J. FANDEL

OFFICE OF PERSONNEL DEVELOPMENT

The Office of Personnel Development continued to provide services and programs to approximately 1,700 M.I.T. employees during the past year.

Programs and activities of O.P.D. during the past year included the following: The 26th Lincoln Laboratory Management and Supervisory Development Program, in which approximately 650 Laboratory managers, supervisors, and technical staff members have participated, was completed. The 12th Administrative Development Program (A.D.P.) was completed, as was the organizational psychology section of A.D.P. XIII. In collaboration with the Office of Personnel Services, a revised version of the campus Supervisory Development Program was presented. Four sections of the Administrative Procedures Program were presented to more than 110 support and exempt staff. Orientation sessions were coordinated and presented to more than 400 support staff members. Technical typing classes were resumed in a new location and taught by Margaret Lech from the Office of the Vice President for Administration and Personnel to approximately 25 employees whose jobs involved the use of that skill. A community-wide Communications Skills Workshop was presented to a group of employees representing most Institute payroll categories. The Tuition Assistance Plan was used by approximately 800 employees, a majority of whom were members of the support staff. And a special Writing Skills Workshop was presented to a departmental work group at their request.

The highly favorable participant evaluation responses to programs show that benefit has been gained by individual employees who have used our services. Benefits to the Institute also have been reported by personnel from various areas of the Institute, and collaboration among the various parts of Personnel and with Lincoln Laboratory represent positive outcomes.

All voluntary programs continue to be oversubscribed, and the Lincoln Laboratory Program, which is mandatory, has been well attended and favorably received. A number of recommendations to offer the Lincoln Program on campus have been made, and several discussions suggest that possibility for next year.

Approximately 350 people have participated in the Administrative Development Program to date. During the past year the A.D.P. II group sponsored four reunion sessions, the last of which was presented by the O.P.D. Follow-up on the O.P.D. reunion session is expected to generate development needs from alumni and possible ideas for new O.P.D.-related programs.

The O.P.D. also has provided secretarial support for the Working Group on Office/Clerical Issues and several staff members have served as resource people to members of task groups. Other

Vice President, Administration and Personnel

activities during the past year have included: a Women's Forum presentation on stress and follow-up assistance in planning a Women's Forum Workshop on this subject; responding to a limited number of requests for individual career-development counseling and providing information about available resources; involvement in an informal job internship committee; as well as continuing to respond to departmental requests for participation in conflict resolution efforts.

MAUREEN M. YAGODKA
F. ADAM YAGODKA

OFFICE OF PERSONNEL SERVICES

A significant achievement by the Office was the completion and distribution this year of the new *M.I.T. Personnel Policy Manual* under the direction of Susan Lester. The new manual provides information on policy for all non-academic personnel on campus and at Lincoln Laboratory. The last two sections of the *Manual* will be distributed in September. The *Manual* was produced with assistance from an advisory group composed of 25 supervisors and employees representing each organizational area on campus, and from an editorial board of Personnel Office staff.

New recruiting approaches directed toward identifying a greater number of qualified office clerical applicants were begun under the leadership of Peggy O'Brien. A new secretarial school poster called "Graduate to M.I.T.," bolder newspaper advertising, Tuesday evening interviewing to facilitate appointments for working applicants, and a new brochure entitled *This is M.I.T.* were among the new efforts. Another significant event for the Office was the approval by the Committee for Space Planning of a proposal to renovate the reception area to represent M.I.T. more effectively to applicants and other visitors. This work is expected to be completed in the late fall.

The Personnel Information Services Group was very busy again this year. Among other projects completed this year were the installation of four new salary review systems, the transfer of records to the office for approximately 200 research professionals, and the installation and training activities associated with the acquisition of new word processing equipment for the department. This equipment has assisted us enormously in the preparation of correspondence to employees and supervisors, and has enabled us to acknowledge the receipt of more than 4,000 resumes this year.

We participated again this year in the Cambridge Employment Opportunity Commission and the Somerville Youth Employment Program summer employment programs. Patricia Williams coordinated the placement of 19 young people in jobs developed by 16 departments. Other Personnel Services activities included participation in the Employee Open House, Supervisory Development Programs and four task groups of the Working Group on Office/Clerical Issues.

Employment Activity

The non-academic employment population on campus, as of March 31, 1979, was 4,500, an increase of approximately eight percent over the past year. There was also an increase of 10 percent in available positions resulting in a busy year in trying to fill these positions. Campus employment activity showed a decrease in numbers of applicants to the Personnel Office from a record 4,000 last year to 3,390 this year. Of the 3,390 persons who applied to our office, 2,970 were interviewed by Personnel Officers; of these, 2,610 were referred to supervisors and 1,011 of those referred were hired. This is a 15 percent increase over the past year's hires of 876. In addition, the Office processed over 3,800 additional resumes which were received, reviewed, and referred to supervisors for available positions in advance of personal interviews.

During this period, 810 Institute employees applied for transfers to other suitable positions at M.I.T. A total of 326 were placed successfully in new positions, an increase over the past year's number of 319. The total number of employees transferred and applicants hired combined for a total of 1,337 placements. This represents a 12 percent increase in total hires over a total of 1,195 reported last year.

Personnel Office

The sources of referral of applicants for employment on campus continued to follow historic trends. Referrals from *Tech Talk*, M.I.T. relatives and friends, former employees, and student referrals accounted for more than half of the candidates applying this year. Responses to advertising efforts produced 13.5 percent of all applicants, and agencies supplied another 5 percent. Interest in working in a university was responsible for another 10 percent of all applicants.

CLAUDIA B. LIEBESNY

WAGE AND SALARY ADMINISTRATION

The modification of the Staff Salary Administration Program that was adopted last year has proved to be most successful. Over 100 positions have been reviewed by the Wage and Salary Office since the new approach was implemented. These reviews included evaluations of newly established positions and promotional recommendations as well as a number of requests to reassess existing positions. In addition to establishing fair and equitable salary ranges, these reviews have added substantially to our already large pool of information concerning position requirements and responsibilities. This information continues to be a valuable resource with respect to individual career planning.

During the spring the Classification Task Group of the Working Group on Office/Clerical Issues completed its three-year study of the Institute's Biweekly classification structure. This study includes the development of position standards which set forth characteristic elements of job content for classifications in the Office/Clerical area. In addition, each standard describes the minimum education and experience level required to perform the functions described. These new standards, as well as other recommendations of the Task Force, were approved by the Academic Council and implemented as of July 15, 1979. It is our hope that these changes represent a significant improvement in clearer and fairer criteria concerning individual jobs. Recommendations also were approved which change the name of this group to "support staff" and permit a wider latitude in titles for each individual.

KERRY B. WILSON

M.I.T. Quarter Century Club

The M.I.T. Quarter Century Club was founded in 1950. In July 1978, the Club was recognized as an Institute administrative department, reporting to the Office of the Vice President, Administration and Personnel.

The activities of the Club can be categorized into three main areas. It provides a service to its members, to the Institute, and to the Alumni of the Institute.

The Club holds three functions per year for its members. In the spring, an annual membership meeting is held. There are usually 100 to 125 new members each year. A social meeting is held in midsummer; and in December, a holiday gathering takes place.

The Club provides a service to the Institute by providing administrative and logistical support to the Institute's annual United Way campaign and to its annual retirement dinner. In the past, it has been asked to organize additional special meetings of an Institute-wide nature.

It also provides a service to the Institute and its alumni by coordinating a number of trips each year. These trips are usually to other parts of the world, for vacation purposes, but the Club also provides assistance on request to other groups with their travel plans, such as the French Section of the Humanities Department for an educational exchange, and the Alumni Association when alumni clubs meet.

Vice President, Administration and Personnel

The staff of the Club consists of Robert J. Radocchia, who in addition to being the Chairman of the Board of Directors serves as Office Manager, and two staff assistants, M. Frances Daly and Ann M. Perkins. The department is headed by John E. Newcomb who also serves as Executive Director of the Club.

The Board of Directors of the Club are: Franklin A. Bidwell, Paul V. Cusick, Joseph Greene, Mary J. Hovnanian, Francis B. Magurn, Lawrence Paglierani, Professor J. Francis Reintjes, and Professor Henry J. Zimmermann.

The Officers of the Club are: Jeri Whitman, president; James J. Fandel, vice president; Daniel H. Gould, treasurer; and M. Frances Daly, secretary.

The membership of the Club now totals more than 1,350 members, each of whom has contributed more than 25 years of service to the Institute.

The Club has seven honorary members. They are: John E. Newcomb, Dr. Howard W. Johnson, Mrs. Karl T. Compton, Mrs. George R. Harrison, Joanne S. Miller, James W. Coleman, and Robert J. Davis.

JOHN E. NEWCOMB

Vice President, Financial Operations

The financial operating results for the year show the Institute to be essentially in balance between income and expenses as it has been in the two previous years. Budget estimates made in May 1979 for fiscal 1980 showed this precarious balance would probably hold for at least another year. However, with inflation continuing at a higher rate than predicted along with recent evidence that our direct cost of energy will increase at an alarming rate, our optimism that we can maintain a financial equilibrium for this period has diminished considerably. Continued budget reductions, efficiencies in operations, a strong fund-raising capability, and the willingness of those who support M.I.T. to maintain and even increase that support are very much the order of the day and will continue so indefinitely.

The Federal Office of Management and Budget issued in February 1979 its revision of the cost principles under which colleges and universities are reimbursed for their sponsored research costs. These revisions had been in process for approximately four years, and earlier proposals made by the Federal government would have had severe financial impact on all colleges and universities, including M.I.T. The M.I.T. figure for the revision proposed approximately one year before the final document was issued, was estimated to be a minimum of \$2.2 million per year. A major effort of the senior officers of M.I.T. together with close coordination with several Washington-based organizations, particularly the American Association of Universities, the Committee on Governmental Relations of the National Association of College and University Business Officers, and the National Council of University Research Administrators along with many other senior administrators of the large graduate research universities, resulted in a final document which is generally acceptable to both the Federal government and the college and university community. In M.I.T.'s case in particular, the possibility of a severe reduction in the reimbursement of indirect costs for sponsored research was eliminated. From all of this activity has come not only a reasonable solution to the cost reimbursement problem but a new spirit of teamwork and cooperation among the colleges and universities and a better understanding on the part of many people in both the executive and congressional branches of the Federal government. While there has undoubtedly been very stormy weather over the past few years in the Federal/university relationship and there will always be clouds of one kind or another, there is sufficient blue sky now that it appears that the pendulum is swinging back to the positive side of the relationship, and momentum is building towards greater support of basic research in the nation's colleges and universities.

Major realignments of organizational responsibilities at M.I.T. during the year were the reporting of the Lincoln Fiscal Office to the Comptroller and the transfer from the Comptroller to the Director of Finance of the Student Accounts Office and the Student Loan Office.

For a more fully detailed report on financial operations, please refer to a companion publication, *Report of the Treasurer* for the Year Ended June 30, 1979. For a broader and more descriptive report of the Federal/university relationship, please refer to the President's own section of this *Report*.

STUART H. COWEN

Audit Division

The traditional role of the Audit Division was affected and expanded during fiscal year 1979 with the completion of a financial and compliance audit of M.I.T.'s Federally funded student financial aid programs, as required by the Department of Health, Education and Welfare. This is the first audit conducted to the specifications of an HEW audit guide with the results of the audit tests and final reports being submitted directly to the Federal government for review and subsequent follow-up.

It is important to note that the HEW regulations which required the audit allowed the use of internal auditors only if a certain degree of independence could be proven. The fact that the M.I.T. Audit Division met this independence test provided a significant cost savings to the Institute.

Departmental reviews were conducted for academic and research units of the Institute. These reviews indicated a significant improvement in the internal control and accounting procedures employed by departmental personnel. This was evidenced in the change in audit recommendation emphasis from basic improvement in financial procedures to the description of sophisticated management techniques to improve budgeting and forecasting. The audit schedule for fiscal year 1980 will continue to emphasize departmental reviews.

Annual functional reviews include inventory validation, cash and checking account controls, and confirmation of receivables and travel advances. In addition to determining a valuation of assets for balance sheet presentation, these reviews concentrated upon the procedures and control features employed by the Comptroller's Accounting Office and/or the responsible department.

The EDP (Electronic Data Processing) Audit Staff has responsibility for the review and evaluation of data processing -- manual and computerized systems. The scope of review includes four major areas: Systems Development, Post-Installation Audit, Application Systems in Operation, and Management Services. In Systems Development, the staff performed an extensive audit for the MIT Press on their new order entry, inventory control, and cash receipts computerized system. The staff is currently reviewing the procurement and accounts payable departments providing a management review study which will be available for a procurement/payables management system. In post-installation audit, the EDP audit staff has finalized Phase 1 of the student-related financial systems audits, by completing audits of the Registrar's, Student Accounts receivable, and Student Loan systems. In the application systems in operation, the staff audited the cash receipts system, and in the area of management services, has continued its work in the Student Financial Aid Office.

The Audit Division consists of the director, five general and two EDP auditors. The staff size has increased from the prior year as two auditors were employed when an auditor transferred to the Center for International Studies as administrative officer.

In the area of personnel development, three auditors sat for the November CPA (Certified Public Accountant) exam with one auditor completing the exam and the others receiving partial credits. The auditors who are presently CPAs are subject to the new continuing professional education requirements adopted by the Massachusetts Board of Public Accountancy. One of these CPAs has recently become a lecturer in the evening division of a local college. The two EDP auditors were accepted as Certified Data Processing Auditors, and also gave a lecture on EDP Auditing to the accounting society of a local college. The Manager of EDP Audit, William J. Coady, continued as the president of the New England Chapter of the EDP Auditors Association, and another EDP Auditor, John M. Flynn, conducted a seminar for the Association on "Auditing System Documentation On- and Off-line." The development of the entire group continues with attendance at the monthly meetings of professional organizations such as the EDP Auditors Association, the Institute of Internal Auditors, and The Massachusetts Society of CPAs.

EDWARD L. MCCORMACK

Office of the Comptroller

During fiscal year 1979, effort continued toward the completion of a new integrated payroll system. The gross pay to net pay portion of the Exempt Payroll was implemented using a new software package. The distribution function of the Exempt Payroll was converted for inclusion with the Staff distribution. Further implementation of Gross Pay to Net Pay has been deferred in favor of the design of the front end (time input). It is anticipated that significant progress will be made toward final implementation during fiscal year 1980.

A feasibility study to encompass purchasing, travel, and the accounts payable system, including commitments, has recently been undertaken and will continue during the coming fiscal year.

New funding provided by the government to cover the cost of Lincoln Laboratory operations during fiscal year 1979 totaled \$116.7 million. The Department of Defense continues to afford the principal support for the Laboratory, furnishing 89.5 percent of the total. Other funds were provided by the Department of Transportation (4.6 percent) and the Department of Energy (4.9 percent). The balance of the support was received from the National Science Foundation and the Bureau of Mines.

The volume of sponsored research performed at Lincoln Laboratory during fiscal year 1979, excluding prior year overhead adjustments, is expected to approximate \$111.8 million, an increase of 6.1 percent over the total of \$105.4 million the past year. This includes \$542,000 representing the cost of research performed by on-campus laboratories for Lincoln Laboratory. In addition, 28 M.I.T. faculty members and 36 graduate students participated in research programs at the Laboratory during the year.

Personnel Changes

There were several staff changes during the past year. Ronald Calderon joined the Institute as Senior Staff Accountant in June 1978. Patricia A. Lewis, who joined the Institute in 1973, was promoted to Senior Staff Accountant in July 1978. James F. Hanlon, who joined the Institute in 1975, was promoted to Staff Accountant in August 1978. In January 1979, John S. Lavalle was promoted to Senior Accounting Officer for Fund and Sponsored Accounting.

A reorganization of the Lincoln Laboratory Fiscal Office as of January 1, 1979 resulted in the following promotions: Robert V. Dodd to Associate Comptroller, Bruce K. Willard to Assistant Comptroller, and Philip M. McMahon to Accounting Officer.

PHILIP J. KEOHAN

Office of Sponsored Programs

For fiscal year 1979, the total volume of sponsored research performed on campus is expected to approximate \$141,306,000, an increase of 18.5 percent over the fiscal 1978 volume of \$119,274,000.

As shown in the tabulation below, the fiscal 1979 on-campus research supported by three Federal agencies will exceed \$20 million each after significant growth over the past 12 years. Most striking is the fact that the volume of research sponsored by the Department of Energy has doubled in the last two years.

CAMPUS RESEARCH VOLUME BY SPONSOR
(In thousands of dollars)

	<u>1967</u>	<u>1972</u>	<u>1976(*)</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>
Department of Defense	17,477	14,731	13,220	11,678	13,694	15,223
Department of Energy	8,089	7,607	13,923	20,943	32,338	42,005
Department of Health, Education and Welfare	6,411	11,460	17,334	19,140	18,855	22,061
National Aeronautics and Space Administration	6,267	11,422	7,004	7,997	8,064	9,505
National Science Foundation	5,508	11,274	20,845	21,469	21,832	23,469
Other Federal Sponsors	<u>1,548</u>	<u>3,329</u>	<u>5,007</u>	<u>6,313</u>	<u>7,363</u>	<u>8,727</u>
<u>Total Federal Sponsorship</u>	<u>45,300</u>	<u>59,823</u>	<u>77,333</u>	<u>87,540</u>	<u>102,146</u>	<u>120,990</u>
Industry	2,045	1,595	5,504	5,957	6,745	8,151
Foundations and Other Nonprofits	2,606	7,735	8,832	7,674	7,917	9,538
Other	<u>646</u>	<u>1,505</u>	<u>2,674</u>	<u>2,907</u>	<u>2,466</u>	<u>2,627</u>
<u>Total Non-Federal</u>	<u>5,297</u>	<u>10,835</u>	<u>17,010</u>	<u>16,538</u>	<u>17,128</u>	<u>20,316</u>
<u>Total Research Volume</u>	<u>50,597</u>	<u>70,658</u>	<u>94,343</u>	<u>104,078</u>	<u>119,274</u>	<u>141,306</u>

(*) Reclassified for purposes of comparison.

New Programs and Facilities

A Mining and Minerals Resources Research Institute was established at M.I.T. last fall by the Office of Surface Mining of the Department of the Interior. Of the 20 institutes created in the United States under the Surface Mining Control and Reclamation Act of 1977, it is the only one to be located at a private institution of higher education. The M.I.T. proposal included plans for a consortium of universities and colleges in Massachusetts for the purpose of coordinating teaching and research activities related to mineral resources.

In March, the formation of the Center for Cognitive Science was announced. The new Center will provide an intellectual and administrative focus for individual and collaborative research by scientists working in such diverse fields as linguistics and philosophy, psychology, artificial intelligence and computer science, neuroscience, education, and medicine. Establishment of the Center reflects the growth of scientific interest and research both at M.I.T. and elsewhere concerning the basis of human mental faculties.

Four departments of the M.I.T. School of Engineering joined this spring to establish a new Joint Computer Facility with sufficient power and sophistication to meet the curriculum and research computing demands of the departments through the mid-1980s. Joining the Departments of Mechanical and Civil Engineering -- which inaugurated the facility in 1972 -- were the Departments of Ocean Engineering and Aeronautics and Astronautics.

In April the Presidents of M.I.T. and Harvard University announced that His Highness The Aga Khan has provided financial support for a joint program designed to conduct research on the history and contemporary problems of Islamic architecture and to acquaint teachers and architects with the relationship between architecture and the values and traditions of Islamic culture. The total grant will exceed \$11.5 million.

Office of the Director of Finance

In May the Program in Science, Technology, and Society received \$930,000 from the Max C. Fleischmann Foundation for the renovation of space at 70 Memorial Drive (Building E51) -- the former National Research Corporation building -- to house the Program's faculty and staff, and to provide facilities for lectures, seminars, research projects, and other Program activities. The Program in Science, Technology, and Society will share the building with the Sloan School of Management. Renovation is scheduled to begin this summer.

Groundbreaking ceremonies were held on June 4 to initiate construction of a major teaching, research, and health services complex which will provide a new focus for M.I.T.'s broad and growing program of health-related activities. The \$29 million, two-building complex located on Carleton Street on East Campus will total 223,000 square feet and include the Whitaker College of Health Sciences, Technology, and Management building, and the M.I.T. Medical Department building. They will be the first wholly new facilities on the East Campus, with occupancy scheduled for September of 1981.

With M.I.T. as the lead institution, 13 universities in New England and New York have joined to form the University Coal Research Consortium of the Northeast, with the goal of developing a comprehensive research, educational, and industrial program to promote the clean use of coal and to foster the development of national coal resources. The consortium's first major public event was a conference on clean coal utilization held at M.I.T. on June 12-15. The consortium intends to submit a proposal to the Department of Energy in an effort to obtain funding as one of 13 university coal research laboratories called for under the Surface Mining Control and Reclamation Act of 1977.

Personnel Changes

During the year the following staff changes occurred in the Office of Sponsored Programs: Wendell A. Derry, O.S.P. Property Officer, transferred to the Office of Facilities Management Systems as Institute Property Officer effective July 1, 1978. John J. Hynes, Assistant Director, transferred to the Department of Nuclear Engineering as Administrative Officer effective May 1, 1979.

GEORGE H. DUMMER

Office of the Director of Finance

Fiscal year 1979 can be characterized as one in which the nation's economy was in a period of slow growth. Inflation, which began the year at an annual rate of about six percent, ended the year in double digits. M.I.T.'s economy, on the other hand, showed continued growth as total expenses increased by 11.9 percent from \$319,356,000 in fiscal 1978 to \$357,409,000 in fiscal 1979. The departmental and interdepartmental research programs were the main source of this growth, increasing in real terms over inflation by about five percent. The Energy Laboratory, Magnet Laboratory, and the Plasma Fusion Center were areas of notable growth.

As we entered fiscal 1979, the budget program recognized the continued demands created by shifting enrollment patterns. Approximately \$1.1 million of unrestricted funds were added to the departmental and interdepartmental laboratories to support their academic programs, a portion of which is supported by short-term funding over the next four years. Growth in the administrative and physical plant areas was minimal and driven primarily by outside inflationary pressures.

The year ended on a positive financial note with a small surplus of \$56,000. This is the second year in a row that we have had a surplus, and it resulted substantially because of the responsible management of the various departments and laboratories that make up M.I.T.

The Office of Business Systems Development (B.S.D.) and the Office of the Director of Finance are in the final stages of completing the functional requirements analysis for the budget and management information system project. Included in the analysis process has been the user

Vice President, Financial Operations

consensus ranking of each requirement statement, a procedure developed by B.S.D. In addition a process called Systematic Design Methodology (S.D.M.), developed by the Center for Information Systems Research at the Sloan School of Management, was also employed. Both the consensus ranking and the S.D.M. will be of considerable value in the next phase of the system's development, which is the design and implementation of the features that will support the system requirements.

The final documents required by the Department of Housing and Urban Development under the College Housing Loan Program prior to the funding of two renovation projects are being completed. These renovations have helped alleviate the current student housing shortage.

Student loan notes receivable outstanding were \$28.6 million at the close of the fiscal year, an increase of 5.5 percent over the prior year. These notes are funded by \$8,838,000 of M.I.T. loan funds established by friends and alumni of the Institute; \$13,520,000 of Federal funds in support of the National Direct Student Loan program (NDSL); \$492,000 in funds borrowed from the Federal government to support our contribution to the NDSL program; \$2,000,000 borrowed from the Student Loan Marketing Association; and \$3,750,000 from a local bank. Our total borrowings to support student loans was unchanged from the previous year.

Several changes did occur in our loan programs this year. Co-makers were required on many loans not guaranteed by the Federal government. The US Office of Education established procedures for taking back uncollectable NDSL notes, and after 15 years in this program we turned back approximately 200 loans valued at \$300,000.

Beginning on January 1, 1979, the Student Loan Office under the leadership of John R. Rogers and the Student Accounts Office under James F. Brady began reporting to this office. This shift was a natural one as the financing of students through loans, scholarships, fellowships, assistantships, term-time work, and the collection of "foreign receivables" supporting students become an ever more important element of M.I.T.'s fiscal plan. During the year, Karen E. Goode was promoted to Senior Staff Accountant in the Student Accounts Office where she handles accounts of students in the Schools of Engineering and Management.

Richard M. Hill joined the staff in February as Assistant Director of Finance. His S.M. degrees from M.I.T. in Management and Aeronautics and Astronautics and his experience in the Army and industry provide a strong analytical background and a good balance to the accounting strength of the rest of the staff.

During the year Richard M. McDevitt and Kenneth F. LeVie, who transferred to the Credit Union as Assistant Manager, resigned. Doreen Morris was promoted to Budget Officer to fill one of these positions, and Nicholas Ruggiero was hired to fill the other position. We look forward to the contribution of these two individuals to the financial management and support of M.I.T.'s programs.

Finally, I am pleased to report that the significant contribution of Robert M. Dankese was recognized this year by his promotion to Associate Budget Director.

JOHN A. CURRIE

Vice President, Operations

After a period of several years of reduced construction activity, we are now in the early phases of a building program that will result in several sorely needed new facilities on the campus. In the reports that follow, some of the facilities mentioned are the Whitaker College of Health Sciences, Technology, and Management and the Medical Department Building; the Athletic Facility; and a new Institute dormitory. During this past year, efforts were concentrated on planning and programming these facilities, and the coming year will witness substantial construction activity.

A major part of this planning involved the study and design of a framework for the sound development of the Institute's campus east of Ames Street. A master plan was created and the coming year will see the beginnings of its fulfillment.

The supply of energy and its efficient use continue to play a dominant role in the physical operation of our plant. The report of the Director of Physical Plant describes the all-pervading consequences and what I believe to be our good efforts in this regard.

As energy has come to play a dominant role in plant operating concerns, so has the problem of the control and disposal of hazardous chemicals come to occupy a significant place in our safety concerns. The increasing use of new toxic chemicals, new regulations regarding their disposal, and environmental and health considerations combine to pose significant problems for M.I.T. and other research-oriented institutions. These matters are receiving much attention, not only at the Institute but nationwide.

From time to time, there come events in life at the Institute that call for new and challenging efforts on the part of people normally engaged in regularized services and operations. Such an event took place this year in the form of our first outdoor Commencement this past June. The event was dignified, colorful, and satisfying. It was also exciting to prepare for this event. The service employees who had the opportunity to assist in its preparation were happy to be a part of it and merit our appreciation for their fine efforts in its behalf.

What may well be a feature with considerable impact on the living environment at the Institute is the in-depth study of dining activities conducted during this past year by an ad hoc committee of faculty, students, and staff members. This is described in the report of the Director of Housing and Food Services who, among others, has devoted considerable time to this study. It is hoped by all that the forthcoming recommendations will be fresh, useful, and able to be implemented.

Barry M. Rowe assumed his duties as Director of Purchasing and Stores at the beginning of the fiscal year. His experienced and energetic leadership is being felt in many constructive ways.

During the year, the Office of Facilities Management Systems (O.F.M.S.) came into the area of responsibility of the Vice President, Operations from that of the Vice President, Administration and Personnel. In light of the important and useful interaction that the activities of this Office have with the Department of Physical Plant, the Planning Office, and the Purchasing Office, among others, this change is proving to have the constructive effects which were desired. Among the activities of that Office is the new responsibility for administration of the Institute's property management program. The expertise of O.F.M.S. is being uniquely brought to bear on an area which is becoming increasingly important to the Institute as a vital management tool.

PHILIP A. STODDARD

PHYSICAL PLANT

Utilities

Fiscal year 1979 saw the significant effects of recent energy legislation and regulation on the operations of the Physical Plant department. The National Energy Act of 1978 has had an impact on the Institute in several areas where specific requirements are making themselves felt at the operating and planning level.

Energy conservation at M.I.T. through revised building operating procedures and modification of building systems has been documented in prior years. It has been an ongoing activity at M.I.T. since 1973. Many of our past voluntary energy conservation programs and procedures are now mandated by the Energy Conservation Policy Act (ECPA). For example, it was noted in last year's report that a campus-wide lighting energy audit for compliance with the new state building code was scheduled for the summer of 1978. This audit was completed during the year, filed with the state, and specific compliance modifications have been made. Other mandated requirements for energy conservation include a programmed analysis of each building's energy consumption and the modification of certain systems for improved efficiency. This program is known as the energy audit. Incentive is provided by grants in support of the costs of making these audits and subsequent modifications.

During the year, M.I.T. finalized an internal energy conservation effort which we identified as the Building Energy Audit and Modification Program (B.E.A.M.) whereby a group of 17 energy-intensive buildings were designated for extensive energy audits. Upon completion, specific recommendations for modifications will be made. This \$800,000 program has a two-year payback period and is planned to be implemented over a three-year period. It is expected that the B.E.A.M. program will put M.I.T. ahead of the legislative requirements for energy conservation and will generate funding through the grants program.

The second of the legislated sections of the National Energy Act, the Fuel Use Act (FUA), has seriously complicated the Institute's ability to plan for additional boiler facilities on campus. Because the Institute qualifies as a major installation, the requirements of the Act are going to make the planning and construction of new boiler facilities a much longer and more expensive process. It appears that we must seriously consider the utilization of coal as the primary boiler fuel in all future plans. As a result of this requirement, M.I.T.'s Energy Laboratory, which undertook the original cogeneration study for Physical Plant, has agreed to extend the analysis to coal-fired cogeneration in a study currently under way.

Finally, the regulatory policy section of the National Energy Act is resulting in a new electric rate schedule for the major power purchases of the Institute. We will soon be required to change to a Time-Of-Use-Rate (TOUR) schedule for main campus electric consumption. We do not foresee that this change will have a negative budget impact because studies indicate that M.I.T. is presently a high load factor consumer. As such, we meet the intent of Time-Of-Use-Rates more closely than the average industrial or commercial consumer, and thus benefit from the new rate schedule. However, Time-Of-Use-Rates are going to change the way the Institute evaluates future energy consumption modifications.

During the past year we experienced a fuel cost escalation for our residual oil supply which was as severe as the 1973 embargo increase. The Institute has been fortunate in that the impact of the 65 percent increase in the cost of fuel oil has been largely offset by the shift in the mix of our use of basic energy fuels from oil to natural gas. We can burn either fuel oil or natural gas in our power plant. The increased availability of natural gas at a price substantially lower than that of fuel oil has reduced our exposure to substantial budget overruns in this transition period.

Construction on the east and west campuses is resulting in a need to extend our utility systems to serve these new facilities. The design of an east campus chilled water plant to be located in the Webster Building (E40) is well under way together with the design of a chilled water distribution system to serve the new Whitaker College of Health Sciences, Technology, and Management and the Medical Department Building, as well as other major Institute buildings east of Ames Street.

Construction of the Athletic Facility justifies an extension of the original central chilled water plant distribution system across Massachusetts Avenue to serve the west campus area. This change will permit retirement of the obsolete and inefficient refrigeration equipment in Kresge Auditorium and the Stratton Student Center. A decision was made early in 1979 to extend the Institute's steam distribution system to serve the Westgate Apartment complex. This modification will carry the benefits of central plant steam heat operation to the whole on-campus housing system.

Architecture, Engineering, and Construction

Construction of a facility to house a 10-megawatt, superconducting, cryogenic generator adjacent to the High Voltage Laboratory was completed during the year. The generator, driven by a gas turbine engine, will eventually have its output fed into the Cambridge Electric Company system for a 30-day period to test the feasibility of this innovative approach to electric generation.

Other construction projects completed during the year included a 13,000 gross square foot (gsf) Interim Animal Care Facility on Vassar Street; renovations to the Suffolk Building (E38) at 292 Main Street; and construction of three lecture halls for the Sloan School of Management within Building E51, the former National Research Building.

The following projects are in active design: a 122,000 gsf College of Health Sciences, Technology, and Management; a 95,000 gsf Medical Department Building; a 111,000 gsf Athletic Facility; an 8,000 gsf Animal Care Facility within Building E18; and a complete renovation program for the former Webster Building (E40).

Numerous space change renovations and renewal projects were completed during the year. Included among these were facilities for the Laboratory for Nuclear Science, Departments of Architecture, Biology, Chemistry, and Meteorology, Research Laboratory of Electronics, Center for Materials Research in Archaeology and Ethnology, and Center for Materials Science and Engineering.

Building Operations/Support Services

The Physical Plant maintenance shops were involved during the year with a number of operational problems brought on by new energy conservation measures, the start-up of a complex laboratory animal care facility, and the continuing aging of the Second Century Fund buildings constructed during the 1960s. New organizational, operational, and training procedures were put into effect in an effort to limit continually increasing labor and material costs. One of these was the combining of all daytime control functions in one place -- including the Facilities Control computer console, communications, and work dispatching.

On June 4, M.I.T. held its first outdoor Commencement Exercises in more than 50 years. To accomplish this task, personnel of the Building Operations and Support Services groups transformed the Killian Court into an amphitheatre for this most ceremonious event of the year. The effort included the construction of a main stage and its appurtenances, installation of a sophisticated sound system, and the set-up of over 6,500 chairs for the event. The move outdoors was made at the request of graduating seniors who wanted a site that would allow seating for a maximum number of relatives and guests. The spectators were nearly twice in number those who were able to attend in recent years when Commencement was held in Rockwell Cage. In spite of a period of light rain, the ceremony was acclaimed a resounding success.

Telecommunications

The Telecommunications Office continued to provide assistance in the growth of on-campus data networks. This took form in the design and installation of cables dedicated to on-campus data communications for the Registrar's Office, the Energy Laboratory, the Architecture Machine Group, the Department of Mathematics, and the Information Processing Services.

The number of Centrex telephone lines or stations increased from 7,584 in June 1978 to an estimated 8,100 in June 1979, an increase of seven percent.

WILLIAM R. DICKSON

PLANNING OFFICE

The highlights of the year's efforts have included planning for a number of academic programs, housing and student life, service facilities and improvements to our campus environment, transportation and parking plans, community development issues, and the continuing impact of government, at all levels, in our campus planning and development.

Academic Programs

East Campus. We have continued to be involved in the work of the architects and planners for the East Campus, with particular concern that the first buildings to be designed as a part of the East Campus plan -- facilities for the health sciences and health services -- are consistent with the Institute's long-range planning objectives. In addition, we have been active in studying the expansion in East Campus of other health-related facilities and academic activities such as the brain sciences and the Department of Psychology, and have been aware of the need to accommodate the necessary parking needs and displacements made necessary by the new construction.

Sloan School of Management. Several planning efforts for the Sloan School of Management were undertaken this year: new teaching facilities at 70 Memorial Drive; the preparation of planning studies to illustrate how the Sloan School could expand its academic programs through the use of new space allocated to them; and a study of the expansion potential of Endicott House. These efforts will be continued in the coming year.

School of Architecture and Planning. The Planning Office assisted the Dean of the School of Architecture and Planning in a major review of the School's facilities plan. This included a review of space utilization, the refining of capital requirements, and the preparation of proposals for the staged development of the School's growth and accommodations.

School of Engineering. We initiated earlier this year, with the new Dean of the School of Engineering, a preliminary review of the context for the School's future planning. We expect that this effort will continue over the next several years, reflecting the major shifts of student interest in engineering.

Department of Physics. We have, at the direction of the Provost, worked closely with the Physics Department to develop planning alternatives for the consolidation of the Department's activities and the exploration of a long-term opportunity for the development of new facilities for the Department.

The Plasma Fusion Center. The planning implications of this fast growing laboratory are extensive. A major user of space, land, and utilities, it will be important to direct its growth in ways that are both supportive of its own objectives and are consistent with the Institute's overall plans.

Program in Science, Technology, and Society. We have continued this year to provide planning assistance to this new program and we have focused on the development of a preliminary facilities program and the development of a number of alternatives for the program's occupancy of space at 70 Memorial Drive (Building E51).

Arts and Media Technology. The Planning Office provided staff support throughout the year to a faculty planning group in Arts and Media Technology. The development of an initial program has been accomplished. In addition, the Planning Office staff coordinated the planning efforts of the architect assigned to this project, I. M. Pei, and assisted in the development of a proposal to the National Endowment for the Arts and Humanities for this project.

Vice President, Operations

Animal Care Plan. A review of the 1978 animal care plan was conducted this year by consultants to the Planning Office. This review suggests that if the current growth level of animal use continues and no alternative for the use of animals in laboratory research develops, then the Institute faces the need to make a major investment in long-term animal care facilities by the mid-1980s.

Housing and Student Life

Undergraduate Housing Study. In response to a shortage of housing for the undergraduate body, we participated in the fall and winter in a series of studies that have culminated in the proposal to move forward on the next undergraduate house. It will be located between New House and Tang Hall and will necessitate the relocation of a major student parking facility.

Graduate Student Facilities. The Planning Office retained the services of a consultant to assist in a review of graduate student community needs. This study, which was shared with the Student Affairs Visiting Committee in the fall of 1978, has been a useful resource in measuring the needs of M.I.T.'s graduate community.

Service and Environment

We completed this year the three-year implementation plan for making the campus accessible to the handicapped. We also have revived the landscape plan for Amherst Alley and have initiated a landscape development plan for Amherst Street.

Transportation and Parking

Following on from earlier efforts, the planning staff completed the development of a Vanpool program which will start this summer. Greater efforts to encourage the use of the MBTA pass plan were undertaken and met with considerable success. In addition, replacement parking plans required by several new construction projects were completed.

External Planning Affairs

The staff has been engaged in a continuing effort to encourage the development of the former Simplex properties. Together with other Institute officers, we have worked toward the fulfillment of the Institute's goals of new economic development, the provision of new commercial services, housing, and community facilities in the area.

In nearby Kendall Square we have been engaged most recently in monitoring a major development proposed to the Cambridge Redevelopment Authority for this area.

At the city, state, and Federal level, we see several events which represent a growing number of constraints on the Institute's development and therefore on our planning efforts. As an example, a new version of the Zoning Enabling Act permits the City of Cambridge to exercise some additional controls over the Institute's new buildings. Environmental protection, energy controls, and other similar actions at the Federal level also will have a profound effect on the future of the Institute's plans.

In closing this report, I should like to note that the major Institute planning issues we see ahead include land resources, transportation, housing, a changing Institute demography, and, as always, space.

O. ROBERT SIMHA

HOUSING AND FOOD SERVICES

In the late fall of 1978, after careful study of admissions information, campus housing retention rates, and alternatives to relieve some of the resulting dormitory overcrowding problems, the administration made the decision to begin the planning for an undergraduate housing facility for 300 students. A "Program Planning Group" consisting of student, faculty, and staff was formed. This group, coordinated by a planning consultant, maintained an intensive programming effort throughout the month of January and produced a report which, in turn, is now being used to generate a facilities program. It is expected that construction will begin in March of 1980 and occupancy is scheduled for September 1981.

The major maintenance program to upgrade the quality of the residential facilities continues with several projects completed or under way. A major project for the coming year is the conversion of the Westgate heating system from an independent boiler unit to the central steam system. It is expected to be completed before the next heating season begins and will provide a more efficient and economical system. Major renovations to the graduate residents' facilities in Baker House also are under way. The sprinkler protection program, planned in conjunction with the Safety Office, is proceeding with the completion of the McCormick Hall public areas and half of the apartment kitchens in Eastgate.

During this past year we experienced a much higher than anticipated inflation rate in raw food products. Because food costs are approximately half of our operational costs, it has required significant effort and skill to maintain a quality menu and a balanced budget. We do not see any easing of this trend in the future. We did introduce a variety of new menu items and services which, for the most part, have been well received.

At the initiative of the Vice President, Operations and the Dean for Student Affairs, the Chancellor appointed a Committee on Campus Dining, chaired by Professor John G. Kassakian. The committee is charged to review the broad range of existing dining programs and opportunities, and to arrive at recommendations which will enhance the quality of the living, learning, and working environment on the campus. It is anticipated that these recommendations will be made early next year.

Our Staff members continue to participate in professional association conferences and workshops, including the Administrative and Supervisor Development Programs. Also, we were pleased to have one of the Department's members, Clarence V. Wilson, named as a co-recipient of the James N. Murphy Award. Mr. Wilson is a service employee of 39 years in Ashdown House.

A satisfying conclusion to this year's work was, once again, the provision of housing and the catering of functions to the many alumni returning to the campus for class reunions and Technology Day.

HARMON E. BRAMMER

CAMPUS PATROL

The Campus Patrol continues in its efforts to provide for the safety and welfare of students, faculty, staff, and visitors, seven days a week, 24 hours a day, utilizing the visible foot patrol officers augmented by patrol cars.

In the most important area -- crimes against persons -- our records indicate very little change in the serious crime totals. The total for 1978 was 37 cases as compared to 36 in 1977.

As with last year, there is a continuing upward trend in the number of service calls handled by the Campus Patrol. This year's total of 9,974 represents an increase of 553 calls over last year's total. This increase is almost wholly in the category of requests for escort services. Members of the M.I.T. community are encouraged to call Campus Police when traveling to remote areas of the campus after normal working hours.

The Campus Patrol ambulance service responded to 1,619 requests for medical assistance. This figure includes true emergencies as well as routine transfers and shuttles. At this time, the Patrol has 22 emergency medical technicians as certified under the 81-hour EMT course.

The Institute property larceny total went up slightly this year. Sharp rises in this figure have been curtailed by the yearly "Crime Prevention Program." This program, now in its fourth year, involves crime prevention officers in one-to-one contact with employees in all departments at M.I.T. The community is constantly updated on the trends in campus crime and the necessity of extra awareness due to the 24-hour open campus policy.

Dormitory larceny totals, on the other hand, increased this year to \$16,121. In an effort to combat the rise in student property losses, a student crime prevention audiovisual program is being developed. It is hoped that by educating the resident population to the problems of an urban environment and by seeking their assistance through increased vigilance, these problems can be dealt with more effectively.

A substantial decrease in the number of bicycle thefts was reported to the Campus Patrol this year. The number of motor vehicles stolen from the campus and the surrounding city streets totaled 98 for the year -- the same reported loss as in 1977.

The overall external and in-service training program, under the direction of the Supervisor of Training, continues to provide the Patrol with the level of professionalism required to fulfill our mission. This year, a total of 2,960 training hours was devoted to maintaining these high standards.

JAMES OLIVIERI

SAFETY OFFICE

The highlight of this past year was the significant change in the scope of responsibility imposed on the Safety Office as conditions both inside and outside the Institute created new demands for safety services. The activities of the various Institute Safety Committees have accelerated safety concerns in many areas, and increased activities in energy, biomedicine, and toxicology research have tended to include safety and health evaluation as part of the total research program. A brief review of the components follows.

Laboratory Safety

The new spill cart which was introduced last year on a trial basis has proved to be effective in providing emergency clean up equipment in a centrally located area.

The volume of chemical waste has continued to increase. Outside influences on waste disposal methods are making it more costly to dispose of waste chemicals properly.

Cardiopulmonary Resuscitation (CPR) courses continue to be very much in demand at the Institute and at our remote sites. As a result, an extensive overall look at a CPR program has been initiated. Hopefully, some of the load will be taken off of the Safety Office which provided 42 courses and trained 426 persons this past year.

A Laser Facility Guide has been developed in conjunction with the Environmental Medical Service and this will be distributed this year.

Fire Protection

Activity in fire protection progressed on many fronts. Installations of automatic sprinklers were made in the following buildings: Eastgate Apartments, McCormick Hall, the Earth Sciences building,

and Endicott House. The independent living groups have begun implementing recommendations for sprinkler protection in their houses with close to 50 percent of them having completed their installations. Fire and evacuation procedures for the libraries were reviewed with representatives of each library area. The fire hydrant system also was checked out and upgraded considerably.

Physical Facilities

Review of new building plans, space changes, and renovations continues to be a major activity of the Safety Office. New buildings included the athletic facility and the health sciences/health services complex. Over 30 remodeling projects required safety evaluations as well. In the research area, the Plasma Fusion Center continued to expand its personnel and facilities. Energy research projects in the Sloan Automotive Laboratories building and in the Landau building also called for Safety Office evaluations.

Off-Campus Sites

The Lincoln Laboratory safety program is now the responsibility of the main campus Safety Office. A major effort is being made to upgrade the safety program there and a number of staff members have become involved with this program. In conjunction with Lincoln Laboratory, Safety Office personnel have made trips to such locations as Nebraska, Utah, and the island of Kwajalein for safety evaluations. The facilities at Haystack, Millstone, Firepond, and Endicott House continue to receive safety services.

Industrial Accidents

I am pleased to be able to report that for the past year the number of compensable injuries per 100 employees has declined seven percent, and the dollar loss per 100 employees has declined by 24 percent. This occurred while the number of employees was increasing by eight percent.

Personnel

The Safety Office staff continued to be active in upgrading their professional competence. William MacLachlan passed his Certified Safety Professional examination and was promoted to staff. He is also chairman of the Public Relations Committee of the local Society of Safety Engineers.

JOHN M. FRESINA

GRAPHIC ARTS AND AUDIO-VISUAL SERVICES

Work order volume and gross revenue continued to increase in all departments at Graphic Arts Services. Total revenue was up approximately 15 percent to \$3 million for the year. The largest department, offset printing, accounted for one-third of the volume, accumulating over \$1 million in income for the first time.

Because of severe space limitations, the expanding volume in the copy centers began to create a situation in which it became increasingly difficult to properly serve the community's quick copy needs. In an effort to alleviate this condition, new and faster equipment, including a Xerox 9400 two-sided high speed copier, was procured. Increased efficiency via the new equipment route appears to have approached its limits, however. An interesting sidelight to the expansion in volume was the increased use of self-service copiers. There are presently nine such copiers in the two largest locations, Building 3 and the Sloan Building.

Vice President, Operations

It is interesting to compare the present quick copy equipment with the equipment used in the first copy center in 1960. We have expanded from one copier at one location in 1960 to 20 pieces of equipment of varying sizes and speeds at four locations now. Prices during that time have gradually decreased from 10 cents per copy to the currently familiar 3,2,1-cent price range.

New equipment in the department included two mini-computers to enhance estimating, costing, and analysis of offset printing, a 19 x 25-inch offset press, and a faster embossing machine for student identification cards.

The audio-visual section was deeply involved in the installation of new sound and projection equipment in the renovated Huntington Hall and continues to provide a vital service to the Institute.

JAMES W. COLEMAN

PURCHASING AND STORES

The past year was marked in broad terms by 1) a critical analysis of the policies and operations of the General Purchasing Office, 2) a review of the budget and functions of various separate purchasing agencies at the Institute, 3) the establishment of a formal Minority Business Enterprise Subcontracting and Purchasing Program, and 4) investigations into the development of an automated purchasing and accounts payable system.

General Purchasing Office

Some 35,000 purchase orders were processed by a relatively small staff of buying and clerical support personnel who were unable to provide the desired level of administrative support to the departments at the Institute. Changes are now in progress to augment this staff, to strengthen the operation of the office, and to accommodate an increasing work load of the Office of Laboratory Supplies and some of the separate purchasing agencies.

Plans also are being studied for establishing a central subcontract administration section within the General Purchasing Office which would be capable of servicing all Institute departments and laboratories for all of their complex subcontract procurement needs. The subcontract administration function does not work as well on a decentralized basis.

Office of Laboratory Supplies

Of the 25,000 purchase orders issued by the Office of Laboratory Supplies this past year, some 18,000 were "low dollar orders" and were for items not normally carried in our stockrooms. This type of order consumes an inordinate amount of the staff's time and in the future will be handled by the more adequately staffed General Purchasing Office.

This past year marked the institution in this office of a newly designed automated sales reporting system. This system allows automatic pricing of requisitions in the stockrooms, facilitates the billing process, and enables a continuous monitoring of monthly "sales" performance.

Separate Purchasing Agencies

Steps have been taken during the past year to consolidate into the General Purchasing Office or otherwise to reduce the staffing levels of several of these agencies. We are trying to streamline purchasing operations in response to Federal audit agency recommendations.

Vice President, Operations

Minority Business Purchasing Program

During the past year approximately 425 purchase orders worth \$450,000 were placed with minority business enterprises. Increased effort will be made in the General Purchasing Office to locate and introduce additional minority and women-owned business enterprises to Institute purchasing channels.

Automated Purchasing and Accounts Payable System

Representatives of the General Purchasing Office, the Comptroller's Accounting Office, the Institute Auditor's Office, and the Information Processing Services have met on a regular basis during the year to define an automated purchasing and accounts payable system. It is hoped that system definition can be completed and the system implemented during the coming year.

BARRY M. ROWE

OFFICE OF FACILITIES MANAGEMENT SYSTEMS (O.F.M.S.)

Facilities Inventory

The Office of Facilities Management Systems is responsible for the collection, maintenance, and reporting of data for more than 21,000 individual spaces at M.I.T., comprising nearly seven million net usable square feet. Using the M.I.T.-developed space accounting system, INSITE II, two major updates to the space inventory were completed. Each update was followed by the distribution of several reports to academic and administrative offices, as well as numerous special reports produced throughout the year for use by the Committee for Review of Space Planning, the Comptroller, Director of Finance, Physical Plant, Planning Office, School of Engineering, and others.

Nearing completion is the development of the INSITE III system. This system will provide a significantly enhanced capability as an aid to the process of allocating, operating, and planning for space. The design also includes both an equipment inventory and a grant-tracking capability.

INSITE Consortium

Another major responsibility of O.F.M.S. is to provide support to the existing consortium of external users of the INSITE II technology as well as to foster the continued growth of the consortium in both its membership and the quality of its facilities management. This past year saw four new members of the consortium: Atlantic Richfield Company, University of Michigan Hospital, Bell Laboratories, and De Paul University. This brings to 27 the number of organizations that employ the INSITE II system and its associated methodology to both manage their inventories of building space as well as to share their knowledge and experience in this area with M.I.T.

To assist each institution in reaping the fullest benefits of the INSITE II technology, O.F.M.S. offered four courses in the use of the INSITE II system as a management tool, two training courses on the INSITE II-related Space Cost Analysis System, a conference for all consortium members to exchange information on facilities management techniques, and a one-day workshop to continue the training of those already using the system. The Office also presented a one-week summer session program on Facilities Management Systems and Inventory Techniques.

Property Management

The first year of operation within O.F.M.S. of the former Property Office, previously based within the Office of Sponsored Programs, was rewarding to all involved. A new organization

Vice President, Operations

structure was designed, positions were staffed, and the difficult task of tracking and accounting for an estimated 100,000 pieces of equipment within M.I.T. commenced. In order to provide for more accurate and timely tracking of equipment at M.I.T. in the future, bar coded labels have been researched, designed, and manufactured. The first few hundred of these new equipment identification labels have been affixed. While awaiting the INSITE II system capability, the existing equipment inventory files were maintained to provide basic data for a number of users. Over 10,000 changes to the existing 70,000 pieces of equipment in the file, with an actual acquisition value of \$100 million, were processed.

A much sharper focus on the acquisition of government excess equipment, and the disposition of M.I.T.-owned surplus equipment, has been accomplished in this past year. Over \$1.4 million of government excess equipment was acquired, with 21 academic departments and laboratories being the major recipients. This program, only six months old, is further enhanced by the existence of a new Specific Needs File within which 24 departments and laboratories to date have filed their equipment needs in hopes of having them fulfilled. O.F.M.S. also has joined the National Association for the Exchange of Industrial Resources, a nonprofit corporation that attempts to place excess corporate equipment into nonprofit institutions.

Also new this past year was the responsibility for the operation of M.I.T.'s storage facility at 224 Albany Street. This facility provides for the storage needs of 26 departments, with pressure mounting for additional tenants.

The Office also presented a one-day Property Management Seminar, with over 200 in attendance from across the nation, and speakers ranging from our own office to the leading government agencies responsible for equipment funding and tracking. We also hope to establish a sorely needed professional Society of Property Managers.

KREON L. CYROS

ENDICOTT HOUSE

The house was used 274 days and 168 nights during this year. Resident use of the house decreased considerably from the previous year. Of the 22 resident conferences held during the year, 12 were M.I.T. groups, accounting for 4,160 overnights; 10 were non-M.I.T. groups, accounting for 556 overnights. These totals gave us an average of 28 guests per night of operation.

Non-resident use of the house increased significantly: 121 non-resident groups, with a total of 8,384 guests, used the house. Of these, 102 were M.I.T. groups, whose guests totaled 7,042 and 19 were non-M.I.T. groups, whose guests totaled 1,342.

During the year, 23,221 meals were served -- averaging over 84 meals per day of operation.

A number of physical improvements were completed during a two-week shutdown period in August 1978. These included renovations and some new equipment for the kitchen, a bathroom renovation, and the upgrading of some electrical systems.

We are looking forward to our 25th anniversary as an M.I.T. department in 1980.

AIMEE PIERSON

Vice President, Research

The 1978-79 year has been one of change and growth beyond anticipation.

The Energy Laboratory grew by about 25 percent last year. Approximately one-third of the research concerns policy analysis and development of policy guides -- work of immediate value in dealing with energy shortages. The studies include analyzing transportation contingency plans for use in the event of an energy emergency. The other two-thirds of the research is longer-range studies of technology. Energy research, which was spotty and isolated six years ago, now constitutes a significant proportion of on-campus research.

The Nuclear Reactor Laboratory (N.R.L.), which was decommissioned for remodeling in 1974, is now in full-time (three shift) operation at its rated five-megawatt power level. The operating deficit has been reduced, and research involving reactor use is over \$1.5 million per year.

The Center for Materials Science and Engineering (C.M.S.E.) continues to be a major focus for interdisciplinary research in materials. C.M.S.E. has given strong leadership to the development of interdisciplinary research in polymers and now publishes an annual report on polymer research in addition to its annual materials research report. The laboratory has expanded considerably its central instrumentation facilities which are made available to the entire Institute community. The aggregate value of the instruments exceeds \$1.5 million. The submicron electronics facility, first reported last year, continues to develop healthily.

The Plasma Fusion Center (P.F.C.) has emerged from the National Magnet Laboratory (N.M.L.) this year. The P.F.C. is "the home of M.I.T.'s famous ALCATORS" and is funded at the \$13 million level. ALCATOR A continues to yield valuable experimental data and ALCATOR C is operating experimentally off of N.M.L.'s 35-megawatt generator while awaiting completion of its own 225-megawatt supply (the generator was donated by Consolidated Edison) and massive microwave supply (salvaged from the Aleutian radars). ALCATOR C is expected to set new milestones in the complex path to fusion energy.

The National Magnet Laboratory (N.M.L.) has continued to expand its unique high-magnetic-field facilities while giving autonomy to the P.F.C. (above). The N.M.L. is distinguishing itself as conceptual designer and prime contractor for a number of mammoth MHD magnets, including superconducting units, for the US Department of Energy. Researches by staff and visitors continue to yield scientific surprises such as, for example, the discovery of magnetite-loaded bacteria that follow the earth's magnetic vector to feeding grounds in the ocean.

The Laboratory for Nuclear Science (L.N.S.) has continued its outstanding researches in heavy ion physics, intermediate energy physics, and high energy physics. A large addition which is being built at Middleton will be ready soon and will increase the capabilities of the Bates Linear Accelerator. The high energy group developed an automatic scanner for bubble chamber tracks some years ago. A duplicate of this scanner is now being evaluated abroad for recognition of cervical cancer cells -- a valuable use far removed from the original purpose. This development, not in the report, is mentioned here as an example of the often overlooked spin-offs of physics research.

The Research Laboratory of Electronics (R.L.E.), M.I.T.'s oldest interdisciplinary laboratory, put in another excellent year's performance in the areas of general physics, plasma dynamics, and communication sciences. The faculty carrying out these research programs has increased from an original two departments (Electrical Engineering and Physics) to more than a dozen disciplines.

The Center for Space Research (C.S.R.) has held its own in terms of support for research scientists but support for space hardware development has all but disappeared while NASA focuses on getting the space shuttle operational. The year was filled with discoveries relating both to planets and X-ray stars.

Vice President, Research

The reports which follow give further details regarding a year in which M.I.T. has made much progress in demonstrating and proving the necessity of the close relationship between teaching and research in science and technology.

THOMAS F. JONES

Francis Bitter National Magnet Laboratory

The growth rate of the Laboratory's programs and personnel in this past year slackened somewhat as compared with the hectic pace of the previous year. Healthy growth continued in the applied programs, but budget limitations restricted activities in the basic core research programs supported by the National Science Foundation (NSF).

The Laboratory's research programs are of an interdisciplinary nature in that they provide for the high-field needs of the faculty and research staff of a number of academic departments and other laboratories at the Institute. In particular, the Laboratory maintains a strong interaction with the Departments of Chemistry, Physics, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Nuclear Engineering. We are closely linked with the Plasma Fusion Center in personnel, space, and technical support, and we expect to continue this ongoing relationship so that all aspects of our programs of mutual interest go forward with good speed and efficiency. The Laboratory interacts with members of the Center for Materials Science and Engineering, Energy Laboratory, Lincoln Laboratory, Research Laboratory of Electronics, and Whitaker College of Health Sciences, Technology, and Management.

The Laboratory has been designated the MHD (magnetohydrodynamic) Magnet Design and Procurement Field Office for the MHD Division of the Department of Energy. In this role, the Laboratory is responsible for the development of a firm engineering base for superconducting magnets, for procuring reliable magnets for Department of Energy installations, and aiding industry in fulfilling their role in producing large superconducting magnets.

During the past year, the Laboratory has continued its focus on the development and operation of the most advanced high field magnets for research by faculty, research staff members, students, and visiting scientists from throughout the country and elsewhere. Use of the magnet facilities by visitors showed a marked increase during the past year, and this trend is expected to continue subject only to the limitations of available magnet time. In addition to the Laboratory's in-house research programs, we provided high-field magnets and other facilities for the Alcator project and for approximately 50 other projects involving more than 100 scientists and engineers from about 20 states in the country. The Users' Committee is continuing to provide important input to the Laboratory for meeting the growing needs of the scientific community for high-field research.

The NSF Advisory Committee and the High Field Panel appointed by the National Research Council have played an important role in helping to shape the future of the Laboratory. As a long-range goal, the High Field Panel has recommended the development of magnets capable of generating continuous fields up to 750 kG and long-pulse "quasistatic" fields in excess of 1 MG. A partial implementation of these goals is being realized through the development of hybrid magnets which combine the water-cooled Bitter magnets with superconducting magnets for generating 300 kG continuous fields, and large volume quasistatic magnets for generating fields up to 500 kG.

Advances in magnet development included the completion of a 120 kG superconducting magnet to be used for a high resolution nuclear magnetic resonance spectrometer. A new cooling hole pattern for Bitter plates optimized by computer techniques has improved the performance of the Laboratory's high field Bitter magnets. Completion of the newest hybrid magnet has been delayed by the failure of a supplier to meet the specifications for the superconductor. An existing complete superconducting coil is being purchased to accelerate the program.

The NSF-funded program supports research in the area of solid-state physics, biophysics, atomic physics, and plasma physics. Some highlights of a number of projects in this program are given below as examples of the current interest.

Spin-Polarized Tunneling

The first successful spin-polarized tunneling measurement into single crystal Ni gave a value of the tunneling electron spin polarization of +13 percent (predominantly majority spin) from the (110) crystal face in agreement with a prediction by Stearns of +12 percent.

The theory of high-field superconductivity has been tested for the first time without adjustment by combining spin polarized tunneling and critical field measurements. The result: a sizable discrepancy as yet unexplained.

Spin-orbit scattering of a monolayer of Pt on a superconducting Al surface raises the critical field by more than a factor of two, and supports the Abrikosov-Gorkov theory of spin-orbit scattering at metal surfaces.

Phase-Transitions

The virtual bicritical point, a new concept related to phase boundaries in magnetic materials, has emerged from a study of the antiferromagnetic material CsMnF_3 in high magnetic fields.

H^- Ions in Semiconductors

Theoretical studies have been carried out which elucidate the behavior of H^- ions in strong magnetic fields. These calculations have enabled the first identification of H^- ions in a semiconductor with a simple conduction band, and have given a simple physical picture of how the magnetic field causes the binding of "new" states, states which are unbound in the absence of the field. An unexpected by-product of the calculations is the proof that a positron will bind to an H atom in a magnetic field, although no bound states exist at zero field.

Magic Angle Sample Spinning in Nuclear Magnetic Resonance

A new Nuclear Magnetic Resonance (NMR) technique, called magic angle sample spinning, has been developed which narrows the otherwise broad, featureless spectral lines observed in solid samples, thereby enabling high resolution spectra to be obtained. It was successfully applied to obtain the first data on the relationship between changes in molecular configurations in bone mineral and the biological development of bone tissue.

Biomagnetic Compass in Bacteria

Bacteria from diverse aquatic environments which orient and swim in a preferred direction in magnetic fields (magnetotaxis) have been shown to contain the magnetic material magnetite, Fe_3O_4 . There is enough magnetite present in a single bacterium to produce orientation of the bacterium in the earth's magnetic field in the face of the disorienting effect of thermal energy (Brownian motion). Thus these bacteria carry an internal biomagnetic compass which they use for navigation.

Synthetic Analogs of the Active Site of Nitrogenase

Nitrogenase is a bacterial enzyme that facilitates the fixation of nitrogen. The enzyme includes a protein that contains molybdenum, iron, and sulfur atoms in its active site in an as-yet unknown structure. Mössbauer spectroscopy has been used to study the electronic properties of a series of double cubane cluster complexes of the form $[\text{MoFe}_3\text{S}_4(\text{SR})_3]_2(\text{SR})_3^{3-}$ which constitute synthetic approaches to the active site of nitrogenase.

Vice President, Research

Laser-Magnetic Resonance Studies of Helium

In the area of atomic spectroscopy, CO₂ and far infrared lasers have been used in laser-magnetic resonance studies of helium. By observing very strongly forbidden transitions, and understanding various novel lineshapes, some important spectroscopic parameters of the helium atom have been determined.

CH₃F Raman Laser

Fifteen new, Raman far infrared (FIR) laser emission lines in CH₃F have been excited by optically pumping up to 24 GHz off resonance with high intensity CO₂ TEA laser radiation (up to 20 MW/cm²). The present results suggest that a nearly continuously tunable source of FIR radiation in the 175-500 μm range could be obtained via Raman laser emission in CH₃F using a tunable, multi-atmospheric CO₂ pump laser.

Coherent Four-Wave Scattering

The coherent four wave scattering properties of electromagnetic waves by a hot, collisionless plasma have been studied theoretically, and the advantages of this technique in plasma diagnostics have been pointed out. The coherent generation of plasma waves by the nonlinear interaction of EM-waves in the plasma and the subsequent scattering of EM-waves by these plasma waves result in several orders of magnitude enhancement of the scattering amplitude when compared to the incoherent Thomson scattering amplitude. Furthermore, the practical implementation of this new technique allows a flexibility that can be used advantageously in a variety of practical settings.

Visitor's Programs

There has been an extremely large demand for the very high fields, particularly for measurement of the properties of high-field superconductors which are of fundamental as well as of technological importance. Much of the world's fundamental superconductor experimentation has been performed at the Laboratory. A number of other visitors have been pursuing a variety of high-field investigations such as electronic structure of transition metals and rare-earth compounds; thermoelectric power and coulomb correlation in Quin (TCNQ)₂ salt; transport measurements in di- and tri-chalcogenides; rare-earth magnetics technology for advanced inertial systems, magnetorefectance and SdH effect in graphite intercalation compounds; electronic and optical properties of semiconductor superlattices GaAs-GaAlAs, InGaAs-GaSbAs, InAs-GaSb; SdH measurements in InAsGaP quaternary alloys; tunneling of CO into heme molecules at low temperatures; viscosity measurements in liquid crystals; performance evaluation of MHD disc generators; Raman scattering in Jahn-Teller systems DyVO₄, TbVO₄; mutagenicity in bacteria; magneto-transport properties of two-dimensional electrons at the Si-SiO₂ and GaAs-GaAlAs interfaces; magnetic field effects in chemical reactions; ¹³C enrichment in photolysis.

NUCLEAR MAGNETIC RESONANCE FACILITY

The Laboratory operates a high-field NMR facility which is jointly supported by the National Institutes of Health (NIH) and the National Science Foundation (NSF). This facility operates on a seven-day-per-week, 24-hour-per-day basis, and serves a large community of physicists, chemists, and biologists primarily from the northeastern region of the country. A number of the visitors come from the local hospitals and medical schools at Harvard, Tufts, and Boston universities.

A number of other programs are supported by the US Department of Energy (DOE), NIH, Air Force Office of Scientific Research (AFOSR), and the National Aeronautics and Space Administration (NASA). Following are some highlights of these programs.

High-Field Superconductors

Two new technologies, the "In Situ" and cold powder metallurgy processes, have been developed as alternatives to conventional techniques for preparing multifilamentary high-field superconductors. Both processes have produced conductors with good electrical properties and superior mechanical properties to those of conventional multifilamentary superconductors. New facilities have been developed for testing mechanical properties of high-field-superconductors.

Internally Cooled, Cabled Superconductors (ICCS)

Initial progress has been made in understanding why bulk helium velocity plays an insignificant part in the stability of the ICCS. This has previously been confirmed experimentally. The D-Coil test program, started in 1977, has been successfully completed. Straight lengths of conductor, located in a cross magnetic field, exhibited equal stability to solenoids during rapid current ramping exercises. Two new programs were initiated: 1) A preliminary design of a 12-tesla solenoid was completed. The coil will be fabricated and tested as part of DOE's national 12 T test program for fusion research; 2) work has started on the fabrication of a test coil for MHD, in which the stainless steel sheathed ICCS will act as a major structural member.

Clearance of Dust from Human Lungs

Continuation of the study of the clearance rate of dust from the human lung has confirmed the earlier result that smokers' lungs clear much more slowly than those of non-smokers.

Nonlinear Optical Absorption

High intensity transmission behavior of 90-ns CO₂ laser pulses through germanium has been studied. The transmitted energy is found to decrease when the incident intensity exceeds a certain limit, which depends upon the length of the crystal. The transmission limit increases by going to lower temperatures. The observed transmission drop is interpreted in terms of multi-photon absorption across the direct band gap followed by absorption of the excess carriers thus generated. By fitting experimental data to a phenomenological model, a room temperature seven-photon absorption coefficient of $1.5 \times 10^{-9} \text{ cm}^{-1}(\text{cm}^2/\text{MW})^6$ is obtained for germanium in the 10 μm region.

Impurities in Semiconductors

Strong magnetic fields along with high-resolution and low-noise Fourier transform spectroscopy are being used to identify contaminating impurities which otherwise limit the electron mobility in gallium arsenide and, therefore, the performance of this technologically important material.

CONFERENCES

A four-day International Conference on "Solids and Plasmas in High Magnetic Fields" was held at M.I.T. from September 18-21, 1978 in order to focus on future prospects and possible new directions for the role of high magnetic fields in both science and technology.

In October, the 1978 Superconducting MHD Magnet Design Conference was held at M.I.T. It was organized by the Technology Development Group under a mandate from DOE/MHD to transfer technology from the Laboratory to industry, and to prepare industry for the construction of commercial MHD systems by the end of the next decade.

BENJAMIN LAX

Center for Materials Science and Engineering

The Center for Materials Science and Engineering is housed in Building 13, the Vannevar Bush Building, and provides the focus for materials research at M.I.T. The aims of C.M.S.E. are to initiate, encourage, fund, and coordinate interdisciplinary research in materials. The focus to the research program is provided through core funding by the National Science Foundation (NSF) Materials Research Laboratories (MRL) Program. The research program is further supported by small block funding and individual grants to faculty members through other government agencies, industry, fellowships, and M.I.T. itself. C.M.S.E. sponsors a weekly colloquium series on Materials Research, and during the past year, a second seminar series on polymers research was initiated.

In 1978-79, a total of about 35 faculty members received project support under the NSF-MRL program, involving about 100 graduate students and postdoctoral fellows, as well as visiting professors and scientists and other staff. C.M.S.E. makes it a practice to provide research funding for high risk SEED projects as well as for newly arrived faculty members. During 1978-79, five faculty members received such SEED funding allocations. Faculty, staff, and students of the Departments of Chemistry, Chemical Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Physics participate in the NSF-MRL program.

In addition to support of research, C.M.S.E. initiates and maintains a large group of Central (Service) Facilities in support of materials research throughout the Institute. Supervised by faculty members and operated by laboratory supervisors on a day-to-day basis, the facilities provide state-of-the-art laboratories for materials preparation, structural and compositional characterization, various testing laboratories, and a machine shop. Major improvements in several central facility areas were made during the past year. In the summer of 1978, C.M.S.E. acquired a Scanning Auger Microprobe (SAM), and a new central facility (Surface Analytical Facility) has been established. This facility is oriented toward multiple-technique characterization of a variety of solid surfaces with regard to atomic structure, surface chemical composition, and chemical bonding characteristics. In addition to the SAM, the facility also provides analytical capabilities within a single vacuum chamber for ESCA/LEED measurements. Additional major items of equipment (Quantimet, SEM, Ion Implanter) are on order and these major additions will significantly enhance our research capabilities.

The NSF-MRL core-funded program supports research in the following areas of thrust: IA Predicting Flow and Fracture in High Temperature Alloys; IB Deformation and Fracture in Polymer Composites; II Structure and Properties of Microcrystalline and Glassy Metals; III Platinum Surfaces and Platinum Based Catalysts; IVA Optical Materials and Devices; IVB Amorphous Semiconductors; IVC Microelectronic Materials and Device Structures; and V Phase Transitions.

Some abbreviated highlights of research follow as examples of the NSF-MRL program. Many programs are the result of close collaboration among faculty members from several departments. For a more complete view of research in materials, the reader is referred to the *Annual Report on Research in Materials at M.I.T.*, a publication which is compiled and issued by C.M.S.E. for an international audience. In addition, we initiated this year an *Annual Report on Polymer Research at M.I.T.*, which has similarly been widely distributed.

HIGHLIGHTS OF THE RESEARCH PROGRAM

Structure of the Smectic B Phase (Professor Robert J. Birgeneau)

The nature of smectic-B liquid crystals has long been a subject of debate. Most workers have described this anomalous form of matter as stacked layers of two-dimensional well-correlated fluids. Indeed, many features of the SmB phase could be rationalized by assuming that the layers correspond to a hexatic 2D fluid, that is, a liquid with long-range orientational order and well-developed by short-range positional order. However, some quite different models, based on the idea that the SmB phase is a variant of a plastic crystal, also have been proposed.

In order to resolve this issue, Professors Birgeneau, James Litster, and Peter Pershan (C.M.S.E. visitor from Harvard) undertook an extensive X-ray scattering investigation of the structure and fluctuations in the SmA and SmB phases of 4.0.8. The results are quite surprising since the SmB phase shows resolution-limited three-dimensional peaks. Specifically, the centers of gravity of the 4.0.8 molecules are ordered three-dimensionally in a simple graphite structure over distances greater than 5,000 Å. Thus the SmB phase in 4.0.8 is closer to being an extremely soft solid than a liquid crystal. The sharp peaks are accompanied by anomalously strong diffuse scattering which indicates that there is extreme disorder on the microscopic level. Indeed, the diffuse scattering accounts for about 80 percent of the total scattering intensity. We are currently carrying out a detailed study of the X-ray diffuse scattering in 4.0.8 SmB; from these results, we hope to construct a new microscopic model for this highly unusual phase of matter.

Ordering in the Smectic C Phase (Professors Litster and Birgeneau)

The combination of X-ray scattering to probe density fluctuations and light scattering to determine the orientational order and fluctuations is an effective way to elucidate the nature of smectic liquid crystal phases. This combined approach by two research groups, made possible through MRL support, has been applied in a detailed study of the smectic C to smectic A (SmC-SmA) phase transition in 8S5. When the molecular orientation is held fixed in a magnetic field, the molecules tilt with respect to the wave vector of the smectic density wave on going from SmA to SmC. The scattering intensity in reciprocal space changes from a point to a ring, and one can measure simultaneously the tilt angle and smectic "layer" spacing. Results for the SmC phase of 8S5 show unambiguously that the tilt angle is the primary order parameter and the layer spacing is a secondary order parameter proportional to the square of the tilt angle. The order parameter has two degrees of freedom, and one would expect nonclassical (helium-like) critical behavior. However, classical (mean field) critical behavior is observed experimentally. This can be quantitatively explained by applying the Ginzburg criterion using heat capacity data as well as estimates of correlation lengths obtained from light scattering measurements. One puzzling aspect of the behavior in the 8S5-7S5 system of liquid crystals now appears to be understood.

High-Pressure Calorimetry on Smectic Liquid Crystals (Professor Carl W. Garland)

Several investigators (Professors Birgeneau, Garland, and Litster) have been concerned recently with a series of cyanobiphenyls which exhibit second-order nematic to smectic A (N-SmA) phase transitions. This transition is predicted by deGennes to be analogous to the lambda transition in liquid helium ($d = 3$, $n = 2$ universality class). To test this proposal, an ac calorimetric technique developed with MRL support was used to study the N-SmA transition in octyloxycyanobiphenyl (80CB) and related compounds at pressures up to 3 kbar. A major result of the work on 80CB is that the critical exponent α does not agree with the nearly logarithmic singularity ($\alpha \approx 0$) required by the helium analogy. The new data yield $\alpha = 0.27 \pm .03$ both at atmospheric pressure and at 500 bar, and this large value for α is consistent with a modified hyperscaling relation $2 - \alpha = \nu_{\parallel} + 2\nu_{\perp}$ and the exponents ν_{\parallel} , ν_{\perp} observed by Professors Birgeneau and Litster for the correlation lengths. It is possible that this N-SmA transition is dominated by the anisotropic fixed point found recently by Lubensky and Chen. A second interesting feature is the very strong pressure dependence

for the amplitude of the N-SmA transition in 8OCB and in 8CB. Whereas the heat capacity peak associated with nematic-isotropic (N-I) transition remains virtually unchanged, the magnitude of the nematic-smectic A peak decreases dramatically with increasing pressure. It was observed that this N-SmA amplitude is a roughly exponential function of the temperature difference $T_{NI} - T_{NSmA}$. This suggests that the degree of nematic order present at the N-SmA transition plays a major role in determining the magnitude of energy fluctuation at this transition.

Coil-Globule Transition in a Single Polymer Chain (Professor Toyochi Tanaka)

We have discovered that a single polyacrylamide chain undergoes a transition from an expanded random-coil configuration to a collapsed configuration when the solvent composition is changed. The hydrodynamic radius of the chain was determined using the technique of photon-correlation spectroscopy, and the radius of gyration was measured from the angular dependence of the scattered light intensity. The observations were made possible by using very pure samples having extremely low polymer concentrations so that intermolecular entanglements were avoided.

This observation opens up a new field of phase transitions in finite systems. We have indeed observed that the first-order transition in the polymer chain is not completely discontinuous but is rounded due to the finite size of the polymer chain. The abrupt change in polymer size may make possible amplification, switching, and memory functions at the molecular level. This concept and phenomenon could have very significant applications in biology, medicine, and chemical engineering.

Mechanisms of Crazeing in K-Resins (Professors Ali S. Argon, Robert E. Cohen, and John Vander Sande)

During the process of synthesizing PS-PB* block copolymers for eventual study in both pure form and in ternary blends with additional homopolymers of PS and PB, a study of crazeing in two commercial block copolymers, Phillips K. Resins, KRO-1 and KRO-3, of similar composition was undertaken. Both morphological studies by electron microscopy (TEM and STEM) of these two resins and measurements of craze growth have been carried out. These have indicated that the morphologies of KRO-1 and KRO-3 can be described as space filling networks of distorted PB rods and corrugated PB sheets in a majority phase of PS, respectively. Detailed electron microscopy of these polymers by both TEM and STEM have shown that the craze structure in KRO-1 resembles the tufted structure of craze matter in homogeneous PS, consuming and reprocessing the phase morphology into craze tufts. This suggests that craze matter in KRO-1 is produced by the same meniscus convolution that is present in PS homopolymer. In KRO-3 considerably different cavitation processes appear to be present. There is mounting evidence that in KRO-3, craze matter production involves considerable interface delamination between the PS and PB phases. Craze growth measurements at both room temperature and at -20°C have indicated that the normalized craze growth rates in K-Resins are between one and two orders of magnitude lower than in homogeneous polystyrene.

Mechanical Properties of Polymer-Ceramic Composites (Professor Donald R. Uhlmann)

During the past year, using Auger analysis, the surface chemistries of both E-glass and S-glass fibers have been determined for fibers processed under a range of conditions. The results indicate a considerable difference between surface chemistry and bulk chemistry, with surfaces in all cases being notably deficient in boron.

Based on these results, special high purity glasses were prepared, using the vapor phase transport techniques employed in the production of optical waveguide glasses. Such glasses were prepared over a range of composition, and their surface chemistries were determined using Auger analysis. These glasses are analogous to the standard fiberglass compositions, but lack the alkaline earth oxide and in some cases the aluminum oxide. They are now being given a variety of surface treatments, particularly with organosilanes.

* polystyrene-polybutadiene

Other research during the year has delineated the conditions under which the quench procedures used in the manufacture of reinforcing fiberglass can lead to the formation of islands of chemical attack and eventually a smooth corrosion layer on the surface of the glass. Specific combinations of glass composition, quench medium, and size formulation have been found to promote the formation of the corrosion layers. Predictions based on these results are presently being explored in novel processing variations.

The research made extensive use of the TEM, SEM, Auger, and ESCA central facilities. This research received important cooperation from Professor Cohen of the Department of Chemical Engineering and Professors Argon and Frank McClintock of the Department of Mechanical Engineering.

Preparation of Platinum Surface Alkyls (Professor George M. Whitesides)

Organic groups bonded to surface metal atoms are intermediates in such important catalytic reactions as hydrogenation and cracking which are run over platinum under reducing conditions. We have undertaken to prepare such intermediates in ways which will allow the study of these species by both chemical and spectroscopic means. During the last year, we have successfully demonstrated the feasibility of a new method of preparation: a preformed soluble platinum alkyl, in this case, 1,5-cyclooctadiene dialkyl platinum (II), is allowed to react with a clean platinum surface in the presence of molecular hydrogen. This surface has previously been examined by electron microscopy to determine the morphology. The alkyls were converted to alkanes and the cyclooctadiene to cyclooctane. At the same time, the platinum (II) was incorporated into the platinum surface. By using deuterium labeling techniques and studying the details of the kinetics of this reaction, we have established that it is an authentic surface reaction. However, much more work needs to be done to characterize the mechanism of this reaction more completely. In particular, we need to find whether the initial adsorption is on platinum (0) or platinum hydride surfaces.

This method of generating surface alkyls is attractive in that their reactivity is directly and convincingly revealed: large quantities of hydrogenated alkyls (RH) are formed and examined chemically. These studies provide a novel and direct method for preparing platinum alkyls, which can then be investigated by chemical and spectroscopic means.

Theoretical Studies of Platinum Surface Alkyls and Platinum-Support Interactions (Professor Keith Johnson)

Low coordination sites on platinum surfaces act as centers for carbon hydrogen reforming and reductive elimination of methane. We have studied the electronic properties of model compounds, such as L_2Pt and $L_2Pt(CH_3)H$ where L can be PH_3 or PPh_3 , which mimic the structure of single coordinatively unsaturated platinum atoms. The electronic structure was computed using the SCF-X α method which has been so successful in treating organometallic complexes. We have found that the platinum atoms in these model compounds can act effectively as centers for the catalytic reactions mentioned above. The electronic structure calculations show that in the intermediate complex $[L_2Pt(CH_3)H]$, the highest occupied orbital is simultaneously *bonding* between CH_3 and H and *antibonding* between Pt and CH_3 and H. This indicates that the Pt facilitates the formation of a bond between a hydrogen atom and an alkyl attached to the Pt.

The Structure and Properties of Metastable, Rapidly Solidified Glassy and Microcrystalline Alloys Quenched from the Melt (Professor Nicholas J. Grant)

The $Pd_{80}-Si_{20}$ glassy alloy, with a glass transition temperature of about 360°C was observed to undergo plastic flow at temperatures as low as 160°C at slow strain rates of 10^{-4} to 10^{-5} per second. At 250°C plastic strains as high as 8 to 10-percent were measured, with the fracture showing about 80 percent reduction of area. No evidence of crystallization was observed. Such high plasticity will be examined for purposes of consolidation of glassy alloy particulates. At the same time the Pd-Si glass has been alloyed with Zr and B, raising the T_g by another 80°C. This may allow for still higher temperature consolidation.

The Corrosion Behavior of Amorphous and Microcrystalline Alloys (Professor Ronald M. Latanision)

We have found that the corrosion resistance of Cu-Zr glasses in acid electrolytes is associated with the cathodic rather than anodic partial process. Indeed, we find that the exchange current density for the hydrogen evolution reaction is substantially lower on the glassy surface than on the crystallized surface. Hence, the glassy surface is a relatively poor catalyst for the hydrogen reaction, perhaps because of the absence of those sites which on a crystalline surface are thought to be recombination centers. In addition, potentiostatic polarization measurements suggest that activated dissolution of Cu-Zr glasses occurs by the electric oxidation of the more active element, Zr, with subsequent Cu oxidation contributing the anodic partial process at more noble potentials. At even more noble potentials the alloy passivates and Auger and ESCA characterization indicates that the largely oxide film is of the order of 60 Å thick. Extensive use of the Central Surface Analytical Facility has been made throughout this program.

Electrical Properties of Transition Metal Dichalcogenides (Professor Mildred S. Dresselhaus)

During the present year we have brought to near completion our program on the study of the electrical properties of the transition metal dichalcogenides. This effort is a joint program with Professor David Adler who focused on the interpretation of the results and Dr. Arthur Linz who focused on the materials preparation. Our major effort for the past year was directed toward the study of the electrical conductivity, thermoelectric power and Hall effect of single crystals of the alloy system $\text{NiS}_{2-x}\text{Se}_x$ in the range $0.1 \leq x \leq 1.5$. Our results cannot be understood using the one-electron approximation, but are explained quantitatively by assuming both strong electronic correlations and strong electron-phonon interactions in the 3d e_g band associated with the nickel ions. The $\text{NiS}_{2-x}\text{Se}_x$ compounds are of particular interest insofar as they permit study of the effect of increasing the bandwidth of NiS_2 without change of the basic occupation of states in the correlation-split e_g bands of NiS_2 . In the previous year we established that NiS_2 is a Mott insulator by a quantitative study of the electrical properties of the $\text{Ni}_{1-y}\text{Co}_y\text{S}_2$ system, where a change of y resulted in a change of the occupation of states in the correlation-split e_g bands. According to our model, pure stoichiometric $\text{NiS}_{2-x}\text{Se}_x$ ($x < 0.6$) is a Mott insulator, with an energy gap due to the correlation-splitting of the nickel e_g band. However, in all real samples, non-stoichiometry and/or trace impurities lead to a small concentration of free carriers at all temperatures. These carriers form small polarons, which ordinarily conduct only by means of thermally activated hopping in a very narrow band. For $0.45 \leq x < 0.6$, the conductivity decreases with increasing temperature below about 100K. We interpret this unusual behavior as due to small-polaron band conduction, a phenomenon predicted by Holstein and others at low temperatures but heretofore unconfirmed. For $x \geq 0.6$, small polarons do not form, and the system is metallic at all temperatures.

Electronic Structure of Defects in Glasses (Professors Marc Kastner and John Joannopoulos)

In the model proposed by Professors Kastner, Adler, and Fritzsche (University of Chicago), the electronic properties of the materials are controlled by pairs of charged defects which may be spatially close (IVAPs) or arranged at random distances (NVAPs). Professors Kastner and Joannopoulos have now probed certain aspects of the model in detail, experimentally and theoretically, respectively.

Professors Higashi and Kastner have provided the first *quantitative microscopic* description of the PL in a chalcogenide glass, As_2S_3 . Measurements of the total light time decay showed that the PL decays as a perfect power law ($t^{-0.9}$ at low temperature) over four decades of time. This shows that the PL arises from centers with an extremely broad distribution of radiative decay rates. It is most likely that such a broad distribution arises from a distribution of distances between partners of a defect pair. Such a model is consistent with the KAF suggestion that the PL centers are IVAPs, the broad distribution being just the range of possible IVAP separations. The Higashi-Kastner work also points out, for the first time, that the temperature dependence of the quantum efficiency of the PL requires an exponential distribution of activation energies for the non-radiative process.

Professor Joannopoulos and his students have recently succeeded in developing a realistic theoretical approach for the study of the electronic structure of defect states in amorphous semiconductors. The technique involves using realistic self-consistent pseudo-potential calculations

on periodic structures containing defects, as a basis for a tight binding model applied to more appropriate isolated defect structures. The one-electron states obtained from these calculations are then used to calculate total energies of defects with a semi-empirical approach. This allows them to determine the extremely important repulsive terms to the total energy (which are rather difficult to calculate) by fitting to experimental bond energies. The results of calculations for bonding coordination defect states in Se show that, contrary to the previous simple models by Mott, both the onefold and threefold coordinated defects give rise to non-degenerate, non-hydrogenic states well within the gap, without Jahn-Teller distortion. A surprising result is the approximate equality of the total energies of the unrelaxed neutral onefold and threefold defects, contrary to earlier estimates.

MILDRED S. DRESSELHAUS

Center for Space Research

The downturn in the number of opportunities for new space experiment development projects at C.S.R., referred to in previous reports, has steepened over the last year. No new starts were proposed in the NASA (National Aeronautics and Space Administration) fiscal 1980 budget, and developmental problems with the Shuttle threaten the limited resources available for space sciences and applications in the coming years. Until a working Space Transportation System is a reality, it appears that the national space program will be in limbo at least insofar as major university scientific participation in experiment development projects is concerned.

Continuation proposals have been submitted for ongoing research programs in X-ray astronomy, plasma physics, infrared astronomy, vestibular experiments on manned space flight, and studies in astrophysics. New proposals also were submitted in response to specific announcements of opportunity from NASA for future Spacelab flights and other programs; however, the current hiatus in national planning has cast doubt on the reality of their near-term funding.

The Small Astronomy Satellite program (SAS-3), under the direction of Professor George W. Clark of the Department of Physics, ceased data collecting operations when SAS-3 reentered on April 9, 1979 after three years and eleven months of orbital operations. Design lifetime was one year. All prelaunch scientific objectives were accomplished. Due to increased atmospheric torques toward the end of the mission, the standard 3-axes stabilized mode of operation had to be abandoned about two weeks prior to reentry. This eventuality was foreseen and the satellite was immediately spun-up to increase the angular momentum and thereby gain stability. An observation of the burst sources in the galactic center was begun. This procedure was so successful that the satellite was still on target, obtaining valid scientific data, on the last orbit prior to reentry.

As of June 1, 1979, a total of 135 papers attributable to SAS-3 have been published, accepted, or submitted to various scientific journals. Of this total, 109 are by the M.I.T. scientific staff, 14 by the Smithsonian Astrophysical Observatory (SAO), and 12 by guest observers (assisted by M.I.T. or SAO). The total has increased by 45 in the 12 months prior to June 1, 1979. At the present time, it is anticipated that NASA will fund the continuation of data analysis, at the current level, for two full years. A systematic analysis of the production data has just been started.

Professor Clark, the principal investigator for the SAS-3 program, is assisted by co-investigators, Professors Hale V.D. Bradt, Walter H.G. Lewin, and Saul A. Rappaport, all of the Department of Physics, as well as numerous scientific research staff, graduate and undergraduate students.

The launch of the Einstein Observatory (HEAO-2) with its X-ray telescope in November 1978 ushered in a new era in X-ray astronomy. The X-ray group at C.S.R. under the direction of Professors Clark and Claude Canizares has prime responsibility for the high resolution Bragg crystal spectrometer instrument which is for the first time performing detailed spectroscopic studies of celestial X-ray sources.

Highlights of this work include: 1) The discovery of emission from hydrogenic oxygen in the Virgo cluster of galaxies suggests the presence of relatively cool intra-cluster material accreting onto the giant galaxy M87. 2) The discovery and measurement of a variety of atomic lines from several galactic supernova remnants has permitted detailed temperature and element abundance determinations. 3) The detection of a broad emission feature from the compact galactic source Sco X-1 is indicative of Doppler velocities of $\sim 5000 \text{ km s}^{-1}$ or of electron scattering effects. Work on several dozen sources is continuing and new observations are being carried out regularly. The group also has used the other experiments on Einstein, particularly those capable of X-ray imaging, to locate new X-ray sources including two which are associated with poor clusters of galaxies and which have important implications for galaxy formation and evolutionary scenarios. Also participating in this effort are Visiting Professor P. Frank Winkler, Drs. Thomas Markert and J. Garrett Jernigan, and graduate students Gerald Kriss, Christopher Berg, and Mark Schattburg as well as several Undergraduate Research Opportunities Program (UROP) students.

Previous to the launch of the Einstein Observatory, a low cost imaging X-ray telescope rocket payload was developed at C.S.R. and was twice flown successfully (sounding rockets 25.021 UH and 25.023 launched in July 1977 and March 1978, respectively). The experiments carried out with this payload represented the first use of a Wolter type I telescope in extrasolar X-ray astronomy, and yielded the first true X-ray images of supernova remnants (Cygnus Loop, Puppis A, and IC443). These images were used to guide the search for spectral line radiation with the solid-state X-ray spectrometer on the Einstein Observatory, and also have stimulated theoretical investigations of the dynamics of supernova blast waves.

A new sounding rocket payload that will carry out a high sensitivity survey of the entire celestial sphere in the wavelength range $50\text{\AA} - 250\text{\AA}$ is currently under construction. The experiment features a wide-field (8° diameter) soft X-ray camera. The camera comprises a grazing incidence X-ray telescope with a microchannel plate detector at the focal plane. The angular resolution of the camera is $\sim 2'$ over the central 4° diameter region and $\sim 5'$ over the remainder of the 8° field. Photon energy discrimination is provided by thin-film filters which divide the wavelength range, $50\text{\AA} - 250\text{\AA}$, into several intervals. An objective grating, and filters which extend the wavelength coverage into the EUV, are planned for future missions.

With only minor modifications, the new sounding rocket payload could provide a valuable experiment for the Space Shuttle. In fact, such a proposal in response to AO-OSS-2-78 has been submitted. The experiment would be fixed in the Shuttle bay, surveying the sky wherever the Shuttle points. Over a series of Shuttle flights, such an experiment could completely survey the sky in the $50\text{\AA} - 250\text{\AA}$ wavelength band with an average sensitivity of $3 \times 10^{-11} \text{ cm}^{-2} \text{ sec}^{-1} \text{ keV}^{-1}$, an order of magnitude greater than could be obtained during sounding rocket flights. Professor Rappaport is the principal investigator for the research project. He is assisted by Professor Bradt.

Observations with the University of California at San Diego/M.I.T. High Energy X-ray and Low Energy Gamma Ray Experiment (A-4) aboard the High Energy Astronomy Observatory satellite (HEAO-1) were ended in January 1979 with the loss of attitude control propellant and the subsequent reentry of the spacecraft in March 1979. In the one and one-half years of operation, the instrument scanned the entire sky three times and also was pointed at a large number of galactic and extragalactic objects for more extensive observations.

A number of interesting results have now been reported. Preliminary analysis of the first six months of data from the sky survey indicates that about 40 celestial sources have been detected above 13 keV, 30 sources above 30 keV, 15 sources above 40 keV, and 5 sources above 80 keV. Three extragalactic objects are included in these statistics: Centaurus A, a nearby active galaxy; NGC 4151, a Seyfert galaxy; and the quasar 3C273. Among the more interesting galactic objects which have been detected are the transient source Nova Ophiuchi 1977, another transient source designated H1830-377, the object GX339-4 which is very similar to Cygnus X-1, and a source which is within 1° of the center of the galaxy. A number of these sources show variability on time scales of days.

Analysis of data obtained when the detectors were pointed at the quasar 3C273 resulted in detection of the object at X-ray energies of up to $\sim 100 \text{ keV}$. This was the first reported detection of high energy X-rays from a quasar.

Pulse profiles were obtained for a number of galactic X-ray pulsars including Hercules X-1, GX1+4, 4U1626-67, 4U0115+63, and OAO1653-40. Detailed analysis of the intensity of the pulse of 4U0115+63 as a function of X-ray energy showed a marked decrease in strength around 20 keV. This has been tentatively interpreted as cyclotron absorption occurring in the superstrong magnetic field close to the neutron star surface. If this interpretation is correct, then the energy of the feature is a direct measurement of the magnetic field strength close to the neutron star. Professor Lewin is the principal investigator of the M.I.T. portion of this collaborative program. He is assisted by Dr. Alan M. Levine of the research staff.

In the early summer during the past four years, Professor Canizares and Dr. Jeffrey M. McClintock have observed galactic and extragalactic counterparts of X-ray sources at Cerro Tololo Inter-American Observatory using the 1.5m and 4m telescopes. In collaboration with Dr. Josh Grandlay of the Center for Astrophysics, the May 1979 observations resulted in: 1) six Einstein X-ray sources with quasars; 2) discovery and study of the optical counterpart of the X-ray nova Centaurus X-4; 3) the search for new counterparts in the globular cluster NGC6712, in the galactic bulge and elsewhere; and 4) the significantly increased data base on the established counterparts of the X-ray burst sources, X-ray pulsars, and Seyfert galaxies.

The level of M.I.T. activity at the McGraw-Hill Observatory has increased significantly during the past year. In addition to the ongoing galactic and extragalactic programs pursued by Drs. Canizares and McClintock, Dr. Lawrence Petro, formerly a postdoctoral student at the Hale Observatories and now at M.I.T., has initiated a long-term program of monitoring the pulsations of HZ Her. Four graduate students are currently part-time participants in our observing programs. During the past year, five manuscripts have been submitted or accepted for publication which are based wholly or in part on M.I.T. observations performed at the McGraw-Hill Observatory. The increased productivity of the Observatory is largely due to the major improvements in instrumentation which have occurred primarily during the past two years including the Michigan Mark II photon-counting spectrometer, a TV guider for positioning very faint stars on the slit of the spectrometer, a computer system provided by the Nierling Foundation of Phoenix, a CAMAC system purchased from M.I.T. funds, and an improved mirror support system.

In May of this year, a new X-ray detector with 1500 cm² area (energy range 20-200 keV) was successfully flown from the National Scientific Balloon Facility in Texas. This hard X-ray detector is the largest and most sensitive ever flown. During 10 hours of observing, three extragalactic and two galactic sources were studied. The extragalactic objects included a quasar, an N galaxy and a Seyfert galaxy. Observations of the N galaxy, 3C382, mark the first successful detection of hard X-rays (>50keV) from this class of objects. Cygnus X-1, one of the two galactic objects studied, is widely regarded as a good candidate for a black hole. These observations of Cyg X-1 should permit more definitive tests of several predictions of black hole models of the source. Professor Lewin and Dr. George R. Ricker are co-principal investigators.

During the past year, Dr. Ricker and his colleagues have completed the initial phase of a CCD X-ray detector program. The principal goal of this phase was to demonstrate the detection of single photons, which was successfully achieved. This program is continuing in cooperation with the Charles Stark Draper Laboratory. The ultimate goal is to develop a detector for use as a focal plane instrument on a large, reflecting X-ray telescope (such as the Advanced X-ray Astrophysics Facility scheduled for launch in the mid-1980s). Such an instrument would offer uniquely high spatial and spectral resolution, good quantum efficiency, and long-term stability in a space environment.

For observations of spectra of cosmic X-ray sources, non-dispersive spectrometers offer unique advantages. Because they are capable of viewing an extended energy range with high efficiency, they are ideally suited to the study of broadened features, as well as continua, and can perform spectral-temporal correlations in fluctuating sources. Previously, such non-dispersive spectrometers required cryogenic cooling for proper operation. During the past year, Dr. George Ricker has undertaken a program to develop a room temperature, non-dispersive spectrometer based on mercuric iodide, a recently developed semiconductor.

Two configurations for this instrument are being considered. The first will be optimized for the energy range where reflecting X-ray optics are effective ($\sim 0.5 - 5$ keV), and should be ideally suited for use as a focal plane instrument on the Advanced X-ray Astrophysics Facility. A second configuration will be optimized for high energies (>20 keV), and should be capable of detecting cyclotron and nuclear lines in cosmic sources at unprecedented levels of sensitivity.

During the past year, extensive studies of a new technique for studying the density and partial composition of the Earth's lower thermosphere were undertaken. This technique uses instrumentation previously developed at M.I.T. for X-ray astronomy studies. The method is based on measuring the attenuation of point-like cosmic X-ray sources as they rise and set through the atmosphere, as observed from a satellite. Flight opportunities for an optimized instrument are planned for in the early-to-mid 1980s in conjunction with the Spacelab or Upper Atmosphere Research Satellite programs. Dr. Ricker is principal investigator for this research program.

The Voyager spacecrafts continue their exploration of the outer solar system. The two spacecrafts were launched in August and September of 1977. Voyager 1 encountered Jupiter at its closest approach on March 5, 1979, and is currently on its way to Saturn where it will arrive in November 1980. Voyager 2 will encounter Saturn in August 1981 and possibly be redirected toward a Uranus encounter in 1986.

The Voyager spacecraft carries 11 scientific experiments. One of these was specifically designed by M.I.T. scientists to explore the ionized particle environments of interplanetary space and the Jovian and Saturnian magnetospheric systems. This plasma experiment measures the plasma properties of both ions and electrons including velocity, density, and temperature for a wide range of flow directions in both the solar wind and the planetary magnetospheres.

At Jupiter, the experiment team will study the interaction of the solar wind with Jupiter; the sources, properties, form, and structure of the Jovian magnetospheric plasma; and the interaction of the magnetospheric plasma with Jupiter's Galilean satellites.

It has been known for almost a decade that neutral sodium atoms exist in the vicinity of the Galilean satellite Io and more recently it has been found that other heavy atoms and ions are concentrated in this region. For this reason a special effort was made to design the Voyager plasma experiment so that these components of the magnetospheric plasma could be measured. At the exciting Voyager 1 encounter with Jupiter (March 5, 1979), the experiment worked better than its designers could have hoped, and unexpectedly large numbers of heavy ions were found just inside the orbit of Io. Possible ionic species include O^{++} , S^+ , S^{++} , S_2^+ , and SO_2^+ . These ions are almost certainly associated with the volcanic activity observed on Io. A comparison of the *in situ* data on plasma ions with that from other Voyager experiments, especially the ultraviolet spectrometer, should provide an explanation for the origin and excitation of the observed ionic species. Professor Herbert S. Bridge is principal investigator for the Plasma Science Experiment on the Voyager spacecrafts. He is assisted by Professors John W. Belcher and Stanislaw Olbert of the Department of Physics, and Drs. George Gordon, Alan J. Lazarus, and James D. Sullivan.

The M.I.T. solar wind experiment on the IMP 8 spacecraft continues to be one of the best sources for interplanetary solar wind observations at a distance of one astronomical unit (A.U.) from the sun (i.e., at Earth's orbit). During the past year, comparisons have been made between observations of interplanetary shock waves at the position of IMP 8 (1 A.U.), HELIOS (0.3 - 1.0 A.U.), and VOYAGER (3 A.U.). These show the radial evolution of such transient phenomena and also are being used to study relatively steady features such as high velocity solar wind streams which corotate with the sun.

The IMP 8 data are also being used in conjunction with rocket-borne X-ray telescope observations of the solar corona (by American Science and Engineering, Inc.) in a joint study of the relationship between coronal holes (areas of low X-ray emission) and high-speed solar wind streams. Such streams could often be traced back to large, equatorial coronal holes when observations were made during the descending phase of the last solar cycle. Now, in the rising portion of the cycle, the corona has no holes clearly traceable to the streams, yet the streams still persist but with lower maximum velocities and somewhat narrower widths. The question to be pursued is whether such a stream can be produced by smaller coronal structures.

The IMP data are also being used as indications of the external input for studies of phenomena within the Earth's magnetosphere.

Professor Bridge is principal investigator and is assisted by Drs. Lazarus and Sullivan.

In the area of infrared astronomy, an outstanding result was obtained this past year with the Fourier Transform Spectrometer on the Kitt Peak 4-m telescope. It is the detection of CO bandheads *in emission* in the $2\mu\text{m}$ spectrum of the Becklin-Neugebauer Object, an infrared source

that is buried in one of the Galaxy's densest molecular clouds and is thought to be a protostar*. The excitation of the upper levels from which CO emission was definitely detected (the $v = 4 \rightarrow 2$ bandhead) corresponds to $E/k \sim 19,000^\circ\text{K}$. Analysis of the absolute fluxes in and shapes of the bandheads indicates that the emission occurs in an extremely compact ($<1 \text{ A.U.}$), dense ($n_{\text{H}} > 10^{10} \text{ cm}^{-3}$) region, caused by collisions with atomic hydrogen. This detection therefore represents a piercing view through the gas and dust surrounding the star, and further studies of the gas dynamics in this region are likely to provide far more specific information on the evolutionary status of the B-N object (e.g., is it still accreting material from the surrounding cloud?) than has been available heretofore. Professor Susan G. Kleinmann of the Department of Physics is principal investigator for this research.

Research by the staff of the Man-Vehicle Laboratory under the direction of Professor Laurence R. Young of the Department of Aeronautics and Astronautics continued in the areas of: habituation to novel visual vestibular interaction and its application to flight simulation; special pedagogic strategies in arithmetic; and ski accident research. Professor Young is assisted in this research by Professor Charles Oman and Drs. Howard Hermann, Alfred Weiss, and Alan Natapoff, all of the Department of Aeronautics and Astronautics.

The Center for Space Research is assisting Professor Young in his research of laboratory and flight tests in Spacelab 1 to investigate space motion sickness, and any associated changes in otolithmediated responses occurring during weightlessness, and the carryover of any such changes to post-flight conditions. The experiments are being prepared in conjunction with other investigators of the Defense and Civil Institute of Environmental Medicine in Canada. Launch of Spacelab 1 is currently scheduled for August 1981 or possibly later depending on resolution of Shuttle development problems.

Highlights of the past year have been the week of crew training, at which time there was an excellent opportunity to get to know the seven candidates for the mission and to obtain some baseline data for comparison with that observed during flight, and the KC-135 flights which gave many members of the Laboratory the opportunity to actually experience weightlessness. These flights were of particular importance in that they provided the opportunity to evaluate equipment and protocols designed in a 1-g reference frame when they were operated in a 0-g environment. Significant modifications were found to be necessary to accommodate the changes imposed by weightlessness, many of which were not conceptually obvious. Further crew training is scheduled for the early fall of 1979.

HERBERT S. BRIDGE

Energy Laboratory

During the past year the Energy Laboratory continued to emphasize three major areas of research: the processing and combustion of *fossil fuels* (both natural and synthetic) and the resulting health and environmental effects; the design of facilities for *central power generation* (both fossil fuel and nuclear) and associated safety and environmental issues; and the effects on *energy supply and demand* of policy, economic, and management influences resulting from the behavior of government, industry, and other groups. Other recent projects fall outside these three main areas, since a concerted effort is being made to broaden both the Laboratory's scope of research and its involvement with other groups.

Operating expenses of the Energy Laboratory during fiscal 1979 were about \$10.5 million -- an increase of about 25 percent above last year. These 1979 expenses were funded by sponsors of research projects (75 percent by the Federal government) supplemented by about \$0.6 million in grants and gifts from industry and foundations. The number of faculty associated with the Laboratory during the year averaged about 45, the Laboratory professional research staff about 95, and participating students about 225.

* A star which has not yet (or only recently) begun hydrogen burning in its core.

While the continuing growth of the Laboratory is evidenced by increased personnel and funding, another change in the character of Laboratory work is also apparent: in many laboratory activities there is increasingly close interaction with people and organizations outside M.I.T.

Four formal vehicles for such interaction -- the Center for Energy Policy Research (C.E.P.R.), the Electric Utility Program, the University Coal Research Consortium of the Northeast, and Advanced System for Process Engineering (ASPEN) -- have become increasingly active. The C.E.P.R. has become well established and in the past year has expanded its Associates membership into new sectors, including labor and urban groups. The C.E.P.R. has held three major meetings, two concerning world oil and one reviewing a new concept developed at the Energy Laboratory for electric utility management and control. These meetings have brought together representatives from government, industry, labor, universities, and public interest groups.

Eight utilities have been participating in the 1979 Electric Utility Seminar and Workshop Program -- the major activity within the Electric Utility Program of the Laboratory. Several workshops have been held, and utility representatives have exchanged ideas with M.I.T. personnel involved in research relevant to utility needs. Proposals developed as a result of workshops in the past year have led to contracts for research on nuclear reactor and plant engineering, environmental management, and coal utilization.

The third and fourth vehicles, ASPEN and the University Coal Research Laboratory of the Northeast, are discussed below.

Work on international energy studies has expanded significantly in the past year. In cooperation with researchers from Harvard University and from the M.I.T. Center for International Studies, members of this Laboratory group organized three years ago an ongoing program of meetings concerning international nuclear energy policy. Since then, three meetings have been held with experts from the Federal Republic of Germany and two with experts from Japan. An endowment of \$1 million pledged to M.I.T. by the Japanese government will encourage cooperative work on international energy policy issues. Much of this work will be based in the Laboratory's international program.

Several of the physical facilities that were being developed a year ago have been completed and are now being used. With support from a group of northeast utilities, researchers are using the new Combustion Research Facility (C.R.F.) to study individual burner control systems that can limit NO_x emissions from combustion of high-nitrogen fuels. The Electric Power Research Institute is funding work using the C.R.F. to investigate combustion of coal-derived liquids. In addition, researchers at the C.R.F. have been approached by several corporations about performing work in the combustion area, and they are now negotiating a contract on burning of coal-oil mixtures. The pilot-scale experimental fluidized bed combustor is also in operation. With support from the Environmental Protection Agency, this combustor is being used to explore ways to reduce NO_x emissions from fluidized combustion.

Several projects involving computer modeling have progressed to the point where interaction with potential users is beginning. Developers of the fluidized bed combustion model are seeking out several boiler manufacturers to help in testing their interim model. Developers of ASPEN (Advanced System for Process Engineering) are approaching about 60 energy, chemical, and other companies to participate in testing it with real process design problems. Participating companies will have access to ASPEN through M.I.T. or in-house facilities.

Members of the Energy Laboratory also have taken active roles in the formation of two new organizations, one on campus and one off. The Energy Laboratory and the Harvard-M.I.T. Division of Health Sciences and Technology established an M.I.T. Center for Health Effects of Fossil Fuels Utilization with associated interdisciplinary research programs on environmental toxicology under grants from the National Institute of Environmental Health Sciences. Over the next five years the new Center will carry out a comprehensive program of interdisciplinary research to: 1) determine the extent and mechanisms of formation of combustion-generated emissions products; 2) evaluate those species for mutagenic and/or carcinogenic potential; and 3) identify control methods to mitigate hazards. This integrated program demands close collaboration among experts in combustion science and engineering, the biological sciences, and the physical sciences.

M.I.T. was recently designated the lead institution of the new University Coal Research Consortium of the Northeast. The consortium consists of 13 universities in New England and New York that are joining together to develop a comprehensive research, educational, and industrial program to promote the clean use of coal and to foster the development of national coal resources. Consortium members chose as director Professor Jean F. Louis, associate director of the Energy Laboratory. The consortium will submit a proposal to the US Department of Energy in an effort to obtain funding as one of the 13 University Coal Laboratories mandated by the Surface Mining Control and Reclamation Act of 1977.

The major administrative change during the past year was the formation of an executive committee within the Laboratory. The committee's purpose is to establish broad policies and guidelines for Energy Laboratory plans and operations, covering program, personnel, and financial matters. Committee members are Loren C. Cox and Barbara A. Johnson (secretary), and Professors Donald R.F. Harleman, Henry D. Jacoby, John P. Longwell, Jean F. Louis, Malcolm A. Weiss (chairman), David C. White, and David O. Wood.

During this year the Energy Laboratory has awarded several Cabot fellowships to graduate students and postdoctoral researchers working in the energy area. Since fall of 1978 graduate student Christopher B. Alt has been supported in his regionally disaggregated study of the industrial demand for energy. D. Alec Sargent, also a graduate student, began in January 1979 to work on various aspects of international coal trade, with particular emphasis on transportation. As of July 1 graduate student Debra Kaden will begin developing new techniques for examining the mutation of human cells in culture; these techniques will be valuable for determining the effects of combustion products on human cells. Starting in the fall of 1979 Dr. Guy Burgess, who received his Ph.D. from the University of Colorado in June, will study the social impacts of energy conservation. All of these fellowships are part of a five-year program established in 1977 by a grant from the Cabot Corporation Foundation.

A second book in the Energy Laboratory Series has been published by the MIT Press. *Electric Power in the United States: Models and Policy Analysis*, by Martin L. Baughman, Paul L. Joskow, and Dilip P. Kamat, describes a unique engineering-economic model developed at the Energy Laboratory and at the University of Texas; it also examines the effects that a wide range of energy policies simulated in the model would have on the demand and supply of electricity and on the utilization of fuels by the electric power industry to the year 2000. The first book in the Energy Laboratory/MIT Press series was *Chemical Equilibria in Carbon-Hydrogen-Oxygen Systems*, by R.E. Baron, J.H. Porter, and O.H. Hammond, Jr., published in 1976.

The office space problems of the Laboratory were eased by the move of members of the C.E.P.R. into the newly renovated fifth floor of the Suffolk Building (E38) in Kendall Square. However, plans for the overall renovation of the Webster Building (E40) have been delayed. According to the new schedule the headquarters and non-research Energy Laboratory people will move into the fourth floor in 1980 and the third floor in 1981.

The summaries that follow describe many of the Energy Laboratory projects active during the past year. Although most projects involve research teams consisting of faculty, staff, and students, only principal investigators are mentioned by name because of space limitations. The project descriptions are organized according to the current Laboratory administrative structure; however, there are projects that do not fall within a specific Laboratory program area. Current examples include identification of improved technology for the large-scale recovery of shale oil, and a project that is developing measures that the government can take during emergencies to cut transportation fuel demand. The latter is a joint project with the Center for Transportation Studies. By maintaining such organizational flexibility, the Laboratory encourages its researchers to investigate new areas, thus ensuring its growth and responsiveness to the interests of its personnel and to the needs of the nation.

ENERGY SYSTEM MODELING AND ANALYSIS

Professors Morris A. Adelman, Gordon Kaufman, and Martin Zimmerman and Dr. John Houghton are undertaking a review and assessment of the methodology of reserve and resource estimation for coal, oil and gas, and uranium.

Dr. Houghton and Professor Kaufman are extending their resources and reserves estimation work to describe a major gap in supply estimation -- the exploration process. A case study of the Grants Mineral Belt in northern New Mexico offers information on such issues as field size distribution and the discovery process.

The US light water reactor sector (and, by extension, the entire nuclear sector) is in danger of withering away, partly because of technological problems, but mainly because of proliferating political and social uncertainty. The entire sector will collapse if these trends continue. Professor David Rose is suggesting new technical and institutional arrangements to reverse these trends.

Professor Kaufman is investigating the potential contributions of modern systems theory to the development of methodologies that will meet the need for judicious and timely evaluation of trends in the availability of primary energy resources. Two prototype models were developed: a disaggregated model of optimal petroleum exploration focusing on the geological, technological, and behavioral determinants of supply at the play level; and an aggregate model of optimal petroleum exploration and production focusing on pricing behavior and the effect of alternative market structures on the optimal curve paths of these activities.

Professor Robert Pindyck is undertaking research to study the linkages between exploration and production of nonrenewable resources, examine the characteristics of optimal exploration patterns, consider the effects of various uncertainties on resource exploration and production, analyze and design government policies affecting natural resource markets, and model the behavior of international resource markets.

Professor Zimmerman is assessing a wide range of trade-offs and costs involved in various US coal policy options using an integrated model of coal supply and demand. The model links together two major submodels: the coal supply model and the demand model. The models are linked in a linear programming formulation that minimizes the cost of mining and transporting coal from mining regions to demand regions. The models have been linked and tested, and policy simulations have been analyzed. Among the issues being examined are Western coal development, taxation policy, nuclear energy as an alternative to coal, and control of air pollution emissions.

Dr. Knut Mork and Mr. Wood are leading an analysis of technology choice, energy conservation, and other issues relevant to the future of the world aluminum industry. Special attention is given to the economic significance of new and emerging technologies. Other topics include the international location of the industry, its competitive structure, and the future of the bauxite cartel.

Dr. Mork and Professor Daniel McFadden are conducting an integrated analysis of the overall economic effects of changes in energy prices. Aspects included are inflation, fluctuations in employment and economic activity, and changes in the energy-GNP ratio. The project includes an analysis of the 1974-75 recession as well as more current events.

Dr. Leon Glicksman is conducting research to identify concepts that could reduce the energy used in space heating and/or substitute nuclear or coal-derived sources for high-grade fossil fuel. Possible technological improvements also are being explored. The work has focused on two main areas. First, the energy savings and economics of solar, heat pumps, and district heating are being evaluated and compared with more conventional systems. Second, identification, performance, projection, and economic evaluation of advanced concepts utilizing electrically driven heat pumps are being performed.

Professor Zimmerman is undertaking research to estimate how rate-of-return regulations, safety regulations, and environmental regulations have affected the costs and uncertainties associated with building new power plants. He hopes to measure the impact of these regulations upon the choice between nuclear and coal facilities in the 1970s. He is currently compiling a data base and will perform the analytical work during the summer of 1979.

Dr. James Gruhl and Professor Fred Schweppe are developing and validating correlations between health impacts and air pollution concentrations. In addition, they are developing mechanisms to use these correlations to determine the desirability of, and research funding priorities for, future energy cycles. The health impact data is being collected in 36 districts that have strong ambient pollutant concentrations but that are in close proximity to one another, to avoid some commonly occurring confounding variables.

Energy policy simulation models are increasingly important tools in policy research and analysis, and in interpreting energy policy decisions. To ensure credibility, models must be subjected to effective peer review and independent assessment. The Energy Model Assessment project, led by Mr. Wood and Dr. Gruhl, has completed independent assessments of two important policy models, the Baughman-Joskow Regionalized Electricity Model and Wharton Annual Energy Model, and is currently engaged in assessing the ICF Coal and Electric Utilities Model. In addition, the project has conducted research on methods of analysis for model structure and on procedures for efficient organization of policy model analysis. The project will be expanded to include assessment of six energy policy models over the next three years.

INTERNATIONAL ENERGY STUDIES

Professors Adelman, Jacoby, and Pindyck are conducting extensive research into the world oil market to develop improved methods and data and a better understanding of the market's characteristics. Included are a study of the OPEC cartel, forecasts of future world oil prices, analysis of consumer- and producer-country policies, study of trade patterns in oil, and analysis of potential financial problems created by changes in oil price and volume. Several supporting economic models have been developed.

Professor Jacoby and Dr. Thomas Neff are studying international nuclear fuel strategies to assure supply of low-enriched uranium fuel. All stages of the nuclear fuel cycle are examined, including supply and demand factors, market and political conditions, and overall operation of the international fuel supply system. Implications for national and international policies are also explored.

Professors Adelman and Jacoby are developing a model that represents the influence of financial considerations on investment and production decisions of oil-producing countries. These decisions can then be analyzed in light of the cost and availability of foreign financing, the risk-return characteristics of external investment, and the risk-return characteristics of internal investment in oil and gas development.

Dr. Neff evaluated the implications of changing nuclear fuel markets on US nonproliferation policies. A principal conclusion is that US nonproliferation goals would be best served by a legislative basis that recognized decreased US leverage in this area and allowed for a more flexible, multilateral approach.

Professor Michael Driscoll and Dr. Neff are studying the technical feasibility and economic and security characteristics of bimodal systems in which breeder development is pursued in one region, while a second region relies on thermal reactors fueled with low-enriched uranium. Economic and political incentives and disincentives for supplier and consumer countries are of particular interest. An overall strategy for assured long-term supplies of nuclear fuel is being formulated.

Dr. Neff and Professor Jacoby are analyzing the industrial and governmental structures of the changing international uranium supply system, with primary emphasis on the evolving market structure and its implications for US policy issues. Particular attention will be given to potential instabilities and vulnerabilities in the supply system.

UTILITY SYSTEMS

Drs. Neff and Richard Tabors, Drew Bottaro, Esq., and Professors Gary Lilien and Thomas Nutt-Powell are leading the photovoltaics project, which provides policy support to the US Department of Energy (DOE) on commercialization and market acceptance of photovoltaics. Research on institutional and potential market responses to photovoltaic power systems is being conducted in conjunction with the technical testing of new systems to facilitate their eventual adoption when system price is reduced. This work seeks to identify potential impediments to

adoption that could prevent significant market penetration or that would require design alteration prior to introduction. It offers a market-oriented input into the photovoltaic development process.

Dr. Tabors assisted the Solar Energy Research Institute (SERI) in analyzing the "market pull" strategy developed by the Photovoltaics Branch of DOE. The Laboratory developed a set of projections for long-term photovoltaics markets in grid-interconnected applications, residences, schools, and central power stations. The analysis estimated the worth of such photovoltaic power systems to their owners. The second portion of the SERI contract involved critical review of documents and methodologies developed by SERI as part of the total venture analysis activity.

Professor Schweppe and Dr. Tabors are investigating the potential impacts of new utility control systems in the coming decades. These systems will permit utilities to charge electric power rates that more nearly equal current costs of generating power, as well as permitting customer generation to be introduced into the full utility system and paid for accordingly.

Dr. Tabors is conducting research to project the eventual economic impact of dispersed residential solar heating and hot-water systems on the New England Electric System (NEES), including: a careful review of literature; analysis of electric demand and socioeconomic growth; a review of solar collector system penetration into the new home construction market; and an analysis of the energy requirements of solar heating and hot water systems. Several growth and market penetration scenarios have been developed.

Dr. Tabors is investigating economic issues that will define the market for advanced flywheel energy storage, which supplements photovoltaic energy conversion systems on a residential scale.

Professor Schweppe and Dr. Tabors are developing techniques for forecasting the development of industrial and commercial cogeneration within a single utility. These methods will be applied to data for the NEES service area to estimate the local potential for cogeneration, its capacity planning impacts, its revenue effects, and aspects of the forecasting effort requiring further research.

Professor Schweppe and Dr. Tabors are developing an electric generation expansion analysis system (EGEAS) to analyze the effect on expansion plans of rate structure changes, load management techniques, cogeneration, new energy technologies, alternative configurations of transmission and distribution, and interconnections between major utility systems.

Professor White developed a model for estimating the impact of industrial cogeneration and for studying its historical economics. The analysis showed that the past decline in cogeneration could be explained by cost considerations, but now its least cost share of total electricity supply will rise to 9 percent by 1985. Too much cogeneration can hurt as much as too little; more than a 20 percent or less than a 4.5 percent share for cogeneration would cost the nation at least \$10 billion extra in discounted capital and fuel expenses. The effort also noted the important interactions between Federal cogeneration and industrial oil and gas replacement policy, suggesting directions for further research.

ENERGY CONVERSION

Professor Louis and Dr. Arthur Sotak are conducting analytical and experimental research to help develop Combined Cycle (gas turbine/steam turbine) power plants that will have efficiency and operation cost advantages over contemporary power plants. Research is focused on three critical areas affecting the gas turbine: turbine cooling, materials corrosion, and high-temperature desulfurization of fuel gas.

Professor James Melcher is conducting an experimental investigation into electrofluidized beds (EFBs) and electropacked beds (EPBs) for the high-temperature collection of particulate products of coal combustion. Experiments cover not only temperatures of interest to the utilities' com-

bustion gas clean-up problems, but temperatures in the range of 600-1500°F as well. Of special interest are applications to atmospheric pressure fluidized bed gas clean-up.

Professor Louis is studying fluid mechanics and heat transfer within closed, sealed thermosyphon loops or cavities operating in large centrifugal and Coriolis acceleration fields. The project will determine feasibility and design criteria for using thermosyphons to cool industrial gas turbine blades.

Professor Louis recently completed a comprehensive interdepartmental research and development project into key aspects of open-cycle coal-fired magnetohydrodynamic (MHD) power generation. The research involved testing and evaluating electrode materials and electrode modules; coal combustion studies; theoretical analysis and modeling of critical phenomena in MHD generators and of MHD plant components; experimental studies in a disk generator; and participation in a joint US/USSR Cooperative Program in MHD Power Generation. This three-year effort was completed in December 1978.

Professor Louis is overseeing a continuing, comprehensive interdepartmental research and development effort on key aspects of open-cycle MHD power generation. Work includes experimental and analytical investigation of: phenomena in MHD generators important for the design of MHD electrode and insulating walls; open-cycle MHD disk generators; testing and development of electrode modules; and coal combustion kinetics research relevant to two-stage combustion.

Professor Carl Peterson organized a three-day working conference held at Endicott House in January 1979, to consider and recommend ways to more rapidly commercialize new coal mining technologies. The meeting included approximately 50 high-level representatives of industry, government agencies, and academia. Recommendations for further action were made, and an additional meeting has been scheduled to develop streamlined procedures for testing new equipment. Further meetings will follow.

Professor Melcher has conducted a survey of legislation that could affect utilities' air pollution limitations. Innovative hardware, including the M.I.T. electrofluidized bed, that might ameliorate the utilities' problems, was chosen and reviewed. Five plants owned by the sponsoring utilities were visited, scenarios for future air pollution requirements were developed, and innovative hardware was deployed to solve the hypothetical plant requirements.

Professor Louis and Dr. Shao Tung oversaw improvements to the fluidized bed combustor (FBC) system model developed during Phase I. All four state-of-the-art component models used as building blocks have been replaced by more adequate models. Model results on combustion efficiency and desulfurization performance have been found reasonable. An FBC-data base management system is being developed.

STATIONARY COMBUSTION

Dr. Joel Levy and Professor Adel Sarofim are examining the chemical processes influencing conversion of fuel-bound nitrogen to nitrogen oxides in the combustion of fossil fuels. Their work will establish the "state of the art" in modeling NO_x emissions from stationary source combustors, and identify critical gaps in the current data base. Both finite-rate homogeneous gas-phase and heterogeneous gas-solid reaction chemistry are considered.

Professors James Keck and John Heywood are developing and testing alternative combustion strategies to reduce the levels of NO_x pollutants generated from synthetic liquid fuels derived from coal and shale oil. Optical techniques to monitor a two-stage burner operation and theoretical models to interpret and predict the experimental results are being developed.

Professors Sarofim and Janos Beer are conducting research to determine the paths and rates of transformation of fuel-nitrogen in pulverized coal particles and liquid fuel droplets. Results will be used to formulate staged combustion design strategies to minimize the conversion of fuel nitrogen to NO_x.

Professor Louis is designing and developing an ultra-high swirl, second-stage combustor for use in an electrical power generation system based on the disk MHD generator. This combustor may eliminate need for the expensive, complex, and inefficient inlet guide vanes now required for MHD disk generators. Large-scale water model tests are under way, as well as an improved mathematical model of the flowfield. A small-scale hot combustor will be designed and tested in a later stage.

Professors Sarofim, Heywood, Keck, and Longwell are investigating a method to reduce NO_x emissions from the combustion of fuels derived from shale and oil, based on use of high air preheat to obtain flame temperatures high enough to overcome kinetic limitations. Experiments have been conducted on premixed flat-flame burners and on an oil-fired furnace. Results demonstrate that increased temperature results in decreased emissions, and a predictive model of NO_x emissions will be developed.

Professor Sarofim and Dr. Levy are continuing to provide general guidance to the Environmental Protection Agency Fundamental Combustion Research (FCR) Program, which is designed to reduce NO_x emissions in coal- and shale-derived fuel combustion. Efforts include assessing models of fuel nitrogen conversion, defining and interpreting experiments, and screening the complete fuel nitrogen gas-phase reaction set.

Professors Beer and Sarofim are developing an optical adaptive feedback control system to maintain thermal efficiency in burner flames and to reduce pollutant emissions. A commercially available system is being tested to develop an optimal air/fuel ratio.

Professors Beer and Sarofim are conducting research to demonstrate the feasibility of controlling NO_x and soot (carbon) emissions through a staged combustion approach. Experiments will be designed and carried out to investigate two types of staged furnace flames commonly used in boilers, and a parametric study will be performed for the effects of primary zone equivalence ratio, air pre-heat temperature, primary zone resident time, and mode of fuel atomization.

TRANSPORTATION PROPULSION

Professor William Unkel is developing analytical models to evaluate practical spark ignition circuit/fuel combinations and to improve engine performance. A constant-volume combustion chamber has been constructed, and further experiments will be performed to confirm ignition theories.

Dr. Joe Rife is conducting engine experiments and modeling to develop physical and mathematical descriptions for incorporating knock into thermodynamic models.

Drs. Rife and David Hoult are applying a rapid distortion theory to follow the turbulent flow field during the engine cycle. Results should produce an improved physical description of fluid motion in an engine cylinder and a method for relating this flow field to engine geometry and operating conditions.

Professors John Heywood and James Keck and Drs. Rife and Rashidi are obtaining correlations for the rate of flame propagation in a spark ignition engine from the simultaneous measurement of pressure and flame dimensions, using high-speed photography. These correlations support existing techniques to predict turbulent flame propagation in the combustion chamber and overall engine performance.

Drs. Rife and Hoult have designed and built a high pressure laboratory burner to explore the influence of fuel characteristics on particulate formation and burnup in gas turbine combustors. Results represent the impact of fuel characteristics on particulate formation in full-scale combustion systems, and the role of mixing on soot formation is being examined.

Dr. Rife and Professor Heywood will perform experiments with a single cylinder diesel engine and a high-pressure laboratory burner to develop a basic modeling methodology for the formation and burnup of particulates in diesel engines.

Dr. Rife is conducting a feasibility study to develop a program to study soot formation in a diesel engine and its biological impact over the practical range of engine operating conditions and fuel types.

Professors Heywood and Keck are studying hydrocarbon formation and oxidation in spark ignition engines. Results are being used to define processes that relate exhaust hydrocarbon levels to engine operating and design variables.

Professor Stephen Pope is developing a numerical model to calculate the properties of turbulent flows with combustion. In particular, the model accounts for the interaction between turbulence and chemical reaction. Calculations have been made and the results compare well with measurements for a chemically reacting turbulent mixing layer.

FUEL CONVERSION AND HEALTH EFFECTS

Professor Jeffrey Steinfeld is using laser-induced fluorescence excitation spectroscopy to determine concentrations of polynuclear aromatic hydrocarbons in fossil-fuel combustion sources.

Professor Longwell is investigating the technical and economic feasibility of producing high heating value, storable, low sulfur fuels by pyrolysis of coal in the presence of dolomitic stones for SO₂ capture. Results have demonstrated that this method provides a pyrolysis gas rich in hydrogen, methane, and higher hydrocarbons and virtually devoid of sulfur compounds, well suited to peaking requirements of electric utilities and large industrial energy consumers.

Professors William Thilly and Ronald Hites are conducting research to chemically characterize organic compounds found in urban air particulates; to develop mass spectrometric methods of isomer differentiation; to develop a way to assess the potential for mutagenesis by both pure compounds and complex mixtures in genetically normal human cells; and to design and perform experiments probing the process of mutation after chemical modification of the genetic material.

Professor Longwell is researching the formation of soot and polynuclear aromatics during combustion of vaporized and premixed liquid fuels. Laboratory equipments should shed light on the chemistry and physics of formation of mutagenes for a variety of shale- and coal-derived fuels.

Professor Longwell is collecting and analyzing samples of particulates produced by commercial combustion systems to determine composition and toxicity. The results will establish the relationship between laboratory-generated particulates and those generated in the field.

Professors Longwell and Jack Howard and Dr. William Peters are investigating the potential for extracting high-quality liquid fuels through thermal degradation of such biomass materials as pure cellulose (paper) and wood. The program will yield better data on the kinds and amounts of liquids that might be obtained from biomass pyrolysis and an indication of what operating conditions provide the most desired products.

Professor Charles Satterfield is studying a slurry-bed reactor for the Fischer-Tropsch synthesis. This will eliminate the "hot spot" formation that plagues fixed-bed operation, and catalyst agglomeration from heavy wax condensation that troubles fluid-bed reactors. The purpose of the investigation is to develop a quantitative understanding of the effects of reaction rate and selectivity of the interplay between intrinsic kinetics and mass transfer in this system.

Professor Thilly is applying methods of bioanalysis that use forward mutation assay in bacterial cells to determine the effect of diesel engine operating conditions on the biological activity of exhausts.

Professor Howard is performing a literature review to ascertain available coal devolatilization data applicable for modeling pressurized fixed-bed and entrained flow coal gasifiers; surveying experimental apparatus to obtain data for use in gasifier models; and developing recommendations for an experimental program to fulfill data needs.

Professor Howard and Dr. Peters are studying three areas of rapid pyrolysis and hydrolysis of coal: 1) optimizing temperature effects of hydrogen pressure, and sample size on conversion behavior; 2) secondary reactions of volatiles within and outside decomposing coal particles; and 3) catalytic effects of inherent coal mineral matter and low-cost additives. Results should improve understanding of how commercial operating conditions influence the rapid pyrolysis and hydrolysis behavior of coal.

Professor Janos Beer is studying the formation of potentially toxic particulates in turbulent diffusion flames, the prevailing type of flame in industry for gaseous and liquid fuel and for pulverized coal, and in fluidized bed combustion. Four different sampling problems have been designed for different parts of the processes. Also, laser diagnostic techniques are being developed.

Dr. Mary Amdur and Professors Sarofim, John Elliott, and Gregory Yurek are conducting an interdisciplinary study to examine the health effects of inorganic particulates. In the first task, Dr. Amdur is analyzing the potential health effects of inorganic fossil fuel combustion products. In Task II, Professors Elliott and Yurek are constructing apparatus for the generation of well-characterized inorganic aerosols. In Task III, Professor Sarofim will analyze fly ash from a variety of coals in simulated combustion conditions; develop coal combustion models to identify health hazard conditions; and provide samples for inhalation studies.

Professor Elliott is working with current theories of the structure of liquid silicates to predict thermodynamic properties of minor constituents in slags, specifically the polymerization of the silicate tetrahedra. He is also producing data and correlation equations for use in combustion calculations.

PROCESS MODELING

Professor Lawrence Evans is developing a system of computer programs for process design and economic analysis of fossil fuel conversion plants. The process design simulator, called ASPEN (Advanced System for Process Engineering), will provide new capabilities and data banks for vapor and liquid processes as well as for those containing solids, as in coal or oil shale processing.

ADVANCED TECHNOLOGY

Drs. John Haggerty and W. Roger Cannon are using laser heat sources to synthesize and modify ceramic powders that will ultimately be used in various new heat engines. Two processes have been investigated. In the first, silicon (Si) and silicon nitride (Si_3N_4) powders, which have nearly ideal characteristics for densification processes, are formed directly from laser-heated gas phase reactants. In the second process, oversized or poorly shaped particles are selectively heated and vaporized with a laser. The selectivity is achieved by controlling the emitted wavelength and energy density. This process has been successfully demonstrated.

Professor C. Forbes Dewey is leading an investigation into the basic physics and chemistry of the laser synthesis of silicon nitride powders. He has developed a model of the laser heating of the reactant gases, and has verified it experimentally. Using optical techniques, he has looked for reaction intermediates and has measured the flame temperature. This information is being used to optimize the synthesis of sinterable powders.

Dr. Haggerty is investigating novel means of utilizing solar energy to advantage. Small exploratory studies are conducted within this program, and larger experimental programs have been funded with separate budgets and program identities.

Mr. Doug Mahone and Professor White conducted a one-year study to define a long-range research agenda for energy and buildings research. Recommendations were to concentrate on the areas of passive solar energy utilization and impacts of energy conservation on buildings. Several research ideas are being developed with the aid of faculty and outside organizations.

Dr. Haggerty is coordinating the Energy Technology Lecture Series, which provides a forum for the discussion of energy-related topics. In prior years speakers were invited to participate in the program. More recently, too, the Series has sponsored various speakers at M.I.T.

Dr. Haggerty is developing processes by which broad band antireflective (AR) coatings can be developed on glass sheets for use in flat plate solar collectors. Under most operating conditions, the AR coatings improve the extractable heat by 35 to 50 percent. Future work will concentrate on low temperature soda lime glass compositions.

Dr. Haggerty is conducting exploratory research on amorphous chalcogenide materials to determine whether it is feasible to dope glass in a manner that will eliminate trap-limited carrier mobilities. If this approach is successful it will be possible to make efficient, low-cost photovoltaics. Thinner, lower purity materials can be employed to make solar cells at the high rates possible only with thin film glasses.

Dr. Haggerty undertook exploratory work to demonstrate that broad band antireflective (AR) coatings could be formed on silicate glass. The AR coated glass is intended for cover plates on flat plate solar collectors. Low reflectivity films were produced by selectively etching intentionally phase separated glass. The object of this program was to demonstrate feasibility prior to proposing to government agencies. A long-term program based on this work has been sponsored by DOE.

Dr. Haggerty and Professor David Adler are studying means to saturate valence alternation pairs (VAPs) in chalcogenide glass semiconductors. This will permit the Fermi level to be unpinned and will eliminate trap-limited mobilities. These materials are being considered for low-cost solar cell applications.

Professor Louis is leading a multi-task project. The first task uses the laser-induced fluorescence technique to study non-free radical species in hydrocarbon/air flames. Future work is expected to show that application to N_2 doped flames will yield information on NO_x . The second task applies laser holographic/interferometric techniques to the study of density disturbances in MHD plasmas through flow visualization. Future work includes expansion and refinement of present experiments. The last task involves novel applications of lasers to the study of flames. Future plans include investigating other uses for lasers in combustion (such as high resolution laser spectroscopy, laser doppler velocimetry, and turbulent intensity measurements of combustion plasmas).

Professor H. Kent Bowen is leading a program to establish a scientific base for electrochemistry in three areas: 1) use of electrolytes to study reactions on surfaces (electrocatalysis); 2) fabrication studies of the NA-ion electrolyte, $NA_3SI_2Zr_2PO_{12}$; and 3) the electrowinning processes for more efficient metals processing.

NUCLEAR

Professor Norman Rasmussen and Dr. Marvin Miller are investigating the transfer of sensitive nuclear technologies to non-nuclear weapons states, the appropriateness of nuclear power in developing countries, and the nonproliferation implications of the heavy water fuel cycle and advanced enrichment technologies.

Professor Rasmussen recently developed a computer code to determine the effect on overall risk of changes in system design using WASH-1400 results as input. The code can be applied to any plant for which fault trees have been prepared.

Professor Driscoll is investigating the potential of recovering uranium from seawater using inorganic adsorbers. Conceptual system design analyses and economic modeling are being carried out to determine a best estimate for the cost of U_3O_8 from this process, and to see whether it is sufficiently inexpensive to permit current converter reactors to compete with breeder reactors. Required adsorber bed capabilities are being defined, and laboratory work of limited scope has been carried out to evaluate key hydraulic parameters.

Professors Driscoll and David Lanning are leading a project to develop and evaluate pressurized water reactor (PWR) core compositions, configurations, and fuel management strategies that will improve the efficiency of uranium utilization. Both recycle and once-through fuel cycles are being considered, with emphasis on once through; similarly, both thorium and uranium-based fuels are being investigated, with emphasis on the latter. A variety of improvements have been investigated showing cumulative ore savings in the 10 to 30 percent range; work is progressing on newer techniques.

Dr. William Hinkle and Professors Peter Griffith, Mujid Kazimi, and Neil Todreas are working on a program that will contribute to understanding sodium voiding behavior in the liquid metal fast breeder reactor (LMFBR). To date, work has included preparation of a state-of-the-art report and initiation of analytical and experimental work. This work will develop computer codes that can be used to analyze subassembly voiding incoherence under postulated accident conditions.

Professor Lothar Wolf recently completed a study that involved: 1) collection and assessment of M.I.T.'s experience with the computer code COBRA-IIIC/MIT; 2) comparisons of reactor transient calculations with COBRA-IIIC/MIT and COBRA-IV-I; and 3) assessment of results to establish limits of applicability of COBRA-IIIC/MIT. Recommendations to improve the COBRA-IIIC/MIT code include: 1) replacement of the fuel pin conduction model by an improved version that incorporates temperature-dependent properties and variable gap heat transfer coefficients; 2) extension of the heat transfer package; and 3) implementation of a two-phase flow mixing model.

In modern nuclear power plants technical specifications call for periodic testing safety systems. Professors Rasmussen and Wolf are conducting research to find the test interval that maximizes the availability of the system using a rational methodology that avoids arbitrary agreement between the applicant and the regulatory staff.

Professor John Meyer is directing a project to estimate the amount of damage if a nuclear reactor core were subjected to a loss-of-coolant accident (LOCA). This project deals with one possible cause for such damage -- the forces imposed by the coolant on the core during the very early (blowdown) stage of a LOCA. Such forces are of large magnitude, short duration, and complicated spatial distribution. The nature and importance of various calculational simplifications are being examined.

Professor Kazimi is undertaking research to improve and demonstrate the capabilities of the transient analysis code THERMIT. This code uses a state-of-the-art two-fluid, two-phase flow and heat transfer model, which has advanced capabilities for light water reactor (LWR) transient thermal-hydraulic analysis. The scope of the work includes modifying the code for subchannel analysis and comparing code predictions with experiments and other transient codes.

Professors Rasmussen and Wolf are developing calculational methods for determining the time-dependent unavailability of systems. The code permits optimization of system test intervals. The present code couples the BIT code with the FRANTIC code so the input can be the system fault tree.

Professor Meyer is directing a project that deals with design/operating criteria for light water reactor fuel rods with stainless steel cladding. Work is concentrating on stress, strain, temperature, and rupture behavior of fuel rods that are producing power for long periods of time, then are subjected to fairly rapid variations in power output. Studies are aimed at establishing criteria for allowable rates of power change and/or other design or operational limitations.

Professors Rasmussen and Wolf are developing a computer code that will identify possible common cause failures. The input of the code will be system fault trees with all components properly identified by a designator to permit searching for components sensitive to certain common cause failures (e.g., fire, rotating machinery failure, etc.).

The COBRA-IIIC/MIT thermal hydraulic code developed by M.I.T. is based on the COBRA-IIIC code. During the past few years, development and application of this code has continued under the sponsorship of several northeastern electric utility companies. Dr. Hinkle is now conducting research as an extension of that work. The objectives are to make several improvements to the current version of the code, and to further assess the code's capability for use by utility engineers for LWR reload core design and licensing.

Professors Griffith and Peter Huber are conducting an experimental and analytical study of steam bubble collapse and pressure wave propagation in a piping system. They will develop models that synthesize the bubble collapse pressure "signature" for various geometric configurations and thermal conditions and that predict concomitant structural response.

Professor Meyer also has directed a continuation of a previous study on the thermal effects of cracking fuel pellets and movement (relocation) of the cracked pieces within the fuel rod. The pellets tend to operate cooler because the broken pieces are closer to the surrounding metallic clad, but also tend to operate hotter because of internal cracks. The study focuses on the net effect of these opposite tendencies; examines the sensitivity of results to input parameters and modeling assumptions; and compares methods against available experimental results.

ENVIRONMENTAL MANAGEMENT

Ocean Thermal Energy Conversion (OTEC) plants derive energy from temperature variations over depth in a tropical ocean. Dr. Eric Adams is using experimental and mathematical models to document the flow and temperature fields surrounding generic OTEC plant designs for the purposes of evaluating potential recirculation (degradation of thermal resource) and providing input for environmental impact assessment.

Professor Harleman is examining cooling alternatives for steam-electric generation when water supply constraints permit only closed-cycle cooling. Two parts are included: a comparison of seasonal and long-term water consumption characteristics for basic cooling system types and an examination of how these systems can be designed and operated to minimize conflict with existing users.

Professor Michael Golay is conducting an experimental and theoretical investigation of capture and reflection mechanisms for droplets colliding with flat surfaces that are either dry or covered with a liquid film. Applications arise from understanding the performance of drift capture devices in cooling towers, stack gas scrubbers, and other industrial air-liquid process devices.

Dr. Glicksman is leading a joint study in which a consistent comparison of the cost, energy consumption, and possible impacts of various systems are being made. The work concerns the characterization of an optimum dry cooling tower configuration to use with the reference power plant. The program developed in this study optimizes the major design parameters of the tower and condenser to yield the lowest total cost of power generation.

Professor Harleman has used exploratory funds to sponsor the following seed projects: Environmental Impacts of Low-Head Hydroelectric Development in New England, Probabilistic Methods in Mineral Exploration, Environmental Monitoring and Compliance Issues at Large Electric Generating Stations, and Salinity Gradient Maintenance of Solar Ponds.

Professor Harleman is studying cost, conversion efficiency, and environmental impacts associated with cooling systems of steam-electric power plants. Five areas are addressed: engineering optimization of dry and wet/dry towers; engineering optimization of artificial cooling ponds; operation of evaporative cooling towers to supplement once-through cooling; comparison of cooling systems at a single site; and national implications associated with cooling system selection.

Professor Golay has developed a numerical simulation model of atmospheric plumes and is currently improving and verifying the model for a broader range of applications. It employs a mixed Eulerian-Lagrangian finite-difference simulation of plume rise, advection, and atmospheric turbulent diffusion with pollutant transport and reactions being treated with detailed space and time dependence. Applications are in point-source air pollution transport modeling, notably for electric power plants, cooling towers, and nuclear plant accidents.

Dr. Adams is analyzing the induced temperature and velocity fields resulting from the submerged discharge of power plant condenser cooling water for a range of diffuser types. He is paying particular attention to the details of discharge port orientation and spacing for a staged diffuser design. Performance is evaluated in terms of the time-temperature relationships of entrained organisms as well as Eulerian descriptions of the induced temperature rise.

Vice President, Research

Professor David Marks is considering the water yields and transfer possibilities of water rights in semiarid western states having large coal reserves. He has developed a model that deals with both institutional and hydrological aspects in considering alternative water rights for energy conversion facilities.

Knowledge of future weather conditions can be used to improve power generation. The statistical heuristic logic of Group Method of Data Handling is being utilized to improve and develop models of temperature prediction. Professor Rafael Bras has developed a program, using National Weather Service data, to identify and test nonlinear temperature prediction models.

Existing thermal plume models usually treat either near-field or far-field processes, but not both. To bridge the gap, Dr. Adams and Professor Keith Stolzenbach are investigating ways to combine both models while retaining the essential features of each. This will allow determination of the extent of far-field recirculation into the near field and the relationship between warming caused by the thermal discharge and that associated with other natural causes.

Professor Golay is improving the existing Drift Elimination Wind Tunnel and is developing a laboratory-standard drift measurement method in preparation for a competition among various proponents of field measurement methods for cooling tower drift eliminator performance. In this competition, proponents of the measurement methods would be invited to test their methods in a spectrum of simulated cooling tower environments, with the laboratory-standard method providing the correct measurement result. This work also has applications for entrained droplet measurements involving stack gas scrubbers and other industrial process devices having interacting air and liquid streams.

Dr. Glicksman also is conducting research on a dry periodic air-water heat exchanger for electrical power plants that promises to be less expensive than conventional dry towers. The exchanger consists of parallel discs that rotate through the hot water and then cooling air. A thin oil layer on the water prevents direct water-to-air contact, thus eliminating evaporation.

ELECTRIC UTILITY PROGRAM

Dr. William Hinkle is coordinating a continuing series of seminars and workshops designed to inform participating utilities about ongoing M.I.T. research projects, to identify and discuss utility research needs and priorities, and to develop new research projects responsive to those needs. Each year a general seminar provides an overview of ongoing M.I.T. research activities, and three or more workshops provide in-depth discussion of M.I.T. research programs and utility needs and priorities in areas of particular interest. In 1979, eight companies are participating in the program. The areas covered by the workshops include coal utilization, nuclear engineering, and environmental management.

As a result of the 1977-78 utility seminars and workshops, 15 research projects focusing on the needs of the participating utilities were initiated. These projects, sponsored by one or more utility company, involve 15 faculty and research staff and 16 students associated with five M.I.T. academic departments.

CENTER FOR ENERGY POLICY RESEARCH AND OTHER POLICY STUDIES AND TECHNOLOGY EVALUATION

The Center for Energy Policy Research (C.E.P.R.) stresses policy research and analysis in the Energy Laboratory, with particular emphasis on making results available and useful to policy-makers. With support from a wide range of corporate and non-corporate interest groups (called Associates), the Center uses conferences and seminars to bring together key government and private organizations to work on energy policy issues.

As of July 1, 1979, Center Associates include the following: Aluminum Company of America, Atlantic Richfield Company, B.P. North America, Inc., Cabot Corporation, Caterpillar Tractor Company, Chem Systems, Inc., E.I. duPont de Nemours and Company, EG&G, Inc., Environmental Defense Fund, Exxon Corporation, General Electric Company, Gulf Oil Corporation, Hughes Tool Company, League of Women Voters of the United States, Massachusetts Audubon Society, National Urban League, New England Electric System, Olin Corporation, Panhandle Eastern Pipe Line Company, The Public Agenda Foundation, Standard Oil Company (Indiana), Sun Company, Texas Eastern Transmission Company, United Auto Workers, and Wheelabrator-Frye, Inc.

Loren Cox moderated a meeting in October 1978, attended by a number of representatives from government, financial institutions, universities, and private companies, to discuss international oil markets. Topics included net demand on OPEC (the Organization of Petroleum Exporting Countries); strength of the international financial/trade/growth system; OPEC capacity creation; and security of the oil supply system.

In April 1978, Mr. Cox moderated a follow-up meeting to the first World Oil meeting, again bringing together representatives from government, financial institutions, universities, private companies, and others. Topics focused on shorter-run issues such as the Iranian oil shutdown, subsequent price increases, and their long-range effect.

A new system developed by Professor Schweppe and Dr. Tabors for electric utility management and control was discussed at a meeting held by the C.E.P.R. in May 1979. The new system, "Homeostatic Electric Utility Control System," was reviewed in the context of existing and probable future regulatory and technical considerations. About 45 people participated, including representatives from M.I.T., C.E.P.R. Associates, industry, utilities, state and Federal regulatory commissions, the White House, government departments, academic institutions, and two trade journals.

Professor Daniel Roos and Dr. Weiss are analyzing several transportation contingency plans for use in the event of an energy emergency, including: 1) an employer-based strategy that would require major employers to provide incentives to employees for energy-efficient commuting; 2) a vehicle sticker plan that would prohibit automobile use for one day per week; and 3) a weekend restriction on the use of general aviation aircraft, power boats, and off-road recreational vehicles.

Dr. Weiss is leading a study of cost reductions that might be attained through better technology if shale oil were produced in the US on a very large scale. Improvements in mining, retorting, and refining are all required to make a major impact on total cost. A workshop of industry experts identified some additional interesting possibilities for those improvements.

Professor White is evaluating the advantages and constraints of using coal for industrial boilers. The advantages of coal as an abundant resource and the constraints imposed by EPA and DOE regulations will be evaluated to determine the economics of different technological and fuel choices faced by industry.

Professors Ben Ball, Jr., and Peter Lorange are conducting research to determine the level of non-energy industry effort to deal with energy-related problems and opportunities, using a strategic planning function.

Professor Jeremy Shapiro has been investigating use of mathematical programming models and methods, especially decomposition techniques, in the analysis of energy planning problems. Topics include: integration of mathematical programming process models with econometric models; derivation of derived demand curves for energy commodities, with applications to coal; derived demand curves and capacity planning under uncertainty; and integration of coal supply and utility demand models.

Professor Lawrence Bacow is preparing a handbook for energy developers, communities, and environmental interest groups that describes how to avoid and resolve disputes over the adverse impacts of development through the use of compensation.

Vice President, Research

Professor Richard Schmalensee is developing rules and approaches for efficient Federal decision making about commercialization of new energy technologies. Current proposals and past activity in this area are being reviewed, using insights from various branches of economics and policy analysis. The goal is not to recommend particular actions, but to clarify general issues.

Dr. John Houghton and Professor Gordon Kaufman undertook studies of primary energy mineral supply. The studies are built on common intellectual threads, such as a disaggregated approach to mineral deposition and discovery, to develop an effective method for generating projections of future discoveries and of future supplies from individual geologic units.

Professor Pindyck is investigating the desirability of government participation in development of new non-conventional energy supplies. Of particular concern is an evaluation of possible sources of market failure, and the likely efficacy of government subsidies to correct the effects of that market failure. Emphasis is on designing government policy for new energy technologies.

DAVID C. WHITE

Laboratory for Nuclear Science

The L.N.S. provides support for research by faculty and research staff members primarily in the fields of basic nuclear and elementary particle physics, including the activities of the Center for Theoretical Physics in these fields. It also supports some projects involving application to other fields of experimental techniques developed in its primary activities. It provides a computing facility for its program. This facility is shared by some activities of the Center for Space Research, the Energy Laboratory, and others. The primary experimental programs are in three areas: the largest effort is in intermediate energy nuclear physics, centered at the Bates Linear Accelerator in Middleton, Massachusetts. The second area is high-energy physics, with major projects at Fermi National Accelerator Laboratory (FNAL) in Batavia, Illinois; at the European Center for Nuclear Research (CERN) in Geneva, Switzerland; and at the German Electron Synchrotron Laboratory (DESY) in Hamburg, Germany. The third field is heavy ion physics with activities at Brookhaven National Laboratory (BNL) and Lawrence Berkeley Laboratory.

INTERMEDIATE ENERGY NUCLEAR PHYSICS

The principal activity in this field is centered at the Bates Linear Accelerator, which functions under the direction of Professor Peter T. Demos. This accelerator has become the national facility for intermediate energy electron physics where a major experimental program to study the properties of the atomic nucleus, using intermediate energy electrons and photons to generate a wide variety of reactions, is under way. Fifteen M.I.T. faculty and Bates staff physicists, and some 80 user physicists from 34 other universities and laboratories in the US, Canada, and Europe, are presently engaged as initiators or collaborators in experiments there. Twenty-two M.I.T. graduate students were associated during the past year with the intermediate energy nuclear physics program. Five Ph.D. and one S.M. physics degrees were awarded at the M.I.T. June 1979 Commencement to students whose thesis research was carried out at the Bates Accelerator.

The intermediate energy program at M.I.T. continues to center about electron scattering experiments using the Bates high-precision electron scattering spectrometer. This rather complete spectroscopic facility is being applied intensively to a majority of the more than 45 experiments authorized for performance at Bates. The other experiments entail mainly studies of photon-induced pion and proton-emitting reactions. The last are also important forerunners of the experimental programs planned for the Laboratory's new large experimental hall, which is now nearing completion and expected to be in active use by early 1980.

Further developments which will extend both its research domain and, together with the new experimental hall, its ability to meet the increasing requirements of users, are in progress at the accelerator. These include importantly the planned installation with Yale physicists of a polarized electron beam source; an extension of Bates' computing and data analysis capability; and the initiation of final design studies for a beam recirculation system to increase the accelerator's maximum energy capability to 700 MeV. Funding for the recirculator is included in the current Department of Energy (DOE) presidential budget submission to the Congress, with construction of the recirculator planned to begin in October 1979, and early to mid-1981 as the estimated time of completion and application.

EXPERIMENTAL HIGH ENERGY PHYSICS

During the fiscal year 1979, the Electromagnetic Interactions Group, headed by Professors Samuel C.C. Ting, Ulrich J. Becker, and Min Chen continued to search for new particles up to the highest available mass at the Intersecting Storage Ring Facility at CERN in Geneva, Switzerland.

They also have completed the equipment and started taking data for a new experiment at PETRA, the e^+e^- colliding beam device at DESY, in Hamburg, Germany. This experiment has confirmed quantum electrodynamics down to distances of 2×10^{-13} cm; it will search for new particles, analogous to the J, but made of heavier quarks; it will search for heavy leptons; and it will look for asymmetries produced by electromagnetic and weak interference in the production of μ mesons.

The Accelerator Physics Collaboration (A.P.C.) group under the leadership of Professors Irwin A. Pless, Robert I. Hulsizer, Jr., Richard K. Yamamoto, and Vera Kistiakowsky continues its program at FNAL to study mechanisms of high energy reactions by means of a bubble chamber and other detectors. They play the leading role in a consortium of United States and European teams which exploits a "hybrid" detector system designed by them and scheduled for a major experiment to start in early 1980. During fiscal year 1979 they were engaged in the development of this system and in the evaluation of earlier experiments.

The Counter Spark Chamber (C.S.C.) group under the leadership of Professors Wit Busza, Jerome I. Friedman, Henry W. Kendall, Louis S. Osborne, and Lawrence Rosenson has completed a series of experiments at FNAL utilizing the particle spectrometer developed by them, in collaboration with other physicists from other institutions, to study the strong interactions of protons, pions, and kaons. These experiments have led to a definitive set of data on a wide range of reactions utilizing pure protonic targets and complex nuclei.

Over the past year the group has turned its attention to the weak interactions, and is involved in a collaborative effort to construct a major new detector for high energy neutrinos at Fermilab. The initial thrust of this experiment will be the detailed study of the weak neutral currents predicted by gauge theories and discovered experimentally several years ago. Modules of the detector (which will contain 400 tons of instrumented material) are currently being tested, and the first experiment, in what should be a several-year program, will begin in late 1980.

HEAVY ION PHYSICS

The study of nuclear interactions with beams of energetic heavy ions explores the properties of nuclei which have high angular momentum and high energy and can be of species far removed from the stable nuclei found in nature. Investigations of these properties continue at Brookhaven National Laboratory and at the Lawrence Radiation Laboratory using newly developed tools, including a zero degree beam separator for fusion studies of exotic nuclei and a gamma-ray hodoscope for the study of high angular momenta.

APPLICATIONS OF NUCLEAR TECHNIQUES

A small group under the leadership of Professor Martin Deutsch, in collaboration with Professor Alexander Rich, is developing an X-ray diffraction facility for protein crystallography based on a wire drift chamber detector originally developed at CERN.

Professor Louis S. Osborne and Dr. Richard C. Lanza have undertaken the development of a positron detector, also based on wire drift chambers, which is designed to be substantially superior to the currently used scintillation detectors in medical applications. A small prototype chamber has been built, tested, and found to operate satisfactorily.

A scanning light ion microprobe has been developed by Professor Lee Grodzins. It is utilized by M.I.T. faculty in chemical engineering (studying the distribution of trace elements in coal particles); biophysics (studying the changes in the distribution of elements during cataract formation); geophysics (examining volatile trace elements in meteorites); and in nutrition (studying zinc and iron levels in control and in malnourished populations).

Several members of the L.N.S. have been engaged in other applied projects, primarily in the biomedical area.

L.N.S. is collaborating with Professor Michael Feld of the Spectroscopy Laboratory in an experimental study of laser-induced nuclear orientation.

NUCLEAR THEORY

The nuclear theory group has addressed a wide range of problems, including the interactions of nuclei with mesonic and electromagnetic probes, the structure of nuclei spanning the periodic table, and heavy ion reactions from below the Coulomb barrier to relativistic energies.

A substantial theoretical effort directed at a microscopic understanding of nuclear static and transition densities has been motivated by the high precision electron scattering experiments performed at the Bates Accelerator.

Significant progress was made in nuclear many body theory and the time dependent theory of nuclear dynamics.

Nucleon-isobar coupled channel effects have been shown to reproduce the nucleon-nucleon resonances observed recently in polarization experiments.

Pion nucleus elastic scattering has been described in terms of isobar-nucleon hole collective doorway states, with a complex isobar-nucleus interaction potential playing a central role.

Possible collective states in single Λ hypernuclei have been re-investigated taking up the issue of the U-spin symmetry potential. It has been found that, within the current quark bag theory, hyperstrange quark matter may be stable to everything but β -decay when the strangeness per baryon is in a small region between two and three.

A general theory of the role of final state fluctuations in two-step nuclear reactions through doorways has been formulated.

PARTICLE THEORY

It is presently believed that the particles which are at the basis of all matter are quarks and leptons. The quarks interact through a vector gauge field with eight internal components which are called "colors." The weak and electromagnetic interactions are also believed to be governed

by a vector field which is coupled in a complex pattern to the different quarks and leptons. Both of these mathematical theories are being investigated intensively by the particle theorists.

At present, all the predictions from the vector gauge theories of quarks and leptons, in so far as they have been put to direct experimental test, have been borne out.

The particle theory group has studied, on the one hand, the free-particle behavior of quarks in hadrons, as seen in the deep inelastic scattering of electrons and neutrinos, and on the other hand, the permanent confinement of quarks in a hadron evidenced by the failure so far to detect an isolated quark experimentally.

These two aspects of properties of quarks have for years been described by two complementary phenomenological models: the parton model and the M.I.T. bag model, respectively.

A major effort has been directed towards an understanding of "hadronic jets," which involves both of the pictures mentioned above. The approach so far is based heavily on kinematics and phenomenology. In this connection we have studied azimuthal angular correlations for the hadronic jets produced in e^+e^- annihilation, and have shown that they can be used as a model independent test of QCD (Quantum Chromodynamics). The azimuthal correlation for the hadronic decay of S-wave heavy-quark anti-quark bound states has been calculated.

Much work has been done on the formal mathematical properties of gauge fields, including investigations of soliton solutions, expansion in inverse powers of the number of colors, and possible mean-field approximations. Investigations initiated last year on a gauge invariant Hamiltonian formulation of Yang-Mills theories are being continued. Various approximations suggested by this form of the theory are being studied. The program of quark confinement in the framework of the $1/N_c$ expansion has been studied (N_c is the number of colors). This is a continuation of earlier work establishing dual models as a simultaneous strong coupling $N_c \rightarrow \infty$ limit (i.e. $N_c \rightarrow \infty$, $N_c g^2 \rightarrow \infty$). We are currently studying quark confinement in the large N limit at fixed (Ng^2) , with the aim of understanding, in a single unified treatment, quark confinement (a long distance effect) and asymptotic freedom (a short distance effect). To this end, a direct group-theoretic approach to the large N_c limit is being attempted. Work also was done on a null-plane lattice formulation of field theory with emphasis on string-like structures implicit therein. Work is continuing to obtain a mean-field description of QCD, such as that customarily used in the theory of superconductivity. The aim is to understand how such a mean-field theory can be defined in terms of appropriate averaging procedures, and to use such a mean-field theory to calculate experimental quantities.

The naive bag model is being studied with corrections incorporating QCD effects, mainly asymptotic freedom, and the existence of a "running" (instead of fixed) coupling constant. This results in a new effective potential between heavy quarks. An improved method of handling the "static" bag model has been developed which, when applied to the bag model pi-meson, has given promising preliminary indications that the quark model pion and the PCAC pion might be reconciled. We have just completed an exhaustive study of the two quark-two antiquark hadrons which may be seen as prominent resonances in the scattering of baryon and antibaryon. We are now studying the effect of multi-quark hadrons on the spherically symmetric scattering of ordinary mesons and baryons. This promises to lead to a rather novel interpretation of low energy scattering processes in which color plays an essential role.

As an application to nuclear physics, the tensor component of the two-nucleon interaction has been calculated from the bag model and found to be in reasonable qualitative agreement with phenomenological potentials.

In other areas of theoretical physics we have shown, using the dimensional regularization method, that supersymmetry invariance is maintained up to one loop order in supersymmetric gauge theories and have calculated the superconformal anomalies.

SUMMARY OF SUPPORT

Participants in the various research programs during the past year amounted to approximately 450 people. This includes 49 academic staff members, 84 graduate students, and at least 86 undergraduates from M.I.T. and other institutions. The latter were involved in senior theses, Undergraduate Research Opportunities Programs, work-study, and similar programs. There were 63 research staff members with Ph.D.s including visitors and guests, and 167 employees in supporting categories such as engineers, technicians, machinists, and computing and administrative personnel. Over 80 active user physicists from some 34 institutions participated in the program at the Bates Linear Accelerator. Thirteen Ph.D.s, five S.M.s, and 16 S.B.s were awarded based on thesis research within L.N.S.

Support during fiscal year 1979 from the contract with the US Department of Energy (DOE) is expected to total \$11,295,000. This represents an increase of about 11 percent over the preceding year. This sum breaks down as follows: operations costs (salaries, wages, materials, services, travel, and overhead) were \$8,715,000; of this \$3,200,000 was for experimental and theoretical high energy physics, \$4,355,000 was for intermediate nuclear energy physics for the support of the Bates Linac facility, and \$1,160,000 was for nuclear structure theory and heavy ion experiments. Equipment costs totaled \$2,280,000; of this, \$870,000 was for high energy physics and \$1,410,000 was for medium energy and heavy ion physics. A total of \$300,000 will be expended for general plant and accelerator improvement projects, projects associated with the Bates Linear Accelerator. Support for relatively new Laboratory programs relating to the application of high energy techniques to medical and biological problems totaled some \$340,000. (Support came from the National Institutes of Health, and from the National Science Foundation.) Support for other programs within L.N.S. including support from other institutions and laboratories for collaborative work undertaken directly by L.N.S. totaled about \$410,000.

FRANCIS LOW

Nuclear Reactor Laboratory

Further new research projects have been initiated in the Nuclear Reactor Laboratory (N.R.L.). A large four-department project in nuclear materials for fusion reactors and a variety of smaller, usually joint, projects involving nuclear trace analysis comprise the bulk of the new research. The M.I.T. Research Reactor MITR-II has continued to function with good reliability. No additional operational problems have been experienced in this recently rebuilt machine. Problems of reactor fuel support and supply have been successfully overcome. The general financial picture of the MITR-II and the N.R.L. has continued to improve despite a large loss in service related to reactor use. Efforts are continuing to broaden the research utilization of MITR-II into two thrust areas, nuclear medicine and neutron scattering.

Research Activities

Neutron beam tube research has continued at a high level of activity. The Department of Physics group under Professor Clifford Shull carried out a broad-based experimental program in neutron diffraction and neutron interferometry. This group also assisted students and professors from several other departments in measurements involving the neutron scattering technique. A high intensity, high resolution inelastic scattering spectrometer was completed and put into operation by the Department of Nuclear Engineering group led by Professor Sow-Hsin Chen. Initial results with this new spectrometer are very promising and the first useful results have led to publications.

Medical research activities continued in areas which include medical isotope development and the therapeutic uses of reactor radiation. Professor Gordon Brownell of the Department of Nuclear Engineering and his associates continued work on boron capture neutron therapy for brain cancer

treatment. Although the level of this work was low in the last year, a proposal for several years of further animal studies has been approved, and research activity will increase in the coming year.

Our research programs in nuclear materials increased. This research is under the direction of Professor Otto Harling, Director of the N.R.L. and Professor of Nuclear Engineering; Professor Nicholas Grant, Materials Science and Engineering; with four other senior academic staff members from Nuclear Engineering, Materials Science and Engineering, and Mechanical Engineering. A new project in fusion reactor first wall structural alloy development was initiated. With this new multidisciplinary project, M.I.T. probably has the largest overall effort in nuclear materials of any American university. Ten master's or doctoral thesis projects are currently in progress in these research areas. A new materials research laboratory has been set up at the N.R.L. and is being equipped with funds obtained through research contracts. A major facility for irradiation testing to simulate the surface and bulk irradiation as well as the cyclic stresses and temperatures of the fusion reactor environment was completed and put into operation at MITR-II.

The trace analysis group has continued to broaden its research activities and its support of projects in several M.I.T. departments. A new senior staff member has been added to assist in meeting the needs for research and services in the trace analysis area. Current research projects range from studies in nutrition and the effects of trace elements on cancer to the study of optimum coal combustion.

Project development has continued with emphasis in the areas of neutron scattering and nuclear trace analysis. Plans have been developed for increased research in several thrust areas. Neutron scattering and nuclear medicine are judged to offer opportunities for further development consistent with M.I.T.'s research mission. Nuclear medicine offers particularly attractive opportunities in the long run because of the unique physical facilities at the N.R.L. and the strong technical and medical expertise at M.I.T. and surrounding institutions.

Operation of MITR-II can be characterized as successful. The new core requires sophisticated fuel management codes which have been or are being developed as student research projects. Performance of the new reactor has improved slowly as further experience has been obtained and remaining bugs were discovered and corrected. A major problem with the assurance of new fuel has been successfully overcome. As a result of a joint effort with other university research reactors, the US government has developed a new fuel manufacturer and has allocated adequate funds to subsidize fuel for reactors such as M.I.T.'s for at least the next few years.

The financial picture of the N.R.L. and MITR-II has continued to improve. The absolute level of deficit has been reduced to around \$200,000 to \$250,000 per year from double this level a few years ago. The research volume supported by the MITR-II was about \$1.7 million in fiscal year 1979.

OTTO HARLING

Patent and Copyright Office Patent Marketing Office

The major staff and physical reorganizations have now been completed and the following activity has occurred during the past fiscal year.

Licensing

During the past fiscal year, 137 invention disclosures were received, 81 US patent applications filed, and 47 US patents issued. Additionally, 102 patent applications were filed in foreign countries corresponding to 16 US applications. Gross royalty income from patent and copyright licensing totaled \$1,178,307.

During this past fiscal year, a concerted effort has been made to improve the marketing director's interaction with the Industrial Liaison Program (I.L.P.), as begun last year. The results continue to appear quite promising. The experimental program with Control Data Corporation is continuing and an agreement has been signed with Worldtech which increases the Institute's licensing and marketing representation abroad on a non-exclusive basis.

Patents

As has been noted in prior years, the direction of the patent program at M.I.T. continues to be heavily dependent on the direction and volume of government-sponsored research and on the patent policies of the various government agencies. Legislation aimed towards a more uniform government patent policy is presently pending and resolution of this matter is anticipated during the coming fiscal year.

For the first time, the Patent and Copyright Office has participated in patent filings under the recent Patent Cooperation Treaty and all indications are very promising. It is anticipated that European filings, at least, will be made primarily through the Patent Cooperation Treaty because of decreased costs and increased flexibility.

During the coming fiscal year, the Patent and Copyright Office plans to concentrate additional time on encouraging patent activity at Lincoln Laboratory through a series of patent education seminars. It is believed that the amount and quality of technology at Lincoln Laboratory warrants this increasing activity.

Copyrights

Faculty Regulation 2.71 governing the copyrighting of theses has been amended by vote of the faculty to reflect the changes required by the new Copyright Law Title 17 of the United States Code. Efforts to license software systems and to negotiate more standard provisions have been continuing with increasing success. Although royalty income from software licensing remains minimal in relation to patent income, it is hoped that this will begin to increase with time.

ARTHUR A. SMITH, JR.

Plasma Fusion Center

The past year has seen important progress in Plasma Fusion Center research and development programs. The development of fusion energy is one of the most complex technical challenges facing society, and progress depends heavily on the outstanding contributions of many individual researchers. In this report, an attempt is made to identify those fusion scientists and engineers at M.I.T. who have played a major role in technical advances during the past year. While only the more established senior researchers are identified, it should be kept in mind that the true strength and potential for the eventual development of fusion energy resides with the younger scientists and engineers, the graduate and undergraduate students, and the dedicated support personnel.

By way of background, the Plasma Fusion Center (PFC) technical programs are supported by the US Department of Energy's Office of Fusion Energy. During the past year, the funding level has been approximately \$13 million. Approximately 220 people are associated with Plasma Fusion Center research activities. They include 25 faculty members (from the Departments of Aeronautics and Astronautics, Electrical Engineering and Computer Science, Materials Science and Engineering, Nuclear Engineering, and Physics), more than 80 research scientists and engineers, 70 graduate students, and 45 support personnel. At the present time, the Plasma Fusion Center's major experimental and engineering facilities are located at several sites on the M.I.T. campus, including Building NW13 (Nuclear Reactor Laboratory), NW14 (National Magnet Laboratory), and Buildings 36 and 38 (Research Laboratory of Electronics).

CONFINEMENT EXPERIMENTS

The successful development of fusion energy requires experimentation on large-scale magnetic confinement devices. The Alcator experimental program constitutes one of the most successful and prominent tokamak confinement programs, both nationally and internationally. The primary objective of the Plasma Fusion Center Confinement Experiments Division, headed by Professor Ronald Parker, is to develop the basic physics understanding of the stability, transport, and radiation properties of high-temperature fusion plasmas at near-reactor conditions.

The main Alcator experimental activity areas are: equilibrium, stability and operations (Drs. David Overskei and Ian Hutchinson); confinement studies (Dr. Awinash Gondhalekar); plasma-wall interactions (Dr. Earl Marmor); lower hybrid heating (Professor Miklos Porkolab, Drs. Jack Schuss and James Meyer); ion cyclotron resonance heating (Dr. Hironori Takahashi). Professors Parker and Bruno Coppi are overall Alcator program principal investigators.

We will summarize here the significant progress made during the past year in several of the Alcator experimental program areas.

Alcator A

During the past year, Alcator A has continued to provide critical basic physics information on high-temperature plasma behavior. For example, one such program is aimed at the understanding and control of plasma-wall interactions and impurity transport. A substantial effort also is being placed on the study of the stability of tokamak plasmas with relatively high toroidal current. This is important since tokamak efficiency improves at a given magnetic field, with increasing current.

An additional major program on Alcator A is a modestly powered (100 kW) RF heating experiment near the lower-hybrid frequency, which is about 2.45 GHz in Alcator A. The experiment is providing important information on the physics of wave penetration, heating mechanisms, and efficiency, as well as information on the technological problems of vacuum window and RF coupler design. This experiment is prototypical of the much higher power experiment planned for Alcator C, and the results are being integrated into the design for the Alcator C heating program.

During the summer of 1979, an ion cyclotron heating experiment will begin on Alcator A. The initial program is aimed at developing practical couplers which can deliver upwards of 1 MW to the plasma near the ion gyrofrequency or its harmonics.

Alcator C

The Alcator C device is an upgrade of Alcator A, in which the minor radius has been increased to 17 cm, the major radius to 64 cm, and the maximum toroidal field strength to 140 kG. The prime power for Alcator C will be supplied by the 225 MW Alternator donated to M.I.T. by Consolidated Edison Company of New York.

As a result of the Alcator C design, parameters even closer to those required for fusion are expected to be achieved. During Phase I of Alcator C operation, the plasma will be ohmically heated to temperatures approaching 2 keV by power supplied to the plasma by the main transformer, and values of the density-confinement time ($n\tau$) product of approximately 10^{14} cm⁻³-sec are expected to be achieved. This value of $n\tau$ is well above the minimum required for energy breakeven, although actual breakeven requires higher temperatures. Plasma equilibrium, stability, fueling, and purity are expected to be the main physics issues investigated during Phase I.

Physics experimentation on Alcator C began in September 1978, with 30 MW of primary power supplied by the National Magnet Laboratory generators. At the present time, Alcator C has been operated at toroidal fields in the range 60 kG - 75 kG and plasma currents up to 450 kA, which represents about 50 percent of the design capability. Under these intermediate conditions,

temperatures of 1 keV and $n\tau$ values of 10^{13} cm⁻³-sec are routinely obtained, with excellent plasma confinement properties. High-field, high-current operation of Alcator C will begin later this summer, when the prime power will be provided by the PFC 225 MW Alternator. Alternator preparation and check-out, including full-speed no-load operation, as well as interconnections to the Robicon rectifier and the Alcator C device, are in the final stages of completion. Assuming no major physics or machine setbacks occur, the Phase I goals of $T \sim 2$ keV and $n\tau \sim 10^{14}$ cm⁻³-sec should be achieved during the latter part of 1979.

RF Heating

Further improvement of plasma parameters in Alcator C will require additional energy input. Phase II of the Alcator C program has as its objective the increase of plasma temperature from 2 keV, to 4 keV or more. For this purpose, two radio frequency heating methods are being developed in parallel, and will be investigated intensively on Alcator C during 1980.

The first heating method will use 4 MW of power at the lower hybrid frequency, which is about 4.6 GHz in Alcator C. The second heating method will employ up to 4 MW of power at the second harmonic of the ion cyclotron frequency. Lower hybrid heating is the primary approach selected for plasma heating on Alcator C. However, the ion cyclotron heating program, which has been initiated on Alcator A, will be explored in parallel with lower hybrid heating and will be emphasized on Alcator C in the event that this method proves more successful. Key physics issues in both RF heating programs include RF wave penetration into the plasma, heating mechanisms, efficiency, and the effect on plasma stability and confinement. Technological issues are concerned with RF power transmission through vacuum interfaces, power densities achievable, and practical RF coupler design.

Alcator D

Successful completion of Phase II will provide the physics basis for a followup experiment to Alcator C. Although plans for the next step are still being formulated, the most ambitious step after Alcator C would be a D-T ignition experiment. By the end of 1980, RF heating and ohmic heating experiments on Alcator C are expected to have reached a level of achievement which will give a clear direction for Alcator D. To support this anticipated decision point, a tokamak design activity has been initiated in 1979 and will be intensified in 1980. Assuming a clear scientific opportunity exists, fiscal year 1981 will see the beginning of major device fabrication and site preparation. Final design activities will be carried out at M.I.T. and with industrial contractors.

FUSION ENGINEERING

The Plasma Fusion Center Engineering Division, headed by Dr. D. Bruce Montgomery, provides critical support for the operating Plasma Fusion Center confinement experiments and the advanced design projects, and develops advanced superconducting magnet technology for the national fusion program. These activities include: mechanical and electrical engineering support for the operation of Alcator A and C (Norton Pierce and James Rose); advanced design projects for Torex-A, Alcator D, the proposed Garching high-field Ignition Test Reactor (ITR), and the magnet systems for the Engineering Test Facility (ETF) (John Williams); the development of forced-flow superconductors for application to advanced fusion devices (Mitchel Hoenig); basic research on the development of ductile superconducting materials (Dr. Simon Foner, Professor Robert Rose, and Dr. Brian Schwartz).

During the past year, there has been significant progress in each of these activities. We summarize here progress in a few selected areas.

ETF Magnetism

The next major step in the United States fusion program will be the Engineering Test Facility (ETF). In December 1978, the Plasma Fusion Center was selected by the US Department of Energy to take responsibility for the Magnetism Branch of the ETF Design Center activities. This work is carried out in close cooperation with the ETF Design Center Headquarters at Oak Ridge National Laboratory, which has overall responsibility for systems integration and management of ETF design activities.

The activities of the ETF Magnetism Branch are divided into several major task areas including, for example, the development of magnetism modeling codes, the development of alternative designs, and interfacing with the national fusion community. Perhaps one of the most important tasks relates to effective interfacing with the national fusion community. The fusion community has a broadly based magnetism capability. Some of these resources have been utilized in previous design studies, others are represented by the present generation of fusion devices, and yet others in the development of superconducting technology. Activities outside the fusion program, such as MHD magnet development, large-scale cryogenic systems with applications in high energy physics, and the widely scattered cryogenics materials evaluation programs are all of potential value to the ETF program. These programs are both national and international, and are located in national laboratories, universities, and in industry. We view the coupling of these activities to ETF as a major responsibility of the ETF Magnetism Branch.

Superconducting Magnet Development

Critical experimental tests are also being carried out in the development of forced-flow conductors for superconducting fusion magnets. The supercritical helium-cooled conductor conceived and developed by the magnet group has been selected by Westinghouse for the 2 x 3 meter niobium-tin coils for the Large Coil Project at the Oak Ridge National Laboratory, and for the 12-tesla High Field Test Facility at the Lawrence Livermore Laboratory.

The magnet group has been approached by the Japan Atomic Energy Research Institute (JAERI) regarding a project on the 12-tesla Japanese Cluster Test Facility. JAERI will build 1 m x 2 m background test coils and has expressed an interest that the United States provide a forced-flow Nb₃Sn coil for testing on this facility. Current plans call for Japan to purchase such a coil in the United States, with material for the cables supplied by Japanese industry. The magnet group would be responsible for the construction of the coil and would participate in the testing in Japan.

Superconducting Materials Development

Basic research on advanced superconducting materials is also a major fusion engineering activity area at M.I.T. The objective is to develop materials and techniques for producing superconductors capable of generating 15-tesla magnetic fields and sufficiently ductile to be suitable for advanced fusion devices. This research emphasizes finely-divided materials, and significant progress has been made during the past year in improving mechanical properties.

FUSION TECHNOLOGY DEVELOPMENT

The demonstration of the scientific feasibility of fusion is not sufficient to ensure that fusion will become ultimately a significant contributor to our energy requirements. The development of fusion reactors for commercial power generation also requires the solution of many difficult technological problems. Many of these problems are similar to, but more difficult than, those associated with fission reactor technology. The Plasma Fusion Center Technology Development Division, headed by Professor Lawrence Lidsky, has the primary objective of investigating the various technology and engineering problems associated with fusion reactors and advanced fusion systems.

Present fusion technology development activities include: safety and environmental studies (Professors Mujid Kazimi and Norman Rasmussen); evaluation of first-wall coolant options (Professors Borivoje Mikić and Neil Todreas); advanced fusion concept development (Professor Lidsky, Dr. Montgomery, and Professor Peter Politzer); advanced tokamak system studies (Dr. Daniel Cohn and Dr. Leslie Bromberg).

During the past year, there has been significant progress in each of the fusion technology development programs. We summarize here recent progress in several selected areas.

Environmental and Safety Studies

The primary emphasis in the fusion safety and environmental studies program is to develop the methodology and quantitative tools for safety and environmental analysis of proposed fusion reactor power plants, and to apply safety-related criteria to fusion reactor design. In a recent investigation, a lithium pool combustion model has been developed to describe the physical and chemical processes that occur during a hypothetical lithium spill and fire. The calculations show that the reference containment may reach pressures as high as 32 psig when one coolant loop is spilled inside the reactor building. These consequences are found to diminish greatly by the incorporation of a number of design strategies, e.g., by including initially subatmospheric containment pressures, enhanced structural surface heat removal capability, etc. It is also found that low volume "racetrack" containment structures have significant advantages. Research is currently in progress to assess the factors that contribute to the uncertainty level of the predicted consequences of tritium releases from fusion reactors to the environment.

Blankets and Structures

The blankets and structures research program emphasizes the development of functional relations between major design requirements of fusion reactor systems, and the identification of concept-limiting technological features. Emphasis during the past year has been on the evaluation of first-wall coolant options. Tubular walls have been examined and analytic expressions for the temperature field and thermal stresses have been obtained for both clad and unclad tubes. It is found that copper cladding can significantly reduce the peak stress for a 316 stainless steel radiation shield tube. Another concept under development is a relatively thick first wall to serve as a protective "armor" with coolant tubes welded or brazed to the near surface.

Advanced Fusion Concepts

The advanced fusion concepts research program emphasizes the development of fusion reactor designs consistent with the best available models of plasma physics and the technological requirements and capabilities of the eventual reactor users. Until recently, fusion reactor design studies have attempted to extrapolate particular plasma confinement geometries to reactor scale. We have concluded that the optimum search scheme requires an inversion of the usual process. That is, a list of desirable reactor properties (steady-state, ignited, etc.) is developed, and a search made for confinement configurations compatible with these requirements. The most promising output of this search is the torsatron configuration, which is a toroidal configuration with confining magnetic field produced by external helical conductors. The technique of applying "desirability-weighted" technology criteria is also proving useful in assessing other candidate confinement configurations.

A natural outgrowth of the torsatron reactor studies has been the design of a major torsatron confinement experiment, Torex A. A detailed proposal has been submitted to the Department of Energy, with construction of Torex A (~30 months) to begin in the fall of 1979. Torex A is the logical extension of presently operating stellarator, torsatron, and heliotron devices around the world, and the project is comparable in scale of effort to the Alcator A program. If funding is approved, construction of Torex A will be the responsibility of the PFC Engineering Division, and the physics objectives and operation of Torex A will be the responsibility of the PFC Confinement Experiments Division. This device would place M.I.T. in the forefront of research on alternate fusion concepts and would complement M.I.T.'s major tokamak experimental activities. The Torex A device, associated staff, and laboratory set-up space would be located in the Nabisco facility.

In addition to the involvement of a broad segment of the M.I.T. fusion community in the Torex A project, discussions have begun with Kyoto University, the principal Japanese laboratory involved in stellarator/torsatron research. Kyoto University is presently building a large torsatron-like device, Heliotron E, which is comparable in size to Torex A, but differs in several important parameters. The Kyoto University research group and their sponsors have expressed strong interest in close collaboration with M.I.T. on the design of a large superconducting torsatron.

Advanced Tokamak System Studies

The main emphasis in the advanced tokamak systems studies program is the development of new concepts and engineering designs for the next generation of tokamak confinement experiments and for demonstration fusion power reactors. Studies are being carried out both for near-term ignition test experiments, which will investigate the basic properties of ignited plasmas, and for longer-term demonstration power reactors, which will test the commercial viability of fusion.

During the past year, a major M.I.T. collaboration with the Max Planck Institute for Plasma Physics has been initiated in the design of a copper high-field Ignition Test Reactor (ITR) to be sited at the Garching Laboratory. The Plasma Fusion Center has been selected by the Department of Energy as the lead laboratory for United States participation in this project, with Dr. Cohn as the chief coordinator for technical inputs from the various fusion laboratories in the United States. Plasma Fusion Center activities in the ITR project center on ignition physics, and the design of the toroidal field magnet system, which must be designed to facilitate extended D-T operation. Extensive tests of the mechanical properties of the copper, steel, and insulator components of the magnet are under way.

Finally, the tokamak systems studies program is also playing an important role in the plasma systems design activities related to the Engineering Test Facility (ETF), which is the next major fusion facility planned for the United States program.

APPLIED PLASMA PHYSICS RESEARCH

The primary objective of Plasma Fusion Center's Applied Physics Research Division, with Professor Ronald Davidson as acting head, is to develop the basic experimental and theoretical understanding of plasma heating and confinement properties. This is required for effective planning and interpretation of data from large-scale confinement experiments. Moreover, given the complexity of the development of fusion energy, it is essential to maintain vigorous ongoing research in basic plasma physics. In the plasma theory area, this is accomplished by the continued development of new analytic and numerical tools for handling complex plasma problems, and by the evolution and improvement of existing models together with the development of new models. In the experimental research area, the continued development of new and improved diagnostic techniques is required to provide a basic understanding of plasma heating and confinement properties.

Present applied physics research activities include: experimental research on the Versator II tokamak (Professors Porkolab and George Bekefi); experimental research on the Constance I and II mirror devices (Professor Louis Smullin); fusion theory and computations (Dr. Tom Antonsen and Professors Coppi, Davidson, Abraham Bers, Thomas Dupree, Jeffrey Freidberg, James McCune, and Kim Molvig); development of the MACSYMA symbolic manipulation system (Professor Joel Moses); plasma diagnostics and laser development (Dr. Cohn and Professor Benjamin Lax).

We summarize here the significant progress made during the past year in several of the applied plasma physics research areas.

Versator II

The medium-sized Versator II research tokamak places primary emphasis on basic investigations of plasma heating and confinement properties. RF heating experiments at the lower-hybrid frequency are now in progress, and a major feasibility study of steady toroidal current drive using high-power microwaves will begin within a few months. Late in 1979, electron cyclotron heating experiments also will be initiated on Versator II using the high-power gyrotron developed by the Naval Research Laboratory. The current-drive and electron cyclotron heating experiments will place Versator II on the forefront of basic tokamak research.

Constance I and II

Until recently, plasma confinement in magnetic mirror configurations has been severely limited by the drift-cyclotron loss-cone (DCLC) instability. The detrimental effect of this instability was significantly reduced in experiments on 2X-IIB at Lawrence Livermore Laboratory by injecting a cool plasma component. However, this had the unfortunate side effect of significantly cooling the electrons. In the Constance I mirror experiment at M.I.T., it was demonstrated that a powerful electron beam injected into the plasma, through oscillations stimulated in the plasma, produces a low-density, hot-electron population that stabilizes the DCLC instability. During the past year, construction of a new mirror facility, Constance II, has been completed. Constance II, which is a somewhat larger experimental device than Constance I, will permit a more realistic simulation of the influence of electron energetics on confinement properties in large-scale mirror experiments (such as the Tandem Mirror Experiment at Livermore), where these techniques will ultimately be employed. During the next year, a good experimental comparison between microwave stabilization (at the electron cyclotron frequency) and electron beam stabilization of the DCLC instability will be established. In the longer term, emphasis will be placed on optimizing these two approaches for maximum effective stabilization.

Fusion Theory and Computations

The main objective of fusion theory and computations research at M.I.T. is to provide the basic physics understanding necessary for interpreting present and past experiments and to formulate the appropriate scaling laws needed for meaningful experimental planning and prediction of the performance of future devices. Both analytical and computational studies are performed; the data obtained on experimental devices operating at different temperatures, densities, and magnetic fields are evaluated to refine and modify existing theories of plasma behavior as well as to formulate new theories.

During the past year, there has been an increased emphasis on providing theoretical support in critical problem areas for the Alcator, Torex, Versator, and Constance experimental programs. The primary plasma theory areas under intense investigation include:

- RF heating and nonlinear wave coupling in toroidal plasmas with emphasis on applications to Alcator A and C and Versator II. Theory of nonlinear waves in plasmas, and induced stochasticity in particle dynamics by coherent waves (Professor Bers).
- Confinement properties of fusion plasmas. These studies include: MHD equilibrium and stability properties of tokamak configurations (Professor Coppi); MHD equilibrium and stability properties of torsatron/stellarator configurations (Professor Freidberg); micro-instabilities and anomalous transport in high-temperature plasmas, including the formulation of self-consistent scaling laws for electron energy transport in tokamaks (Dr. Antonsen, Professor Coppi, and Professor Molvig).
- Nonlinear effects and plasma turbulence. The purpose of these investigations is to develop the basic understanding of a wide variety of nonlinear and turbulent phenomena, including stochastic magnetic fields, clumps, and nonlinear saturation of linear instabilities (Professor Dupree).
- Stability and transport properties of toroidal and linear fusion systems. These investigations include: the effects of ambipolar fields on transport and stability properties of toroidal plasmas,

and the high-beta stability properties of tandem-mirror configurations (Professor McCune); microstability and transport properties of mirror fusion systems with emphasis on applications to the Constance and Livermore experimental programs (Professor Davidson).

Research in these areas is greatly facilitated by the use of high-speed computers and access to the National Magnetic Fusion Energy Computer Center (NMFEECC) at Lawrence Livermore Laboratory. In order to provide the maximum effective access to the NMFEECC, we recently have established a computational support activity headed by Dr. John Kulp to provide computation-related services to the entire PFC user community. The responsibilities include the implementation and maintenance of local facilities for connecting to the NMFEECC via existing network ports and the local network (CHAOS). In addition, the computational support activity provides a centralized administration of the PFC time allocation at the NMFEECC and maintains and distributes documentation for users. Because of the importance of computing in both experimental and theoretical programs, it is imperative that PFC researchers have convenient and efficient access to the NMFEECC.

MACSYMA is a symbolic manipulation program implemented on the MACSYMA consortium PDP-10 at M.I.T. and available to the magnetic fusion community through the National Magnetic Fusion Energy Computer Network. Following a demonstration of the system's capability at the 1976 meeting of the APS Plasma Physics Division, and a workshop held in Berkeley, California in the summer of 1977, there has been a rapid growth in the use of this effective tool by fusion theorists. The Department of Energy provides partial support for the maintenance and development of the MACSYMA system, its underlying MACLISP system, and the ITS operating system which all operate on the MACSYMA consortium PDP-10. In addition to the ongoing research on algorithm development for the symbolic manipulation of algebraic structures, an effort is being made to implement improved I/O facilities such as a two-dimensional display editor for mathematical expressions and handwritten input using a tablet. In addition, software is being developed to make the system available on large-address-space computers and at sites other than M.I.T. Software optimized for fusion applications is also being developed.

Advanced Diagnostics and Laser Development

The primary emphasis in advanced diagnostics and laser development is the development of new millimeter and submillimeter wave technologies for diagnostics and heating of tokamaks and other fusion devices which operate in the 10^{14}cm^{-3} - 10^{15}cm^{-3} density range. During the past year, the concept of using high-power submillimeter lasers to measure ion temperature in magnetically confined plasmas by Thomson scattering has been extensively investigated, and a high power (500 kW - 1 MW) $385\ \mu\text{m}$ D_2O laser and a special heterodyne detection system have been developed. The spatially resolved measurements of ion temperature, impurities, and collective effects which should be possible with this system will ultimately play a significant role in diagnosing the properties of high-temperature fusion plasmas. The development of the appropriate optically pumped laser technology has led to an increased understanding of the quantum electronics of optically pumped lasers. Moreover, the associated heterodyne detector development has led to the development of fast, sensitive, submillimeter detectors which are finding additional applications. During the next 12 months, the ion Thomson scattering diagnostic will be tested on Alcator C and developed into a practical diagnostic tool. In addition, new diagnostic techniques for increased spatial resolution of plasma density and measurement of the plasma current profile will be developed. Finally, a program for the development of advanced high-frequency (100-200 GHz) gyrotron devices has been proposed to the Department of Energy.

APPOINTMENTS AND PROMOTIONS

During the past year, there have been several important appointments and promotions in Plasma Fusion Center program areas.

Appointments include: Professor Lawrence Lidsky (Department of Nuclear Engineering), appointed PFC Associate Director for Technology Development; Dr. D. Bruce Montgomery (Nuclear Engineering and National Magnet Laboratory), appointed PFC Associate Director for Engineering Systems; Professor Ronald Parker (Electrical Engineering and Computer Science), appointed

Vice President, Research

PFC Associate Director for Confinement Experiments; Dr. Daniel Cohn (M.I.T.), appointed Head, Plasma Fusion Center Office of Planning and Advanced Projects; Joyce Cooper (University of Maryland), appointed Secretary to the Director; John Cochrane (M.I.T.), appointed Assistant to the Director for Administration; Dr. Kuo-In Chen (Johns Hopkins University), appointed Postdoctoral Fellow in the Versator II experiment program; Dr. James Chen (Cornell University), appointed Research Scientist in the intense charged particle beam theoretical program; Dr. Stanley Luckhardt (Cornell University), appointed Postdoctoral Fellow in the Versator II experimental program; Dr. Robert Klinkowstein (Rensselaer Polytechnic Institute), appointed Postdoctoral Fellow in the Constance experimental program; Dr. John Rice (M.I.T.), appointed Research Scientist in the Alcator plasma-wall interactions group; Dr. Martin Greenwald (University of California at Berkeley), appointed Research Scientist in the Alcator operations and plasma-wall interactions groups; Richard Rosomoff (Harvard University), appointed to the technical staff of the Alcator operations group; Dr. Alexander Rechester (Institute for Advanced Study), appointed Research Scientist in fusion theory and computations; Dr. John Kulp (M.I.T.), appointed Research Scientist in fusion theory and computations; Dr. Hironori Takahashi (Princeton University), appointed Research Scientist in the Alcator ion cyclotron resonance heating program; Dr. Vladimir Krapchev (M.I.T.), appointed Research Scientist in fusion theory and computations; Dr. Kim Molvig (M.I.T.), appointed Assistant Professor of Nuclear Engineering in fusion theory and computation; Dr. Jeffrey Freidberg (Los Alamos Scientific Laboratory), internationally renowned plasma theorist with expertise in macroscopic equilibrium and stability properties of fusion systems, appointed Professor of Nuclear Engineering.

Institute research promotions in the Plasma Fusion Center include the promotion of several experimental physicists with outstanding individual research accomplishments: Dr. Awinash Gondhalekar, expert in plasma diagnostic studies and laser development, promoted to Principal Research Scientist; Dr. Ian Hutchinson, expert in cyclotron radiation emission from high-temperature plasmas, promoted to Principal Research Scientist; Dr. Earl Marmor, expert in plasma spectroscopy and impurity studies, promoted to Principal Research Scientist; Dr. David Overskei, expert in high-current tokamak equilibrium and stability properties, promoted to Principal Research Scientist.

Internal Plasma Fusion Center promotions and appointments to Group Leader and Project Leader positions of major programmatic responsibility include:

Confinement Experiments Division: Dr. David Overskei and Dr. Ian Hutchinson, co-leaders, Equilibrium, Stability and Operations Group; Dr. Awinash Gondhalekar, leader, Confinement Studies Group; Dr. Earl Marmor, leader, Plasma-Wall Interaction Group; Professor Miklos Porkolab, leader, Lower Hybrid Heating Group; Dr. Hironori Takahashi, acting leader, Ion Cyclotron Resonance Heating Group.

Engineering Division: John E.C. Williams, leader, Project Engineering and Advanced Design Group; Norton Pierce, project leader, Alcator C Mechanical Engineering; James Rose, project leader, Alcator C Power Systems; Mitchel Hoenig, leader, Superconducting Magnet Development Group; Professor Robert Rose and Dr. Brian Schwartz, co-leaders, Superconducting Materials Development Group.

Technology Development Division: Professor Mujid Kazimi, leader, Safety and Environmental Studies Group; Professor Borivoje Mikić, leader, Blankets and Structures Group; Professor Lawrence Lidsky, leader, Advanced Fusion Concepts Group; Professor Lidsky, acting leader, Component Development Group; Dr. Daniel Cohn, leader, Tokamak Systems Studies Group; Dr. Leslie Bromberg, project leader, Ignition Test Reactor Physics Design.

Applied Physics Research Division: Professors George Bekefi and Miklos Porkolab, co-leaders, Tokamak Systems Experimental Research Group; Professor Louis Smullin, leader, Mirror Systems Experimental Research Group; Professor Ronald Davidson, acting leader, Fusion Theory and Computations Group; Professor Joel Moses, leader, MACSYMA Group; Dr. Cohn, leader, Diagnostics and Laser Development Group.

THE NABISCO FACILITY

Nabisco, Inc., with headquarters in East Hanover, New Jersey, announced on May 31, 1978 that it is donating its property at 184-190 Albany Street in Cambridge to M.I.T. The value of the 71,000 square foot building and property is in excess of \$1.5 million. The property will be transferred to M.I.T. during the latter part of 1979.

The Nabisco Building is adjacent to the Plasma Fusion Center 225 MW Alternator (NW20), and fusion research facilities located in the National Magnet Laboratory (NW14), the Department of Nuclear Engineering's Nuclear Reactor Laboratory (NW13 and NW12), and the Plasma Fusion Center headquarters facility (NW16). The close proximity to these facilities and heavy power make the Nabisco Building an ideal location to house the Plasma Fusion Center's major confinement experiments and engineering test facilities, particularly the upgrades/follow-on experimental devices in the Alcator, Versator, and Constance programs, as well as the proposed Torex A device under review by the Department of Energy. The Plasma Fusion Center is currently preparing a comprehensive space utilization plan for the Nabisco facility. The preliminary cost estimate by the M.I.T. Physical Plant for renovation of the facility is \$4.7 million.

RONALD C. DAVIDSON

Research Laboratory of Electronics

The Research Laboratory of Electronics (R.L.E.), established at the end of World War II, was the Institute's first interdepartmental laboratory. In the years since, it has evolved an on-campus research environment which provides faculty members and their students with the diverse services and facilities of a large laboratory. R.L.E. was originally organized to encourage interactions between teaching and research in the Departments of Electrical Engineering and Physics, but has subsequently had projects involving participants from as many as a dozen academic departments. The research groups, which currently number approximately 30, conduct studies in three broad areas: general physics, plasma dynamics, and communication sciences.

Research in R.L.E. is primarily performed by faculty members, postdoctoral associates, and students. Approximately 75 members of the faculty are affiliated with the Laboratory, working with about 300 graduate students and 100 undergraduates. The research covers many topics, thus providing opportunities for a wide variety of student theses. During the past year, work done in the Laboratory served as the basis for 16 doctoral, 3 engineer's, 15 master's, and 29 bachelor's theses.

Major support for the research is provided by the Joint Services Electronics Program of the US Army, Navy, and Air Force, as well as other agencies of the Department of Defense, the Department of Energy, the National Science Foundation, the National Institutes of Health, and the National Aeronautics and Space Administration (NASA).

GENERAL PHYSICS

The general physics area includes such subjects as solid state, atomic physics, quantum electronics, and electromagnetics. The Laboratory's research in general physics is primarily concerned with the structure of matter -- atoms, molecules, and condensed matter. The experimental techniques used in these investigations include radio frequency and optical spectroscopy, X-ray scattering, laser light scattering, photo-acoustic spectroscopy, and nonlinear optics. A few of the research topics in this area are as follows:

Professor Shaoul Ezekiel and his students have developed new techniques for the detection of inertial rotation using lasers and fiber optics for applications in navigation and geophysics. In addition, they have conducted studies, with unprecedented resolution, of the interaction of intense monochromatic fields with atoms and molecules. Folded and cascade three-level systems have been examined, in the presence and absence of Doppler broadening.

The most probable inelastic process for an atom-molecule collision is Rotational Energy Transfer (RET). Professor David Pritchard and his students have measured RET rate constants, $k_{j_0 \rightarrow j_f}$, for laser excited Na_2 colliding with various gas targets. A computerized data acquisition system has allowed the measurement of more than 40 rate constants for each of eight gases. These results go far beyond previous measurements in scope of targets, spread of initial j_0 levels, accuracy, and dynamic range. They should provide a major test of theories of such processes. Already a new empirical scaling law, superior to any previously proposed, has emerged from these data and later been extended to many other RET data sets -- most of them theoretical.

The ultimate RET experiment is one in which all relevant quantum numbers are known before and after collision. As a first step toward this goal, Professor Pritchard's group has recently utilized the Doppler effect to measure the velocity dependence of the RET rate constants in a gas cell. The results show that under certain conditions the rate constants for large angular momentum transfers decrease with increasing velocity -- a result which differs markedly from that expected for collision of a ball and stick.

The detection of infrared radiation (IR) is an important problem in radioastronomy, communications, spectroscopy, and plasma diagnostics. Professor Daniel Kleppner and his colleagues have recently demonstrated a new IR detection technique which makes use of highly excited (Rydberg) atoms. The IR is resonantly absorbed by the Rydberg atoms, transferring them to a nearby energy state. Field ionization is then used to detect the transition. Each IR photon absorbed produces a single charged particle which is individually counted with standard techniques. Because the system is resonant, the detector is inherently frequency-selective. By applying small electric fields, the detector can be tuned throughout the far IR and millimeter wave regions. Operation has been demonstrated at 496μ . The resonance width was less than 1 MHz, and the measured sensitivity was comparable to that of the best existing detectors. Operation at several shorter wavelengths also has been studied.

Professor John D. Joannopoulos' group is continuing studies of the electronic and vibrational excitations at surfaces of semiconductors and insulators. The effects of adsorbed molecules and semiconductor-metal and semiconductor-insulator interfaces also are being investigated. A new theory has been developed to account for defects and disorder at surfaces and interfaces.

Professor Hermann Haus and his group have continued their work on the modelocking of semiconductor diode lasers. The first successful modelocking of semiconductor lasers producing short pulses was achieved a year ago. Different laser diodes, of various compositions and wavelengths, were modelocked this past year. The shortest pulsewidth so far achieved was 16 psec at a pulse-rate of 2 GHz. The wavelengths of the lasers lie between 0.8μ to 1.3μ , an important frequency range for propagation in optical fibers. Work is also in progress on novel signal processing devices compatible with the power levels from diode lasers (a few milliwatts average power).

Professor Jin Au Kong and his students have carried out a number of projects in electromagnetic wave propagation and radiation, including 1) active and passive remote sensing of earth terrain, 2) microstrip antenna studies, 3) geophysical subsurface probing and communication with dipole antennas, and 4) fiber optics and integrated optics. Seven journal articles, seven symposium articles, and several technical reports have been published in the past year.

Professors Alan H. Barrett and Philip C. Myers and students have continued their radio-astronomical studies of the interstellar medium. Among their recent findings are: 1) detection of unusually wide spectral lines of NH_3 in the Sgr B2 molecular cloud near the galactic center; 2) discovery of the $J_{K-K+} = 3_{12} \rightarrow 3_{13}$ line of H_2CO in the Orion Molecular Cloud; and 3) discovery of two new sources of radiation from the remarkable long-chain molecule HC_5N . These sources have about the same mass as the Sun and linewidths much smaller than that for free-fall.

Professors Barrett, Myers, and their students also have continued their work using microwave radiometry to detect thermal radiation associated with breast cancer. They have installed a new microprocessor-based radiometer at 6 GHz in Faulkner Hospital, Boston. This instrument is now in clinical use.

During the past year, three new satellites carrying passive microwave spectrometers were launched into earth orbit. A team including Professor David Staelin, Research Associate Philip Rosenkranz, and three graduate students, has begun to interpret the microwave data they provide in terms of atmospheric temperature, humidity, and wind fields, and in terms of ocean surface temperature and roughness.

During the first quarter of 1979 postdoctoral associate Michael Shao and Professor Staelin succeeded in tracking fringes of the star Polaris by means of an improved Michelson stellar interferometer located at Mt. Wilson, California. Such measurements of fringe phase make feasible optical astrometry with $\sim 10^{-4}$ arc sec accuracy -- sufficient to detect Jovian planets about nearby stars.

Professor Ralph Staley and his group are developing photoacoustic spectroscopy (PAS) techniques to characterize molecular species on surfaces. Their ultimate aim is to investigate modifications of the physical and chemical properties of surfaces caused by covalent attachment of organic and organometallic molecules. To date they have used PAS to study the attachment of ferrocene to silica surfaces. The spectrum is used to determine the mechanism of attachment, to measure the degree of attachment, and to determine the Fe(II)/Fe(III) ratio for the attached molecules. The use of PAS to obtain spectra of solids in the infrared also has been demonstrated using CO₂ laser lines to observe absorption features in the spectrum of thymol in the 9-11 μ region, and by observing the vibrational overtone features of surface attached molecules in the 1-2 μ region.

Professor F. Read McFeely and his group have completed the testing of an angle-resolved photoemission spectroscopy system. The final addition to this instrument has been a position sensitive detection system in the analyzer -- which replaces the conventional exit slit assembly and increases the analyzer sensitivity by a factor of 20. Increased sensitivity is required for surface photoemission experiments employing polarized HeII excitation. The first measurements, performed on non-polar ZnO surfaces, have shown that photon polarization can have a dramatic effect upon the photoemission spectrum and can be a valuable tool for the elucidation of surface orbital symmetries.

Professor Frederic R. Morgenthaler and his colleagues have continued their studies of the conditions required to contain magnetostatic waves in dc magnetic field gradients. They have investigated rectangular slabs, and solid or hollow cylinders, with the wave propagation parallel to the surfaces and perpendicular to the dc field direction. Although special field profiles were discovered that allow analytic treatment of particular waves, a more complete treatment of the eigenvalue problem has been needed and has now been carried out.

Professor Clifton G. Fonstad and his group have recently demonstrated tunable, thin film grating filters produced by introducing a variable phase shift between two distributed feedback (DFB) gratings. In another program, to develop DFB lead-tin telluride lasers, the first devices have been successfully tested and single mode emission seen over a broad operating range. In his research on III-V quaternaries and devices, Professor Fonstad's group has developed techniques for fabricating segmented-contact, stripe geometry, aluminum gallium arsenide laser diodes. Testing and characterization of these devices is beginning. Companion work on the growth and characterization of indium arsenide antimonide is also proceeding successfully. These materials are now being applied to laser diodes, and work is beginning on the incorporation of these materials into integrated optic couplers for high-speed pulse train multiplexers, and into high-speed heterojunction phototransistors.

Professors Peter A. Wolff and Dirk J. Muehlner and graduate students are continuing studies of resonant, spin-induced, four-photon mixing in (Cd,Hg)Te. They observe several distinct spin resonances in their (Cd,Hg)Te sample -- a result which indicates that the crystal is inhomogeneous. This experiment is now being used by Honeywell as an analytic technique to determine g-value and alloy composition as a function of position in (Cd,Hg)Te.

Professor Wolff's group is also continuing studies of resonant, impurity-induced, four-photon mixing in n-Ge and n-Si. During the past year, the group observed resonances in the third order nonlinear coefficient caused by impurity levels in Si -- the resonance being at the valley-orbit splitting energy of the donor levels. To date, the impurity resonances in these four-photon mixing experiments have been studied by step-tuning the CO₂ lasers. More precise data can be obtained by sweeping the impurity levels with magnetic field. These experiments, which are now under way, will determine: 1) magnetic structure of donor levels in n-Ge and n-Si, 2) precise linewidths of valley-orbit transitions, and 3) excitation transfer rates between donor levels.

Professor Marc Kastner and his group are studying amorphous silicon dioxide (a-SiO₂), the most important glass, and one of the most important of all technological materials. Optical fibers are drawn from ultra pure a-SiO₂ and most silicon electronics technology relies on a-SiO₂ as an insulator and dielectric. It has long been known that defects in a-SiO₂ have deleterious effects on the optical and electronic properties of these materials. However, progress in characterizing these defects has been slow. On the other hand, much progress had been made in understanding the defects in chemically similar chalcogenide glasses with smaller band gaps. In the past year, Professor Kastner has obtained evidence that intrinsic defects, similar to those in chalcogenides, occur in a-SiO₂ as well. His group has made the first observation of intrinsic photoluminescence in a-SiO₂, and shown that it has the same properties as the photoluminescence from excited defects in narrower band gap chalcogenides -- in particular, the luminescence Stokes shift and linewidth scale with band gap and the temperature dependence scales with the glass transition temperature. These results bring an understanding of the nature of the defects much closer.

During the past year, Professor Robert J. Birgeneau and his group have initiated a new and important venture in the use of X-ray scattering techniques to probe the structure and thermodynamics of two-dimensional solids and liquids. Specifically, they have discovered that by carrying out X-ray scattering experiments from monolayers of heavy atoms, such as krypton or xenon, adsorbed onto the surfaces of such light materials as graphite, one may obtain structural information about the adsorbate at a level which has hitherto been unknown. This approach has been used to study such phenomena as two-dimensional gas-solid coexistence and melting in two dimensions. They also have discovered that such melting processes are most often continuous; i.e., that in two dimensions solid and liquid do not coexist, as they do, for example, for ice cubes in a glass of water. These studies will play an important role in elucidating the problem of melting -- a basic process in nature which is still barely understood.

The work done by Professor Henry I. Smith and Principal Research Scientist John Melngailis in the Microstructures Laboratory during the past year falls into two main categories:

- 1) Putting the campus laboratory into operation. The facilities now operating are: substrate cleaning station, photolithography, high power optical microscopy, laser holography, X-ray lithography, ion etching, and plasma etching.
- 2) Collaborative research projects, which depend on advancing the state of the microstructure art, are under way or being started. They include: physics of transport in very small conductors; alignment of liquid crystals on grating structures; control of thin film growth by artificial microstructures; molecular attachment to surfaces; and measurement of electrical signals in individual living cells. The only preliminary result which can be reported at this time is that when a grating is used, liquid crystal 408 can be formed in the smectic B phase. This is difficult to do by other techniques since the phase exists only in a narrow temperature range.

During the past year, Professor Michael Salour and his colleagues have established a Picosecond Optics Laboratory employing a state-of-the-art picosecond dye laser oscillator-amplifier system in synchronism with picosecond diagnostic tools. A number of picosecond time scale optical effects are now under study, including nonlinear absorption and transmission, enhanced spontaneous and stimulated light-scattering, and various ultrafast processes in semiconductors.

PLASMA DYNAMICS

The plasma dynamics program seeks to understand the basic properties of ionized media, in plasma regimes that are of interest to controlled fusion, space physics, and astrophysics. Research in this area includes studies of plasma turbulence, heating, confinement, and stability. Plasma diagnostic techniques involve measurements in various portions of the electromagnetic spectrum including the microwave, millimeter wave, infrared, and optical regions.

Professor Bruno Coppi and his group are collaborating with experimentalists at the Plasma Fusion Center who have recently achieved record values of the plasma confinement parameter in the Alcator A device. These studies will soon be extended to Alcator C, a larger and more advanced version of the Alcator A which recently has been brought to operation and achieved plasma currents close to half megampere. A relatively large-scale program for the heating of the plasmas in the Alcator C device, by the injection of about four megawatt of microwave power at the lower hybrid frequency, is under way.

Professor Coppi and his colleagues also are developing a parallel program, with a similar goal, but employing a different frequency range and hardware from a dismantled military radar facility. The experimental effort has been integrated with a theoretical program directed at identifying the regimes of plasma operation that are best suited for this form of external plasma heating.

On the basis of recent experimental evidence, theoretical descriptions of the solar corona based on a spatially homogeneous structure have been abandoned. A new model developed by Professor Coppi, in collaboration with a team from Harvard, attributes the heating of the solar corona to magnetically confined plasma loops in the so-called active regions. The heating results from a sequence of physical processes that have all been experimentally realized in laboratory plasmas. The inhomogeneous corona model has attracted a great deal of interest in the solar physics community.

Research with relativistic electron beams under the direction of Professor George Bekefi is being carried out on two experimental facilities: the NEREUS accelerator (500 kV, 100 kA, 20 nsec) and the Physics International Pulserad 110A accelerator (1.5 MeV, 20 kA, 30 nsec). The NEREUS facility is being used in the study of beam dynamics in relativistic electron beam diodes; the Pulserad 110A accelerator for the generation of intense microwave and submillimeter radiation. Microwaves of centimeter wavelengths are generated in a novel magnetron device; submillimeter radiation is produced in a free electron laser of recent construction.

The Versator II research tokamak, under the direction of Professors Bekefi and Miklos Porkolab, is now fully operational. The device is primarily being used as a test bed for various microwave heating experiments. Heating experiments at the lower-hybrid frequency, using a 200 kW, 800 MHz microwave supply, are under way. Later in the year RF heating experiments at the electron-cyclotron frequency will be attempted. This work will be carried out in cooperation with the Naval Research Laboratory where a novel 200 kW, 36 GHz gyrotron tube has been developed. The group also will investigate the possibility of inducing a current in the plasma through an appropriate injection of microwave power.

Professor Abraham Bers and his research group are continuing their studies of nonlinear wave phenomena involved in the heating of plasmas for energy generation by nuclear fusion. A recently completed work by our visiting scientist, Dr. Elena Villalon, has analyzed in detail the nonlinear evolution of certain parametric excitations, and correlated their behavior with recent experimental observations on microwave heating of plasmas in Alcator A. Drs. Vladimir Krapchev and Abhay Ram have demonstrated the existence of new types of nonlinear modes in plasmas. These modes may be important in understanding how high-power electromagnetic energy can be coupled to a plasma for the purpose of heating it.

Professor Louis D. Smullin and students are using two experimental magnetic mirror systems, Constance I and II, to study the suppression of drift-cyclotron-loss-cone instabilities by "hot" electrons. The hot electrons are produced either by electron-cyclotron-resonant heating with microwave power, or by the interaction between the plasma and an injected electron beam. Both techniques have been shown to suppress instabilities. Graduate student Joseph P. Rymer is studying the production of a mirror-trapped plasma by injection of a stream from a plasma gun, and graduate student Amin K. Ezzeddine is studying the production of hot electrons by electron-beam plasma interactions.

Professor Thomas H. Dupree and his group are working on a variety of analytic and computational plasma problems relating to nonlinear plasma physics, turbulence, heating, and confinement. The analysis is mainly in the area of turbulence and stochasticity. Recent work has included the theory of magnetic field line stochasticity and its relation to drift and tearing modes. In addition, the study of one-dimensional phenomena involving BGK modes, holes, and clumps is continuing. The analytic work is carried out in conjunction with a program of plasma simulations. The group is currently carrying out simulations of turbulent holes, BGK modes, and vortices. To make possible the simulation of more physically realistic problems in higher dimensions with more particles, a computational facility involving an array processor and mini-computer is being developed.

COMMUNICATION SCIENCES AND ENGINEERING

Research in communication sciences and engineering deals with fundamental studies of signals and systems, and such applications as speech and picture transmission, seismic detection, and optical communication. Much of the effort is related to the life sciences. A combined program of research and training in communications bioengineering includes communications biophysics, neurophysiology, cognitive information processing, and speech communication. Most of this work concerns the sensory or perceptual mechanisms. A related program in linguistics seeks to improve our understanding of languages, which form the basis for communication.

The research of Professors Robert S. Kennedy, Jeffrey H. Shapiro, Dr. Horace P. Yuen, and their students is concerned with the extension of communication theory to optical frequencies. The main objectives of this work are to 1) formulate propagation models for important optical channels from the underlying physical processes, 2) determine the fundamental limits on detection and communication performance that can be realized with these channels, 3) develop techniques for optical detection and communication which achieve or approach these limits, and 4) establish, by means of experiment, the validity of the theoretical results and guide their future development. During the past year, a series of papers which resolve many of the questions concerning the propagation and detection of quantum fields have been prepared and published.

Professors William F. Schreiber, Donald E. Troxel, and their students are continuing research on computer-assisted image processing systems for graphic arts applications. One system of their design, known as the "Electronic Darkroom," is already in daily use at Associated Press headquarters in New York City, while a second is in pilot production at a large printing company. These sophisticated systems enable nontechnical operators to perform a wide variety of "photographic" operations by computer, resulting in substantial savings in time and materials, while at the same time enhancing quality.

Professor Jonathan Allen and his co-workers have made extensive improvements in the overall system for conversion of unrestricted English text to speech. Intelligibility and comprehension tests indicate that the speech quality is comparable to that of humans, and thus can be used in many applications for speech output from computers. The system is available under license, and a short summer course has been presented.

Research in the area of speech communication, under the direction of Professor Kenneth N. Stevens, is concerned with the representation of speech events at the acoustical, perceptual, and physiological levels, and with the development of models of the speech production and perception processes. New research directions over the past year include experimental studies of the coding of speech-like sounds in the auditory nerve (carried out in collaboration with the Eaton-Peabody Laboratory at the Massachusetts Eye and Ear Infirmary), investigations of a number of modifications in the properties of speech sounds when they occur in sentences, and the interpretation of the physiological state of infants from measurements of the properties of their cries.

Professors Alan V. Oppenheim, James H. McClellan, and Arthur B. Baggeroer, with several graduate students, have developed a number of new digital signal processing techniques, and applied them to speech processing and seismic data processing. New algorithms for fast computation of Fourier transforms have been studied and implemented. The speech processing

work is directed towards low-cost speech compression and enhancement of degraded speech -- as experienced, for example, on a faulty communication channel. The seismic data processing studies have led to new techniques potentially useful for exploration seismology.

Research by Professor Louis Braida and his colleagues (Research Scientist Nathaniel Durlach, Lecturer Adrian Houtsma, and Research Associates Steven Colburn and Charlotte Reed) continues to focus on intensity perception and loudness, binaural interaction, pitch perception, and aids for the deaf. In the first area, they have tested a theory of loudness comparisons with particular emphasis on comparisons between normal and impaired ears for the same stimulus type. In the second, they have further developed a unified theory of binaural interaction based on auditory nerve data, and initiated studies of binaural interaction in impaired listeners. In the third, they have evaluated a number of current models of central pitch processing through experiments using complex tones and AM noise, and explored certain pitch anomalies in impaired listeners. In the fourth, they have continued to study multiband amplitude compression as a hearing aid technique for people with reduced dynamic range, and nonuniform frequency lowering for listeners with severe losses at high frequencies, and evaluated the predictions of a new theoretical model to help guide the choice of frequency-gain characteristic in hearing aids. In addition, they are exploring various methods of encoding and displaying speech through the tactile sense as a potential aid in communication for persons with both severe auditory and visual impairments.

Professors William T. Peake and Thomas F. Weiss, and Drs. Nelson Y.S. Kiang, John J. Guinan Jr., and Terrance R. Bourk are continuing their studies of the auditory system in cooperation with the Eaton-Peabody Laboratory at the Massachusetts Eye and Ear Infirmary. Two recent developments are: 1) Measurements of mechanical and electrical signals in the inner ear of lizards have demonstrated that the frequency analysis of these signals involves receptor cell structures to an extent not heretofore realized. (This conclusion will help to focus the search for the frequency selective mechanisms, which are probably related to those of mammals); and 2) experimental studies of electric responses of the auditory nerve (in cats) have provided a basis for interpretation of these responses for diagnostic purposes in humans.

Professor Lawrence S. Frishkopf and his group have continued studies of mechanisms of transduction in hair-cell organs of the vertebrate acustico-lateralis system. Research in the past year has focused on mechanical properties of hair-cell cilia; such properties may determine, in part, the frequency response and frequency-related nonlinear characteristics of these organs. Mechanical parameters of cupula motion in the semicircular canal of the skate also have been directly measured.

During the past year the neurophysiology group, under the direction of Professor Jerome Lettvin, has produced the following studies: Dr. Edward R. Gruberg has completed work on the isthmic nucleus of the frog, showing it to be connected exclusively to and from the tectum; Dr. Gruberg and Professor Lettvin have shown that the axons of tectal cells were active, although the cell bodies were not thus solving the paradox in which isthmic cells encoded visual information that they couldn't possibly receive if the cell-firing of the tectum were taken as the output from the tectum. Professor Jerome Lettvin also has finished a theory of membrane control that explains the Hodgkin-Huxley equations, and has built a model to demonstrate the consequences of the theory.

The research of the R.L.E. Linguistics group has continued along the same general lines as in previous years. Professors Kenneth Hale, Morris Halle, and Rene P.V. Kiparsky have been investigating the suprasegmental organization of the phonological string. It appears that a single organizational principle underlies such superficially disparate phenomena as syllable structure, stress assignment, and vowel and consonant harmony. The dissertation on the phonology of Arabic and Hebrew, completed in the spring of 1979 by graduate student John J. McCarthy III, was an important contribution to these studies. During the academic year, Professor Kiparsky finished a monograph on analogic changes in language, and on the light that these changes shed on the proper formulation of linguistic theory. The presence of visiting scientists Drs. E. Williams and Margaret Allen, who have done pioneering work in the area of morphology, has created great interest in this topic on the part of faculty and students. Two doctoral dissertations dealing with problems in this area are under way, and additional work is being planned by several members of the group.

PETER A. WOLFF

Lincoln Laboratory

For the past year, Lincoln Laboratory has continued in its role as a Federal contract research center for advanced electronics, with agencies of the US Department of Defense -- the Air Force, Army, Navy, and DARPA (Defense Advanced Research Projects Agency) -- supplying 90 percent of the Laboratory's budgetary support. The size of the Laboratory has also remained essentially constant. In fiscal year 1979 the operating budget was \$114 million, supporting the efforts of 811 professional staff -- 67 percent of whom hold advanced degrees. The level of staffing for defense work has now been fixed by agreement between Congress and the Department of Defense, and it is expected to remain stable through the next few years at least.

Innovations in radar, digital processing, and communications, individually and in combination, have long been hallmarks of Lincoln Laboratory's technical activities. This year has been no exception, as work is proceeding on three new radar systems: a tactical netted radar system for use on the battlefield, a millimeter wave radar for collecting information on reentry vehicles, and an airborne infrared wavelength radar for aiding pilots at night or in fog.

Many of the radars currently deployed by the Army for tactical ground surveillance and air surveillance are some 20 years old in their design or in the technology they embody. Their performance in the field places heavy demands on operating personnel and is sensitive to operator training and individual skills. In addition, these radars are very vulnerable to current countermeasure capabilities.

Recent technological advances in, for example, the size and cost of digital signal processing devices, surface-acoustic-wave components, and array antennas, together with experience in the management of large sensor networks, have introduced new options in the type and uses of radar for tactical applications. In particular, it is possible to support mobile forces with improved target acquisition and dissemination for surveillance, control, intelligence, and targeting through the use of automated radar/communication networks. A program is under way at Lincoln Laboratory to develop the hardware and software necessary to demonstrate the feasibility and performance of tactical netted radar systems.

A basic demonstration network of ground surveillance radars has been successfully field tested by the Laboratory at Fort Sill, Oklahoma. Two existing Army radars were modified (very substantially) with advanced signal and data processors to produce "clean" digital target reports for transmission over narrow-bandwidth communications links. A radar control center van was equipped to accept the remotely generated radar reports and correlate them into single target tracks on display. During these tests, fully automatic acquisition and tracking of ground targets was demonstrated, with data from the two radars automatically combined to form single tracks. The netted radars carried out comprehensive surveillance in the presence of main-beam jamming and performed real-time automatic jammer location. Multi-function benefits of netted radars (such as simultaneous surveillance and shellburst location) were also demonstrated, with real-time target location in map grid coordinates.

Continuing development of netting algorithms will support future field tests and advanced netting capabilities. In particular, the existing radar control center is being modified to accept data from two additional radars: an existing airborne radar and a new radar now being developed.

The new radar is a truly modern tactical radar that employs a cylindrical, electronically step-scanned (360-degree) array antenna, solid-state transmitter, fully adaptive signal processor, automatic radar status reporting, and extensive electronic counter-countermeasure features to make it suitable for use in a flexible, mobile, netted system in an electronically hostile environment. This advanced radar will be capable of operating simultaneously in several modes (e.g., surveillance, shellburst location, Doppler target signature). It will also provide 360-degree low-altitude air surveillance and will serve for integral communications with the radar control center.

In addition to the development of systems of netted radars, the Laboratory is concerned with extending the scope of radar technology in various directions. Ever since the application of radar to military operations in World War II, there has been an effort to realize the advantages of higher frequencies, such as wider signal bandwidths, more accurate angle and range measurement, and finer velocity information.

After development of radars near 10 GHz, a major advance has been made in high radar frequency operation by the development of the laser. Experience in the last two decades with lasers indicates that propagation through the atmosphere at long range can attenuate the signal strength considerably and can decrease the signal quality. It has been known for some time that the propagation loss through the atmosphere has relative minima at 35 GHz and 95 GHz, but serious radar research in these frequency regions has been limited by the lack of high power sources. Recent developments in microwave technology have now yielded levels of kilowatts in peak power.

In the past year, a project has been initiated to develop a new high power instrumentation radar operating at millimeter wavelengths. The objectives of this effort are to design, construct, and install, at Kwajalein Atoll, an instrumentation radar operating at frequencies of 35 GHz and 95.5 GHz. This radar will not only serve as a test bed for radar system technology in these new frequency regions, but will also collect active and passive target signature data to provide a data base for future developments of millimeter wave radar systems.

Recent advances in infrared technology have opened new opportunities for high-resolution coherent laser radar design. The Laboratory began a program in 1976 to apply this technology to a long-needed tactical aircraft system for surveillance and target acquisition, which may be switched from a radar mode to a high-resolution imaging mode for target identification. Using a 50-watt carbon-dioxide laser, these capabilities can be realized at ranges up to 10 kilometers in clear weather, and up to 5 kilometers even in light fog.

During the last two years a laboratory test-bed radar has been built and employed for a variety of experiments. A data base of target and background returns has facilitated the development of digital signal processing techniques. These algorithms reduce speckle noise, enhance image quality, provide real-time range/intensity maps of terrain features, and provide target tracking. Infrared radar system component development also has been pursued, emphasizing component life and reliability and laser output stability, which is very important for coherent illumination and heterodyne detection.

Moving target indication is being studied using appropriate modifications to the test-bed to determine velocity resolution limits. Target radial velocities as low as one mile per hour appear to offer detection in surrounding ground clutter. A transportable measurement radar, using fairly rugged components, improved optics, a 12-detector array, and a real-time signal processor, is being constructed to gather further data in the field. Ultimately, a flyable system will be built and tested.

In the communications area, the Laboratory has continued its work in voice coding ("vocoding") technology for the transmission of voice signals in digital networks. Vocoder techniques for speech processing have traditionally been directed at the problem of reducing the required digital transmission rate for speech communication. Whereas straightforward digital coding of the speech signal may require 64,000 bits per second of transmission rate, a vocoder can reduce this rate to 2,400 bits per second. Vocoders at this bit rate allow satisfactory speech transmission under ideal conditions, but generally are not "robust," that is, resistant to adverse conditions, such as: 1) acoustically coupled background noise at the vocoder input; 2) transmission of the speech over a degraded analog telephone channel before vocoding; 3) talker variability in the sense that vocoders perform better for some talkers than for others; and 4) bit errors in the digital transmission channel.

Recent work at the Laboratory has produced improvements in vocoder robustness. One scheme employs a novel technique for estimating the spectral envelope of the speech, which adapts automatically to the pitch of the specific talker and is relatively insensitive to background noise. This method has been combined with a robust pitch detector and a noise-suppression algorithm integrated with the vocoder. The result is a high quality vocoder which is quite reliable in acoustic noise and performs well across a broad class of talkers. Another scheme addresses specifically the problem of acoustic background noise, such as one might encounter if the

vocoder is operated on board an aircraft. The noise is suppressed prior to vocoding by a preprocessor consisting of a filter bank with an adaptive set of weights that are controlled by continuous estimates of the signal-to-noise ratios from each filter. When the preprocessor is combined with a vocoder incorporating a robust pitch estimator designed for the noisy environment, overall intelligibility and quality is enhanced. Work is continuing in the areas of pitch extraction and formant estimation in noisy speech, as well as in potential methods for improving the quality of speech that has suffered prior environmental degradation.

There have been two recent developments that may help to reduce the cost of solar cells for generating electrical energy. The first concerns a new method for causing uniform crystal orientation in a thin wafer of silicon deposited on an amorphous silica glass substrate, the first time that oriented crystalline silicon has been produced on a substrate that is itself not a crystal. Silicon wafers for solar cells are conventionally sliced from large, costly boules of silicon crystal; at least as much crystal is wasted in the slicing as is preserved in the wafer, and it has been estimated that a solar cell of this kind must operate for several years in the field to generate as much electrical energy as is required to create it. The new process consists of etching a very fine grating on the surface of the amorphous substrate, depositing polycrystalline silicon on the surface, and then repeatedly melting the silicon by scanning it with a laser. The grating encourages the crystal grains to align themselves with the surface structure, until (after several passes of the laser) they are oriented with a degree of uniformity sufficient to serve as the wafer for a solar cell (or even, for that matter, for the fabrication of microelectronic integrated circuits). The experimental grating had a square-wave cross section with a 3.8-micrometer period, a 100-nanometer depth, and corner radii of about 5 nanometers. This process of using an artificial surface pattern to induce crystal orientation is termed graphoepitaxy by its inventors. As a new application of microstructure fabrication, it may lead to new combinations of substrates and over-layer films, and perhaps to three-dimensionally integrated electronic devices and other novel configurations.

Gallium arsenide solar cells of a new type have recently been developed, with conversion efficiencies exceeding 20 percent under terrestrial conditions, i.e., significantly higher than the efficiency of silicon solar cells. These new gallium arsenide cells are fabricated by a simplified technique, involving chemical vapor deposition, that does not require any vacuum processing. They have been successfully fabricated on germanium substrates as well as on gallium arsenide; those prepared on germanium are the first efficient gallium arsenide solar cells that have been fabricated on a substrate material other than gallium arsenide itself. The substitution of germanium for gallium arsenide substrates will permit a major saving in gallium consumption as well as a reduction in cell cost. Initial experiments on the effect of high-energy electron radiation on the new cells indicate that these devices would be much more resistant to radiation in space than either silicon or conventional gallium arsenide cells. Thus the new cells appear promising for space as well as terrestrial applications.

WALTER E. MORROW, JR.

Vice President, Resource Development

At the time last year's report was prepared, approximately one and three-quarters years of the five-year M.I.T. Leadership Campaign remained. Three major tasks faced the senior officers of the Institute, co-chairmen of the Campaign, and the Resource Development staff:

- 1) Acquiring the remaining total of \$58 million needed to reach the \$225 million Campaign goal;
- 2) Achieving each of the individual goals within the \$225 million total, as set out in the original Campaign plans;
- 3) Meeting funding goals created by the need to pursue scientific breakthroughs, by the ever-changing and increasing needs of the vital and dynamic faculty and students that form M.I.T.'s core, and by the need for additional facilities, personnel, and research support to enable M.I.T. to continue to make important contributions to the solutions of emerging societal problems.

Added to these major tasks was the need for increased support to counteract the eroding effects of inflation on our existing plant, our endowment, and the building of new facilities.

A year later, with commitments totaling \$214 million and approximately nine months of the Campaign remaining, despite the tremendous progress made towards the overall Campaign goal, certain individual components have not been met. Moreover, as is typical of most capital campaigns, greatly increased efforts will be required to achieve the remaining sums needed, in terms of both the total goal and specific items.

Chief among the needs requiring fulfillment at this time is endowment for professorships -- both senior chairs for distinguished faculty members, and career development chairs for promising junior faculty members. To this must be added the urgent needs for student housing, student financial aid, and new research programs and innovation.

Since early 1978, funding priorities totaling approximately \$20 million -- carried in the original Campaign goals as "Support for Special School and Departmental Needs" -- have been defined for the School of Engineering, Sloan School of Management, new Center for Cognitive Sciences, and the prospective College of Science, Technology, and Society. Some \$6.7 million has been realized to date toward these programs.

The remaining months of the Campaign will test the stamina, creativity, and ingenuity of all concerned in order to acquire the funds needed to maintain M.I.T. as a private institution that has significant impact on society, both nationally and internationally.

Another problem facing M.I.T. Resource Development in this final Campaign year is that many more educational and nonprofit institutions have embarked on, or are about to begin, major capital funding campaigns. Thus the competition for the funds available for charitable purposes will be far greater than ever before. Moreover, M.I.T.'s financial requirements -- simply to maintain a "steady state" (that is, at the very least, to support the present level of activity, assuming no new programs) -- will become increasingly difficult to meet.

The post-Campaign era will thus allow for no easing of activity on the part of Resource Development. In fact, an increase in activity coupled with increased ingenuity, efficiency, and personnel capability and performance will be required. Better interaction with and utilization of assistance from the faculty will be a major goal, as well as closer coordination and working relations with the M.I.T. Alumni Association.

Lastly, the needs for unrestricted income will be increasing in the years ahead. It is only with this source of funding, so difficult to secure, that new programs can be initiated, nurtured, and developed; that salaries that have not kept up with inflation can be improved; that members of the faculty can be added; and that M.I.T.'s position of world leadership can be maintained.

In summary, tremendous progress has been made in the past year, as evidenced by the reports that follow. As we enter the final months of the Campaign, however, the greatest challenge remains: to meet successfully all the Campaign goals by April 23, 1980, and to plan for the continuing post-Campaign efforts that will be needed to maintain M.I.T.'s leadership in society. This planning progress on the part of the Resource Development senior staff is now under way.

PRIVATE SUPPORT

Total private support of M.I.T. during the past year was \$37.4 million, comprising of \$33.9 million in gifts, grants, and bequests and \$3.4 million in support through membership in corporate liaison programs (discussed elsewhere in this report). This total is a five-year high, compared with \$34.4 million in 1978, \$29.4 million in 1977, \$23.9 million in 1976, and \$21.7 million in 1975. The increased total for 1979 continues to reflect the impact of the M.I.T. Leadership Campaign.

Sources of gifts for fiscal year 1979 were: alumni, \$10.98 million; nonalumni friends, \$4.3 million; corporations, corporate foundations, and trade associations, \$8.1 million; foundations and charitable trusts, \$10.5 million; others, \$.1 million. Included in the totals for alumni and friends are gifts of \$.25 million made to the William Barton Rogers Pooled Income Fund, which was inaugurated in the fall of 1975. Total income for corporate liaison programs was \$3.4 million, a 10 percent increase over the total for fiscal year 1978.

Donors designated expendable and endowed funds as follows: unrestricted, \$4.1 million; departments, \$8.6 million; faculty salaries, \$3.7 million; graduate scholarships and fellowships, \$2.2 million; undergraduate grants, awards, and loan funds, \$1.7 million; building construction funds, \$6.0 million; other funds, \$7.6 million.

M.I.T. LEADERSHIP CAMPAIGN

Campaign Progress

A strong fourth Campaign year brought total commitments by the end of fiscal 1979 to \$214 million, an increase of \$47 million over the total a year ago and 95 percent of the Campaign's \$225 million goal. These data include the nucleus fund of \$43 million accumulated between January 1, 1974 and the announcement of the official start of the Campaign in April 1975.

Senior officers, together with Campaign co-chairmen, continued to make Campaign requests to major individual, foundation, and corporation prospects. Principal commitments made during the year included: \$1 million each from two distinguished alumni and \$1 million from the Kresge Foundation, for the athletics complex; \$1.5 million each from a husband and wife for the new arts facilities; \$930,000 from the Fleischmann Foundation for facilities renovation for the Program in Science, Technology, and Society; more than \$3.5 million from an alumnus for endowed professorships and student aid; \$1 million from Lester Wolfe, Class of 1919, for a professorship in molecular biology; \$1 million from the Ford Foundation for arms control research; \$1 million from a corporation for support of engineering and other programs; \$1 million from an individual for a professorship in brain sciences and behavior; more than \$5.75 million from the Aga-Khan for a joint program in Islamic architecture with Harvard University; \$2 million from the Government of Japan for a special program in international energy policy studies.

The Volunteer Leadership Appeal (discussed elsewhere in this report) made strong progress towards all area goals and by the end of the year 12 areas had already gone over the top.

The National Business Committee added a large number of new prospects and completed more than 63 calls on corporations throughout the country, primarily involving volunteers and members of the N.B.C. staff.

A special Campaign objective has been endowed professorships. By the end of this past year, 32 fully endowed and career development chairs had been established during the Campaign. A special Committee on Endowed Professorships was set up during the year, chaired by Edward O. Vetter, Class of 1942, to help bring in additional chairs.

Campaign Organization and Staffing

During the year Robert C. Gunness, Class of 1934, and John S. Reed, Class of 1961, accepted invitations from Howard W. Johnson, chairman of the M.I.T. Leadership Campaign, to become co-chairmen of the drive, joining co-chairmen Paul F. Hellmuth, Class of 1947, J. Kenneth Jamieson, Class of 1931, William B. Murphy and Edward O. Vetter, Class of 1942. (The detailed organization was described in the 1974-75 annual report).

Campaign Planning Meetings and Post-Campaign Priorities

During the year a number of special Campaign planning sessions were held involving senior officers, Campaign co-chairmen, members of the Campaign Steering Committee, and members of the Corporation Executive Committee. Topics of particular importance were the definition of key funding objectives for the balance of the Campaign period and the formation of core, post-campaign funding goals which will be developed in detail during the coming year. These new goals included: special support for the School of Engineering, the Alfred P. Sloan School of Management, and the School of Architecture and Planning; support for facilities and research in the brain sciences; and support for the creative arts. A number of other urgent needs are currently being discussed.

CORPORATION DEVELOPMENT COMMITTEE

The Corporation Development Committee continued to provide strong leadership for the Campaign through identification of prospects, approaches, Campaign planning, and other volunteer efforts.

The annual meeting was held on campus on November 2, 1978, with approximately 65 members in attendance. The morning program included presentations by faculty members on microelectronics and the cognitive sciences. Chancellor Paul E. Gray was the luncheon speaker. An afternoon panel discussion focused on the management of technological innovation, and was followed by a panel discussion with members of the Volunteer Leadership Appeal, who described their experiences in the field. The Marshall B. Dalton Award for exceptional service to M.I.T. was presented to J. Kenneth Jamieson, Class of 1931.

During the year, the 170 members of the Committee, including 30 who are also Members of the Corporation, were involved in a wide variety of Institute activities, including Committee assignments and alumni events.

The Committee was saddened by the passing of Thomas K. Meloy, Class of 1917, and Paul D. Sheeline, Class of 1919.

VOLUNTEER LEADERSHIP APPEAL

The Volunteer Leadership Appeal consists of 540 volunteers in 48 organized areas supported by Donald P. Severance and a staff of five district officers. It is estimated that singly and in teams, volunteers and staff have made approximately 1,900 solicitation visits to prospective donors in fiscal 1979.

During the final 10 months of the Campaign and in the post-Campaign years, 800 additional Leadership prospects will be cultivated and solicited by 375 of our volunteer solicitors.

Vice President, Resource Development

District officers have worked closely with the Office of Planned Giving and Legal Affairs in organizing and conducting meetings with alumni interested in planning for gifts especially by establishing life income plans and other forms of trusts and individually tailored programs of giving for the benefit of M.I.T.

Increasingly, the district officers and volunteers have assisted with identification and cultivation of foundations and National Business Committee corporations, and have participated in visits to these prospective donors.

At the beginning of the Campaign, the staff developed individual goals for each area based on income from gifts of up to \$250,000. A year ago, four area organizations had exceeded their goals. During this fiscal year, the area chairmen and their associates in an additional eight areas achieved this distinction, and many other areas have done truly outstanding and successful work for the Campaign.

Gordon W. Moore, Class of 1960, a management consultant in Denver, had to relinquish his part-time responsibilities as district officer for the far western states. His duties are being absorbed by Donald P. Severance and Robert H. Bliss.

RESOURCE PLANNING

Resource Planning, under the direction of Nelson C. Lees, continued to carry principal responsibility for support and planning functions for the Leadership Campaign, for direct assistance to faculty in their funding needs, and in the solicitation of a large number of foundations. Highlights of the year's activities are summarized below.

Development Office

The Development Office maintained and expanded its role of providing central support for the Institute's development activities and the M.I.T. Leadership Campaign. The Office, which maintains the central data bank for development at M.I.T., identified and evaluated major donors and prospects; researched and developed funding strategies; made major visit recommendations; coordinated development contacts by senior officers, deans, faculty members, and Resource Development staff; and responded to dozens of queries weekly from sources inside and outside the Institute. Over the year, the Development Office initiated contacts with faculty members and assisted them with funding needs.

In August of 1979 Donald B. Johnson, the Director, will leave M.I.T. to become the Director of Fund Development at the Cleveland Clinic Foundation. He will be greatly missed.

In other major personnel actions during the year, Richard W. Keefe was appointed Associate Director, G. Rodger Crowe was appointed Assistant Director, and Phyllis M. Gallant was appointed Business and Personnel Manager.

Proposals and Publications

The preparation of proposals in support of the fund-raising activities of M.I.T.'s senior officers, faculty members, and Leadership Campaign staff was the primary focus of activities in the Office of Proposals and Publications, under the direction of Deborah J. Cohen. During the year a number of new and updated Campaign publications were also produced.

In July 1978, M.I.T. received the CASE Grand Award for Campaign publications prepared by the Office, and designed by Nancy C. Pokross of M.I.T.'s Design Services. CASE (the Council for the Advancement and Support of Education) is the national professional association for campus officers responsible for public relations, fund raising and development, publications, alumni administration, and government relations. The cash award was donated to the Leadership Campaign, for undergraduate scholarship support, in memory of Lt. General James B. Lampert.

Donor Relations

A substantially larger number of letters of acknowledgement and cultivation was drafted by Donor Relations on behalf of the Institute's senior officers, faculty members, the Volunteer Leadership Appeal, and others. Donor Relations is directed by Barbara V. Zeilenga, supported by Martha L. Bertrand. Further donor cultivation has been continued by stewardship reporting (primarily to foundations and corporations) on the use of previous gifts, by expressing appreciation for volunteer work in the field in support of the Leadership Campaign, and by publication mailings to thank special appeal donors.

INDIVIDUAL GIVING

Gifts, grants, and bequests from alumni and friends totaled \$15,215,677 this year. The Planned Giving Program, which encourages outright current gifts, gifts in trust, and plans for bequests through individual programs of giving, generated 55 percent of this total. The Program and the Office of Planned Giving and Legal Affairs are under the direction of D. Hugh Darden, assisted by Thomas R. Henneberry. The following table details the results of the Program.

	<u>Donors</u>	<u>Dollars</u>
Outright gifts generated by Program	49	\$2,539,526
Separately invested unitrusts	5	4,049,669*
William Barton Rogers Pooled Income Fund	18	254,656
Receipts from bequests, testamentary and other trust arrangements	<u>64</u>	<u>1,721,995</u>
TOTAL	136	\$8,565,846

* In addition, five new trusts totaling \$1,429,750 were established outside M.I.T. and are reflected in the trust table below.

As of June 30, 1979, there were on record with the Institute 1,124 records or notifications of irrevocable trusts in which the Institute now has a vested future interest or plans for future gifts through bequests. During the year, 31 estates and outside trusts were closed and fully distributed (amount included in table above). Irrevocable trusts totaled 206 (see table below).

	<u>Number</u>	<u>Dollars</u> <u>(Current Market Value)</u>
Trusts held by M.I.T.	101	\$10,479,636
Trusts held outside M.I.T.	<u>105</u>	<u>22,387,220</u>
TOTAL	206	\$32,866,856

During the year, two trust funds held by the Institute totaling \$189,856 were closed and transferred over free of trust for Institute purposes.

The year was marked by numerous opportunities to assist donors, senior officers, faculty and administrative staff, especially Resource Development and Alumni Association staff, in developing or concluding gift arrangements.

During the months of December, January, and February, the booklet *Planning Your Gifts* was mailed to over 45,000 alumni as a joint effort of the Alumni Association and the Leadership Campaign. As a result of this mailing and the responses that have been received, 24 prospects have been designated for personal contact.

Several luncheon meetings also were held during the year at various geographic locations. From these meetings, an additional 19 prospects were designated for follow-up. As a result of the mailing and the luncheon meetings, an intense effort is currently under way to arrange meetings with all individuals who have been designated for personal contact.

Continuing attention was given to those proposed changes in the Federal tax law or regulatory rules that could affect the Institute adversely, especially in the area of gift support. The Office continued to advise and counsel on a wide variety of legal matters concerning gift arrangements, institutional management, and other matters relating to the Institute's operation.

During the year the Office, which has formal ties with the Office of the Treasurer, also worked more closely with the Alumni Association.

FOUNDATION SUPPORT

Staff responsibility for foundation matters remained in the Development Office, under the direction of Donald B. Johnson. Mr. Johnson continued his close contact with the Provost and many faculty members in recommending, planning, and carrying out visits to foundations in support of academic programs.

NATIONAL BUSINESS COMMITTEE

The National Business Committee, chaired by Richard L. Terrell, Class of 1958, continued actively in its expanded form with a membership of 48. The full membership was listed in last year's *Report*. Two changes occurred during the year: Donald J. Atwood, Class of 1948, became a member, and the Committee was saddened by the death of Dr. Henry A. Hill, Class of 1942.

Supplementing the efforts of the formal Committee, 36 alumni accepted requests to assist with solicitations, substantially increasing the organization's productivity.

Internal staff support continued under the executive direction of Irwin W. Sizer, Dean Emeritus of the M.I.T. Graduate School and Consultant to Resource Development. Robert Hagopian, Director of Corporate Relations with principal operational responsibility for all functions, was assisted by James T. King, Manager of Corporate Support Programs; Robert H. Bliss, District Officer; and Alice W. Tripp, Administrative Assistant for Special Projects. J. Francis Reintjes, Professor Emeritus in the Department of Electrical Engineering and Computer Science, provided part-time assistance.

Committee members and other alumni reviewed new and more comprehensive lists of corporate prospects. Approximately 1,100 companies (1,000 of the largest public and 100 of the largest private) were reviewed. Committee members accepted a total of 121 assignments and other alumni accepted 70, for a total of 191 assigned companies. A total of 63 visits was arranged by Committee members and others. In addition, several on-campus visits were arranged as follow-ups to visits made previously at the companies. Currently, 129 additional companies are assigned and visits are anticipated in coming months.

Nearly all visits completed thus far have been of excellent quality. Typically these visits have been with corporate chief executives, with the alumnus volunteer accompanying an M.I.T. senior officer or faculty member and a representative of Resource Development. In addition to providing introductions to corporate officers, Committee members have helped guide proposals and assisted in follow-up actions.

The visits have drawn favorable comments from Committee members as to their quality. The alumni who have participated have been pleased to be part of visit teams which have made well-received presentations. In most instances, however, alumni have cautioned that the competition for support is intense. Most visits are in areas where local institutions draw primary attention. Philanthropic support is receiving increasingly careful scrutiny by management and shareholders alike, amplifying the need for a *quid-pro-quo*. For this reason, many visits have focused on M.I.T.'s liaison programs. The national and international reputation of M.I.T. and its historically close ties with private industry have been most helpful in overcoming some of the foregoing obstacles.

The strong participation of senior officers and faculty members in visits has been of paramount importance. A large number of faculty members have given willingly and enthusiastically of their time in visits held at M.I.T. In addition, senior officers and faculty members have responded generously to requests to visit companies at headquarters located throughout the country.

The National Business Committee, in its current, expanded form, was organized in the summer of 1977. During the past two years, Committee members have played active roles in the submission of proposals totaling \$9,725,000 which have resulted in commitments to date of \$3,560,000, with several proposals still outstanding. Nineteen Industrial Liaison Program memberships and two Associates Program memberships have been added through the Committee's efforts. A number of other proposals for membership are under active consideration.

CORPORATE LEADERSHIP AWARD

Twelve Alumni received the 1978 Corporate Leadership Award. Established in 1976, the Award is presented to M.I.T. alumni who are senior officers in major United States corporations. This year's presentations were made following the M.I.T. Corporation luncheon in December.

INDUSTRIAL LIAISON

The industrial liaison activities of the Institute continued to grow during the 1978-79 year, with firms in the Industrial Liaison Program (I.L.P.) totaling 188 and those in the Associates Program (A.P.) totaling 49. For fiscal 1979, the gross revenue of the I.L.P. was \$3,148,800 and the gross revenue of the A.P. was \$284,900. The combined revenue of \$3,433,700, represents an increase of nearly 10 percent from the \$3,135,000 total for 1978, and is more than double the gross revenue of three years ago. The numbers of I.L.P. member companies in Europe and Japan also continued to increase, and presently stand at 27 and 25, respectively.

The success of the Institute's industrial liaison activities is due to the continued, enthusiastic participation of the faculty and the strong interaction of the liaison officers with member companies, coupling company interests with activities on the campus. During a typical year, over half of the Institute's faculty interact with member companies. Industrial liaison interactions take many forms:

- Presentation of symposia and seminars by M.I.T. faculty members. Twenty-five meetings were held during the past year, with total attendance exceeding 1,750. While over half of the meetings were in Cambridge, meetings also were held in Los Angeles, Minneapolis, Pittsburgh, New York, London, Tokyo, and Zurich.
- Visits by member company staff to M.I.T. Approximately 1,500 member company visits occurred during the year, typically involving two to six faculty members per visit.
- Visits by faculty members and staff to company locations. More than 300 such faculty visits took place during the 1978-79 year. In addition, liaison officers made approximately 400 visits to member companies.

- Mailings of M.I.T. preprints, research reports, and other information to member companies. During a typical year, over 10,000 requests are received from member companies and approximately 40,000 copies of documents are mailed.

Of particular note during the past year was a special symposium, "Technology, Innovation, and Corporate Strategy," held in London for executives of I.L.P. member companies in Europe. The symposium was hosted by McKinsey & Co., Inc., and was chaired by Hugh Parker, Class of 1943, and a director of the company. Mr. Parker, together with President Jerome Wiesner, Professor Samuel Goldblith, the Lord Zuckerman, and Eric C. Johnson (then Assistant Director of I.L.P.), planned the event. Participants were: President Wiesner and Professors Lester C. Thurow, J. Herbert Hollomon, Edward B. Roberts, Jay W. Forrester, and James M. Utterback from M.I.T. In addition, the Lord Zuckerman, a leading spokesman for British science and former chief scientific advisor to the British government, summarized the discussion at the close of the day-long meeting.

A new service is now being offered to member companies. The A.P. now publishes videotaped materials and, on behalf of both the A.P. and I.L.P., sells or rents videotaped lectures and short courses to member companies. The materials are designed primarily for the continuing education of executives, engineers, and scientists in industry, and feature M.I.T. faculty members.

A number of personnel changes have occurred within the I.L.P. and A.P. during the past year. Professor James D. Bruce, who was Associate Dean of the School of Engineering, became Director of Industrial Liaison on January 1, 1979. He succeeded Professor Goldblith, who had become Vice President for Resource Development.

Eric C. Johnson, who had been Assistant Director of the I.L.P., was named Executive Officer of M.I.T.'s new Sustaining Fellows Program.

During the year four new appointments were made to the staff. Frederick P. Gross, Jerry R. Horton, and Harry E. Stephens were named Liaison Officers in the I.L.P., and Clyde Kelley was named Assistant Director of the Associates Program.

Dr. Shirley M. Picardi was named Assistant Director of the Industrial Liaison Program, and Janet K. Anderson was named Assistant Director of Administration.

Also during the year, Edwin M. Arripol resigned to enter business in Switzerland.

M.I.T. SUSTAINING FELLOWS

The M.I.T. Sustaining Fellows Program was established during the year to recognize and more effectively involve individuals whose support, encouragement, and commitment to the goals of M.I.T. make them valued members of the M.I.T. community; and to draw into M.I.T. others who want to share and support the Institute's efforts. Individuals will be invited to become either annual or life members of the M.I.T. Sustaining Fellows.

Eric C. Johnson, who has been with the Industrial Liaison Program since 1972, has been appointed to organize and direct the program and will be assisted by E. Barbara Lewis. Breene M. Kerr, Class of 1951, will be chairman of the Sustaining Fellows, and the Chairman of the Corporation and President of M.I.T. will serve as honorary chairmen. A special faculty committee is being appointed to support the effort. A formal announcement of the program and initiation of activities will occur early in the coming year.

SUMMARY

The tremendous progress made during my first year as Vice President for Resource Development would not have been possible without the help, assistance, and devotion of an able staff.

Resource Development today is based largely on the planning, efforts, and achievements of the late Lt. General James B. Lampert, a man of tremendous stature, to whom I owe a great personal debt

Vice President, Resource Development

of gratitude for his friendship, his tireless efforts on behalf of M.I.T., high standards of integrity and performance, and humility. He has no successor.

The progress in this Campaign would never have been realized without the unflagging and successful efforts of the senior officers of the Institute, the Campaign co-chairmen, members of the Volunteer Leadership Appeal and National Business Committee, and a number of senior administration and faculty colleagues.

In closing, I wish to express particular appreciation to Nelson C. Lees for all he has done. His stature in development circles is widely recognized and well deserved. His tireless efforts on behalf of M.I.T., friendship, and support are deeply appreciated.

SAMUEL A. GOLDBLITH

Treasurer of the Corporation

Financial Statements

The financial statements summarize the finances of the Institute during the fiscal year 1978-79 and at the close of the year on June 30, 1979.

Schedule A

The Statement of Revenues and Funds Used to Meet Expenses of Current Operations for the year ended June 30, 1979 with comparative totals for 1978 displays the expenses and the revenues and funds used, categorized as either unrestricted or restricted, and shows the sources of the additional unrestricted revenues and funds needed to meet operating expenses.

Schedule B

The Investment Income for Distribution to Funds for the year ended June 30, 1979 with comparative totals for 1978 reports the year's investment income and other activity in that fund, and details the distribution to funds both in the general investments and in separately invested funds.

Schedule C

The Balance Sheet at June 30, 1979 with comparative totals at June 30, 1978 summarizes the assets, liabilities and fund balances in the major fund categories.

Schedule D

The Condensed Statement of Changes in Financial Position for the year ended June 30, 1979 with comparative totals for 1978 illustrates the changes in total resources resulting from additions, applications, or appropriations during the year, classified between current funds — unrestricted and restricted — and all other funds.

Schedule D-1

The Statement of Changes in Financial Position for the year ended June 30, 1979 with comparative totals for 1978 details the changes in total resources summarized in Schedule D, showing all of the major fund categories.

Schedule E

The Summary of Changes in Invested Fund Balances for the ten years ended June 30, 1979 summarizes the sources and uses of funds each year for the last decade.

Schedule F

The Highlights: A Decade in Review summarizes the several important factors which demonstrate the overall financial position during the last ten years.

Glossary

A background description of fund accounting, so important in understanding college and university finances, can be found following the glossary.

Operations (Schedule A)

Total operating expenses in 1978-79 were \$357,409,000, an increase of 11.9 percent over the 1977-78 total of \$319,356,000. Total operating revenues and funds used to meet these expenses rose to \$351,844,000, an increase of 12.2 percent over the 1977-78 total of \$313,481,000. The additional need for unrestricted revenues and funds required to bring operations into balance was \$5,565,000 in 1978-79 compared to \$5,875,000 in 1977-78. This requirement in 1978-79 was met entirely from current year revenues of \$1,458,000 from the net Use of Facilities Allowances derived from sponsored research programs, \$756,000 from Patent Revenues and \$3,407,000 from Unrestricted Gifts, Grants, and Bequests. These sources totaled \$5,621,000 and all amounts received in these categories were availed of to meet expenses, except for:

- 1) \$56,000 which was the excess of unrestricted funds received over the funds required to balance, and
- 2) \$341,000 of additional Use of Facilities Allowances which was reserved for continuing capital needs, primarily in the area of utility plant renewal and the expansion of utility distribution lines for air conditioning and heating.

Operating expenses of instruction and unsponsored research increased by 13 percent. The most dramatic increase in the year's expenses came in the area of departmental and interdepartmental sponsored research, the direct expenses of which were up by 20 percent. While a substantial amount of the increase was in materials and services as well as expenditures under subcontracts, there was a significant increase in salaries and wages which were up 13 percent over the previous year. This increase was evident at the Lincoln Laboratory, where the change in salaries and wages was almost 12 percent, although total direct expenses increased by only 6 percent. It is the year-to-year change in salaries and wages which is generally most significant in analyzing the activities of sponsored research and it is here that the Institute has had a significant real growth in people for the first time in several years. Research administration and general expenses were up considerably with the major share of the increase attributable to further improvements in animal care facilities. Medical expenses are up only 5 percent and this reflects, in part, the sharing of expenses

and the success of the M.I.T. Health Plan which is treated as part of the employee benefit package. Plant operations and maintenance show an increase of only 3.5 percent but this should not be taken to reflect any dilution in our efforts to maintain a sound physical plant. It is due rather to continued energy savings as well as mirroring the ups and down of cash expenditures for the major plant renovation and renewal projects. The expenses of administration reflect a modest 3 percent increase. The increases in other expenses jointly applicable to instruction and research reflect generally the activities of instruction and unsponsored research and sponsored research, except in the area of student support services which received added emphasis including student participation in the College Work-Study Program.

An analysis of revenues and funds used shows that while tuition and other related income increased at a 9 percent rate, research revenues for departmental and interdepartmental sponsored research increased at a 19 percent rate. Endowment income available to operations increased by only 3.5 percent reflecting the rate of increase in earnings but minimal additions to capital through gifts. While gifts, investment income and other receipts moved ahead to a rate of increase of 19 percent, nearly all of this increase was in the area of restricted purposes. This can relieve some of the demand for unrestricted funds, but in many cases creates an additional demand for unrestricted depending upon the nature of the restrictions and how they are handled in the financial management of the Institute.

The additional need for unrestricted revenues and funds dropped from \$5,875,000 in 1978 to \$5,565,000 in 1979, a decrease of 5.3 percent. Note, however, that three of the sources of funds — namely, Use of Facilities Allowances, Patent Revenues, and Current gifts, grants, and bequests — used in recent years to meet that additional need were down in the aggregate from \$5,943,000 in 1978 to \$5,621,000 in 1979, or a decrease of 5.4 percent. In particular unrestricted receipts of current gifts, grants, and bequests were down from \$3,700,000 in 1978 to \$3,407,000 in 1979. The \$3,407,000 received in 1979 was against a budget forecast of \$4 million. While this category of income is difficult to predict, the shortfall from budget to actual of approximately \$600,000 was the source of some concern as the year drew to a close. Fortunately, the cash flow from current operations produces funds from time to time which can be invested on a short-term basis. An additional investment income stream from this source provided \$700,000 which slightly more than offset the reduction in the flow of current gifts, grants, and bequests. It is significant that no Funds Functioning as Endowment or Other Fund Balances were required to bring operations into balance during the past two years. In 1977 only \$126,000 of Other Fund Balances were used and no Funds Functioning as Endowment had to be drawn upon. In addition, in 1979 the full investment income on the Research Reserve was added to principal for the second time in as many years and a substantial addition was made to the reserve of investment income for distribution to funds. Funds available for operations also contributed substantially to the acquisition from the investment portfolio of real estate for educational plant and provided the additional amount needed to complete the funding of a professorship. Looking ahead to future years, the Institute would like to be in balance at a point which made no demands on three important elements of unrestricted income, namely, Use of Facilities Allowances, Patent Revenues, and Current gifts, grants, and bequests. This was the case prior to the 1970s. During the past decade, however, nearly all of the funds from these sources have had to be used for current operations. A financial objective is to have these funds available for new programs, capital needs, and other purposes which will strengthen the Institute's financial integrity.

A five-year history of the additional need for unrestricted revenues and funds to bring operations into balance, and the source of the funding used to meet the need is shown in the following table. This table presents the years 1975 through 1977 on a comparable basis with the results for 1978 and 1979 shown at the bottom of Schedule A.

(In thousands of dollars)	1975	1976	1977	1978	1979	Total
Additional need for unrestricted revenues and funds	<u>\$9,005</u>	<u>\$6,493</u>	<u>\$5,801</u>	<u>\$5,875</u>	<u>\$5,565</u>	<u>\$32,739</u>
Additional need for unrestricted revenues and funds met from:						
Use of facilities allowances	\$1,351	\$1,220	\$1,308	\$1,433	\$1,458	\$ 6,770
Patent revenues	431	457	629	810	756	3,083
Current gifts, grants and bequests	<u>2,032</u>	<u>2,216</u>	<u>3,738</u>	<u>3,700</u>	<u>3,407</u>	<u>15,093</u>
Total additional current revenues	\$3,814	\$3,893	\$5,675	\$5,943	\$5,621	\$24,946
Less: Funds available for future operations	<u>0</u>	<u>0</u>	<u>0</u>	<u>68</u>	<u>56</u>	<u>124</u>
Net additional current revenues used	3,814	3,893	5,675	5,875	5,565	24,822
Other fund balances	2,581	1,201	126	0	0	3,908
Funds functioning as endowment	<u>2,610</u>	<u>1,399</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>4,009</u>
	<u>\$9,005</u>	<u>\$6,493</u>	<u>\$5,801</u>	<u>\$5,875</u>	<u>\$5,565</u>	<u>\$32,739</u>

Gifts

Gifts, grants, and bequests in 1978-79 and in 1977-78 were as follows:

	1978-79	1977-78
Gifts for endowment	\$ 8,354,000	\$ 6,420,000
Gifts for buildings	6,065,000	8,918,000
Gifts for current and future use — invested	10,338,000	7,249,000
Other gifts for current use	<u>5,823,000</u>	<u>5,649,000</u>
Total gifts to funds	\$ 30,580,000	\$ 28,236,000
Grants-in-aid	<u>3,364,000</u>	<u>3,051,000</u>
Total	\$ 33,944,000	\$ 31,287,000

The total of \$33,944,000 is an 8.5 percent increase above the previous year and is 67 percent above the total of four years ago.

The high level of gifts resulting from the efforts of the M.I.T. Leadership Campaign continued during the year. There was a 30 percent increase in annual gifts to endowment which set a new yearly high. The major gifts received for endowment include the funding for several named professorships and scholarships.

Gifts for buildings declined relative to the large funding received last year, but were the second highest total on record. These important gifts include continued funding to provide facilities for Health Sciences, Technology, and Management, and the Health Services. There were also significant gifts received for the new Athletic Center; the College for Science, Technology, and Society; and a new undergraduate house.

The gifts for current and future use — invested include unrestricted gifts of \$3,407,000, of which \$640,000 was in bequests. These unrestricted gifts declined from the previous year because of the decrease in unrestricted bequests. There was also a decline in the gifts received from bequests of all designations. It is important to note that total gifts for the year increased despite a drop in this important, but fluctuating, source of funds.

Gifts to life income plans exceeding \$4,300,000 resulted in the large increase of 42 percent in gifts for current and future use — invested.

The gifts reported by the Alumni Fund totaled \$5,158,000, a new high, which resulted in part from a meaningful increase in the number of contributors. These gifts are included in the various categories of gifts listed above as received.

The other gifts for current use include gifts restricted as to purpose used primarily for academic programs and student aid. These gifts increased as did the grants-in-aid used to support designated sponsored research activities.

Funds

The book value of the funds was \$583,005,000 on June 30, 1979 as compared with \$548,976,000 on June 30, 1978.

	1978-79	1977-78
Endowment and similar funds:		
Income for unrestricted purposes		
Endowment	\$ 49,341,000	\$ 48,909,000
Funds functioning as endowment	30,311,000	30,307,000
Income for restricted purposes		
Endowment	101,036,000	93,072,000
Funds functioning as endowment	69,634,000	62,247,000
Investment income for distribution to funds ..	15,000,000	10,000,000
Net realized gains from investments	<u>34,941,000</u>	<u>29,346,000</u>
Total endowment funds	\$300,263,000	\$273,881,000
Building and expendable funds	69,098,000	67,100,000
Expended plant funds	172,444,000	169,856,000
Investment income for distribution to funds — current invested	8,578,000	10,710,000
Other funds	<u>32,622,000</u>	<u>27,429,000</u>
Total funds	\$583,005,000	\$548,976,000

The large increase of \$34,029,000 in funds resulted from significant increases in most fund categories. Total endowment funds increased by \$26,382,000, with one-half of this gain resulting from a transfer during the year of \$13,682,000 from expendable funds, including \$5,000,000 from the reserve of investment income for distribution to funds. These funds were not expected to be expended based on the current financial situation of the Institute and this transfer provided for investment based on longer-term considerations.

The increase of \$5,595,000 in the net realized gains from investments resulted from the sale of equities and real estate at prices above book value and more than offset the moderate losses on selected sales of fixed income securities.

The building and expendable funds invested increased by almost \$2,000,000 despite the transfer of some funds to endowment and similar funds. This gain reflects the gifts received in anticipation of the substantial building program now in progress on campus and also reflects the continued increase in the expendable gifts and other receipts resulting from growing academic operations.

The investment income for distribution to funds — current invested declined because of the \$5,000,000 transfer to endowment and similar funds. It would have increased by \$2,868,000 without this transfer.

The other funds total increased primarily because of a large increase in funds subject to life interests in income. These funds were added to the life income plans held by the Institute and will be used for specified academic purposes upon the termination of life interests in income of designated beneficiaries. In addition to the life income plans held by the Institute, we have been informed of an irrevocable vested interest in 105 trusts held outside the Institute with assets of \$22,387,000 at market value. This represents an important source of future gifts to the Institute. There was a modest increase in student loan funds and agency funds held for affiliated organizations.

Plant

A major effort of the Institute in 1978-79 was in the continued expansion and upgrading of the educational plant.

Capital projects with construction under way include the Health Sciences, Technology, and Management Building and the new Health Services Facility on the east campus, and a new athletic facility on the west campus next to Rockwell Cage. A new house for undergraduates on Memorial Drive is in the planning stage.

Major renovations have taken place in support of both teaching and research throughout the campus. The Suffolk Building at 292 Main Street in Kendall Square has now been completely occupied except for a portion of the first floor which is being held for future activities of the M.I.T. Press. Heavy emphasis has been placed in the Albany Street area to support the activities of the Plasma Fusion Center and the National Magnet Laboratory. In further support of these activities the building at 167 Albany Street has been taken out of the investment portfolio and put into educational plant, and the expected gift by Nabisco, Inc. of an adjacent building will soon be the site of extensive renovations, with direct funding hopefully to be provided by the Federal government. A further development in the Albany Street area was the free and clear title to the building at 224 Albany Street which had been given to the Institute by the Federal government 20 years ago, but which had certain restrictions for this 20-year period. The first step was taken to move into the building at 70 Memorial Drive with the construction of three classrooms for the Sloan School of Management. The major renovations to the Webster Building which were expected to be under way in 1978-79 have been temporarily delayed because of the need to include a major new chilled-water facility for the east campus in that building with construction scheduled to begin early in 1979-80. With the completion of the interim animal care facility on Vassar Street, the extensive renovations required by new Federal standards are proceeding in Buildings 16, 56, and E18.

The Institute expects no let-up in the demand for space for activities as it moves to meet the challenges and opportunities presented to it.

The book value of educational plant was \$208,195,000 at June 30, 1979, up from \$205,992,000 on June 30, 1978.

Total mortgage indebtedness at June 30, 1979 was \$30,514,000 consisting of \$9,865,000 of Federal government loans, \$20,498,000 financed through the Massachusetts Health and Educational Facilities Authority, and \$151,000 of other loans.

Investments

The year-to-year change in the endowment and other investments is shown in the following table:³

	<i>June 30, 1979</i>		<i>June 30, 1978</i>	
	<i>Book</i>	<i>Market</i>	<i>Book</i>	<i>Market</i>
General Investments				
Fixed income	\$171,115,000	\$161,517,000	\$152,845,000	\$142,690,000
Equities	143,521,000	231,560,000	129,535,000	200,042,000
Real estate				
For present or future use	9,298,000	9,298,000 ¹	10,220,000	10,220,000 ¹
Other real estate	32,116,000	32,916,000 ²	31,047,000	31,789,000 ²
Total	\$356,050,000	\$435,291,000	\$323,647,000	\$384,741,000
Separately invested	31,159,000 ¹	31,803,000	24,833,000	24,862,000
Total	\$387,209,000	\$467,094,00	\$348,480,000	\$409,603,000

¹ At cost

² At values determined by professional appraisers

³ This table excludes students notes receivable and amounts due from Educational Plant Funds.

There was an increase of \$57,491,000 in the market value of the portfolio in 1978-79 as compared with an increase of \$8,507,000 in 1977-78. Over one-half of this 14 percent increase in value resulted from the retention for investment of gifts and other receipts received during the year. The market appreciation and capital gains realized from the holdings of equities totaled over 35 percent

of the increase. The sale of investment real estate holdings and the appreciation based on contracts to sell real estate also added to the gain in market value.

There was an increase in the amount invested in common stocks and other equity investments during the year caused by a continuation of net purchases and the retention of some common stocks received as gifts. The favorable market gains reflected both the modest gain in the general stock market and the characteristics of the Institute's holdings.

The portfolio of fixed income securities increased because of the investment of gifts and other receipts resulting from academic operations. These holdings were invested primarily in short- and intermediate-term issues, reflecting both a cautious viewpoint and the need to meet the expected costs of the substantial building program now under way. This policy has resulted in a high level of current income and has also moderated the effect of the general decline in bond prices during the past two years.

The investment income received during the year, after administrative expenses, was \$26,581,000 as compared to \$22,441,000 in 1977-78. This increase of over 18 percent was the largest percentage gain in 12 years. The increase resulted primarily from the substantial rise in the income earned on fixed income securities, although the gains in common stock dividends and investment real estate income were also significant. The income from other real estate held primarily for investment purposes increased by more than 35 percent during the year and 98 percent over the past two years. There was a 52 percent increase in the rental income from external sources on property held for present or future Institute use and this amount is over six times higher than two years ago. This increase resulted in part from close coordination of the real estate management and the academic space planning activities of the Institute.

The investment income received significantly exceeded the income distributed to funds which increased by more than 11 percent. The reserve of income for distribution to funds increased by \$2,868,000, the largest increase since this reserve was established 30 years ago. This reserve is divided into both current invested funds and endowment and similar funds. It increased to \$23,578,000, a new high, and the additions during the past three years have totaled more than twice the amount of the \$1,931,000 reduction in this reserve during the 1975-76 and 1974-75 years.

The total gain in investment income of 34 percent over the past two years resulted in part from the higher interest rates earned on fixed income securities. Although a program of emphasizing shorter-term maturities in the fixed income portfolio benefited this increase, it is recognized that these income gains are largely driven by rising rates of inflation. The real returns from these holdings of fixed income securities, net of price inflation, have been small. The reinvestment of a portion of these high levels of interest income may be necessary to maintain the real purchasing power of the funds invested in fixed income securities.

The Investment Committee has expressed a desire to allocate investment returns from assets in a manner that is equitable to both the present and future needs of the Institute. As the inflation rate increases to levels only briefly experienced in the past, there is a need to seek both investment and financial management policies that will assure adequate resources in the future.

The amount of investment income also has been enhanced by the high level of building funds temporarily held for investment. As these building funds are expended for the purposes designated by the donors, the income from investments will be reduced. This process is now beginning and a continued large inflow of gifts for both buildings and the operations of the Institute will be necessary to maintain an adequate growth of investment income.

General

The financial results of the past three years show the Institute to be in approximate balance between income and expenses. However, further effort is required to rebuild and maintain financial reserves and to improve substantially the capital base of the Institute which is now experiencing a very large flow of current funds to support current activities. Many of those activities will undoubtedly become on-going without the assurance of continued funding, particularly because of the usual year-to-year instabilities in support of particular projects by the Federal government and by other sponsors who like to initiate worthwhile projects, but who cannot be counted on for sustained giving or endowment. A further major difficulty is coping with the effects of high rates of inflation. With a strong desire to cooperate in holding down inflation, the Institute is in a position of traditionally announcing tuition, room and board rates well in advance of the period to which they apply. We cannot, however, predict with great accuracy what the rates of inflation in Institute expenses will actually be. The current upsurge in prices, particularly in the cost of energy, is an example. The Institute's operating budget is particularly vulnerable to these effects as the spread between revenues and expenses is very small. As a result, the faculty and staff must continue to live with tight operating budgets and continue to seek reductions in expenses. With continued heavy demands on its financial resources and with the Leadership Campaign coming to a close, it is hardly necessary to have to emphasize that a strong fund-raising capability must be maintained to keep up the vitality of the Institute and the financial integrity of its operations.

Respectfully submitted,

Stuart H. Cowen
Vice President for Financial Operations

Glenn P. Strehle
Treasurer

August 24, 1979

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
STATEMENT OF REVENUES AND FUNDS USED TO MEET EXPENSES OF CURRENT OPERATIONS

for the year ended June 30, 1979
with comparative totals for 1978
(in thousands of dollars)

Schedule A

	<i>Unrestricted</i>	<i>Institute or Donor Restricted</i>	Total 1979	<i>Total 1978</i>
OPERATING EXPENSES:				
Instruction and unsponsored research	\$ 35,037	\$ 18,344	\$ 53,381	\$ 47,245
Sponsored research (Note A):				
Direct expenses:				
Departmental and interdepartmental	—	107,521	107,521	89,736
Lincoln Laboratory	—	102,279	102,279	96,595
Research administration and general expenses	2,766	774	3,540	2,097
Total expenses directly attributable to instruction and research	37,803	228,918	266,721	235,673
Expenses jointly applicable to instruction and research:				
Libraries	4,111	234	4,345	3,884
Medical	3,008	20	3,028	2,877
Plant operations and maintenance	20,398	2,054	22,452	21,699
Administration	5,596	147	5,743	5,589
Fiscal, personnel and other Institute-wide services	11,565	306	11,871	10,673
General expenses	2,655	2,183	4,838	4,321
Other instruction and research support activities	1,084	367	1,451	1,243
Student services	4,831	3,348	8,179	6,886
Other expenses	2,782	20	2,802	2,666
Scholarships and fellowships:				
Undergraduate	1,710	5,120	6,830	6,167
Graduate	777	4,722	5,499	4,918
Dining and Housing	394	8,643	9,037	8,482
M.I.T. Press	—	4,613	4,613	4,278
Total operating expenses (Schedule D)	<u>\$ 96,714</u>	<u>\$ 260,695</u>	<u>\$ 357,409</u>	<u>\$ 319,356</u>
REVENUES AND FUNDS USED:				
Tuition and other related income	\$ 45,028	—	\$ 45,028	\$ 41,366
Research revenues:				
Departmental and interdepartmental	30,706	\$ 107,521	138,227	116,182
Lincoln Laboratory	7,361	102,279	109,640	103,599
Endowment income applied to operations (Schedule B)	6,965	4,689	11,654	11,261
Gifts, investment income and miscellaneous receipts for:				
Scholarships and fellowships	389	9,800	10,189	9,622
Other restricted and unrestricted purposes	700	23,150	23,850	19,100
Dining and Housing	—	8,643	8,643	8,073
M.I.T. Press	—	4,613	4,613	4,278
Total operating revenues and funds used	91,149	260,695	351,844	313,481
Additional need for unrestricted revenues and funds**	5,565	—	5,565	5,875
Total revenues and funds used	<u>\$ 96,714</u>	<u>\$ 260,695</u>	<u>\$ 357,409</u>	<u>\$ 319,356</u>
**Additional need for unrestricted revenues and funds met from:				
Use of Facilities Allowances	\$ 1,458	—	\$ 1,458	\$ 1,433
Patent Revenues	756	—	756	810
Current gifts, grants, and bequests	3,407	—	3,407	3,700
Total additional current revenues	5,621	—	5,621	5,943
Less: funds available for future operations	56	—	56	68
Net additional current revenues used	5,565	—	5,565	5,875
Other fund balances	—	—	—	—
Funds functioning as endowment	—	—	—	—
Total	<u>\$ 5,565</u>	<u>—</u>	<u>\$ 5,565</u>	<u>\$ 5,875</u>

The accompanying notes are an integral part of the financial statements.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
INVESTMENT INCOME FOR DISTRIBUTION TO FUNDS
for the year ended June 30, 1979
with comparative totals for 1978
(in thousands of dollars)

Schedule B

	<i>General Investments</i>	<i>Separately Invested Funds</i>	Total 1979	<i>Total 1978</i>
Investment income before distribution:				
Investment income for distribution to funds, balance beginning of year	\$ 20,710	—	\$ 20,710	\$ 19,582
Investment income, current year	24,775	\$ 1,806	26,581	22,441
Total before distribution	\$ 45,485	\$ 1,806	47,291	42,023
Distribution:				
Income distributed:				
From current year's earnings	(21,907)	(1,806)	(23,713)	(21,313)
From prior years' earnings	—	—	—	—
*Total distribution to funds	(21,907)	(1,806)	(23,713)	(21,313)
Investment income for distribution to funds, balance end of year	\$ 23,578	\$ —	\$ 23,578	\$ 20,710
Balances include:				
Funds functioning as endowment	\$ 15,000	\$ —	\$ 15,000	\$ 10,000
Current invested funds	8,578	—	8,578	10,710
Total	\$ 23,578	\$ —	\$ 23,578	\$ 20,710
			(Schedule C)	(Schedule C)
*Total distribution to funds:				
Endowment funds:				
Used for operations (Schedule A)	\$ 11,640	\$ 14	\$ 11,654	\$ 11,261
Used for scholarships and fellowships	2,714	98	2,812	2,550
Used for other charges	(31)	14	(17)	166
Added to principal	12	146	158	100
Added to unexpended balances of endowment income	176	32	208	41
Transferred to other funds	4,511	73	4,584	3,938
Total	\$ 19,022	\$ 377	19,399	18,056
Other funds:				
Agency funds	38	—	38	36
Life income funds	18	425	443	357
Student loan funds	14	—	14	14
Building funds	850	294	1,144	1,016
Other expendable funds	1,965	710	2,675	1,834
Other funds	2,885	1,429	4,314	3,257
Total distribution to funds	\$ 21,907	\$ 1,806	\$ 23,713	\$ 21,313

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BALANCE SHEET

at June 30, 1979

with comparative totals at June 30, 1978

(in thousands of dollars)

Schedule C

	Current Operating Funds	Current Invested Funds	Student Loan Funds	Endowment and Similar Funds	Educational Plant Funds	Life Income and Agency Funds	Total 1979	Total 1978
ASSETS								
Cash:								
Unrestricted	\$ 2,243	\$ —	\$ —	\$ —	\$ —	\$ —	\$ 2,243	\$ 152
Other	1,509	—	—	1,132	—	—	2,641	2,816
Accounts receivable	12,675	—	—	—	—	—	12,675	11,406
Students' notes receivable	—	—	27,692	—	—	—	27,692	26,727
Contracts in progress, principally U.S.								
Government	8,759	—	—	—	—	—	8,759	8,442
Deferred charges, inventories and other assets	13,696	—	—	—	—	—	13,696	14,512
Investments, at cost (Note B)	—	54,016	—	300,368	21,448	11,377	387,209	348,480
Receivables (payables) arising from								
investment transactions	—	—	—	1,319	—	—	1,319	(347)
Due from other M.I.T. funds	14,936	5,142	—	—	—	—	20,078	11,714
Land, buildings, and equipment, at cost	—	—	—	—	203,468	—	203,468	202,471
Construction in progress	—	—	—	—	4,727	—	4,727	3,521
Total assets	<u>\$53,818</u>	<u>\$59,158</u>	<u>\$27,692</u>	<u>\$302,819</u>	<u>\$229,643</u>	<u>\$11,377</u>	<u>\$684,507</u>	<u>\$629,894</u>
LIABILITIES AND FUND BALANCES								
Liabilities:								
Accounts payable and accruals	\$28,683	\$ —	\$ —	\$ —	\$ —	\$ —	\$ 28,683	\$ 23,905
Withholdings, deposits and other credits	6,491	—	—	—	—	—	6,491	5,389
Advances and unexpended grants for sponsored research:								
U.S. Government	6,264	—	—	—	—	—	6,264	2,366
Private sources	374	—	—	—	—	—	374	356
Due to other M.I.T. funds	—	14,936	(95)	—	5,237	—	20,078	11,714
Borrowings—Mortgage bonds and notes payable (Note E)								
.....	—	—	6,542	2,556	30,514	—	39,612	37,188
Total liabilities	<u>\$41,812</u>	<u>\$14,936</u>	<u>\$ 6,447</u>	<u>\$ 2,556</u>	<u>\$35,751</u>	<u>—</u>	<u>\$101,502</u>	<u>\$ 80,918</u>
Fund Balances:								
Expendable:								
Unrestricted purposes	124	—	—	—	—	—	124	68
Restricted gifts and other receipts available for current expenses								
.....	11,882	—	—	—	—	—	11,882	11,400
Restricted purposes	—	30,866	—	—	—	—	30,866	31,278
Unexpended endowment income for restricted purposes	—	4,778	—	—	—	—	4,778	4,570
Investment income for distribution to funds (Schedule B — Note C)								
.....	—	8,578	—	15,000	—	—	23,578	20,710
Student loan funds (Note D)	—	—	21,245	—	—	—	21,245	20,399
Endowment and similar funds:								
Income for unrestricted purposes:								
Endowment	—	—	—	49,341	—	—	49,341	48,909
Funds functioning as endowment	—	—	—	30,311	—	—	30,311	30,307
Income for restricted purposes:								
Endowment	—	—	—	101,036	—	—	101,036	93,072
Funds functioning as endowment	—	—	—	69,634	—	—	69,634	62,247
Net realized gain from investments	—	—	—	34,941	—	—	34,941	29,346
Educational plant funds:								
Unexpended	—	—	—	—	21,448	—	21,448	19,784
Expended	—	—	—	—	172,444	—	172,444	169,856
Funds subject to life interests in income	—	—	—	—	—	10,641	10,641	6,338
Agency funds	—	—	—	—	—	736	736	692
Total fund balances	<u>12,006</u>	<u>44,222</u>	<u>21,245</u>	<u>300,263</u>	<u>193,892</u>	<u>11,377</u>	<u>583,005</u>	<u>548,976</u>
Total liabilities and fund balances	<u>\$53,818</u>	<u>\$59,158</u>	<u>\$27,692</u>	<u>\$302,819</u>	<u>\$229,643</u>	<u>\$11,377</u>	<u>\$684,507</u>	<u>\$629,894</u>

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CONDENSED STATEMENT OF CHANGES IN FINANCIAL POSITION
for the year ended June 30, 1979
with comparative totals for 1978
(in thousands of dollars)

Schedule D

	<i>Current Funds</i>			<i>Endowment, Plant, and Similar</i>		
	<i>Unrestricted</i>	<i>Institute or Donor Restricted</i>	<i>Total Current Funds</i>	<i>Funds</i>	Total 1979	<i>Total 1978</i>
BALANCES, BEGINNING OF YEAR	\$ 68	\$ 57,958	\$ 58,026	\$528,138	\$586,164	\$566,698
Current Year:						
Revenues, other additions, and borrowings	98,022	266,683	364,705	38,765	403,470	345,528
Operating expenses (Schedule A)	(96,714)	(260,695)	(357,409)	—	(357,409)	(319,356)
Other deductions and repayment of borrowings	(20)	(2,861)	(2,881)	(6,727)	(9,608)	(6,706)
Net increase (decrease) before appropriations	1,288	3,127	4,415	37,038	36,453	19,466
Appropriations among funds	(1,232)	(4,981)	(6,213)	3,213	—	—
NET INCREASE (DECREASE) FOR THE YEAR	56	(1,854)	(1,798)	38,251	36,453	19,466
BALANCES, END OF YEAR	<u>\$ 124</u>	<u>\$ 56,104</u>	<u>\$ 56,228</u>	<u>\$566,389</u>	<u>\$622,617</u>	<u>\$586,164</u>
BALANCES, END OF YEAR INCLUDE:						
Fund balances	\$ 124	\$ 56,104	\$ 56,228	\$526,777	\$583,005	\$548,976
Outstanding borrowings	—	—	—	39,612	39,612	37,188
Total	<u>\$ 124</u>	<u>\$ 56,104</u>	<u>\$ 56,228</u>	<u>\$566,389</u>	<u>\$622,617</u>	<u>\$586,164</u>

This condensed schedule should be examined in conjunction with the detailed Statement of Changes in Financial Position (Schedule D-1) which follows.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
STATEMENT OF CHANGES IN FINANCIAL POSITION
for the year ended June 30, 1979
with comparative totals for 1978
(in thousands of dollars)

Schedule D-1

	<i>Current Funds</i>		<i>Total Current Funds</i>	<i>Student Loan Funds</i>
	<i>Unrestricted</i>	<i>Institute or Donor Restricted</i>		
BALANCES, BEGINNING OF YEAR	\$ 68	\$ 57,958	\$ 58,026	\$ 26,388
REVENUES, OTHER ADDITIONS AND BORROWINGS:				
Tuition and other related income	45,028	—	45,028	—
Research revenues	39,866	209,800	249,666	—
Fees, services and miscellaneous receipts	1,745	7,543	9,288	1,006
Investment income	7,220	17,721	24,941	14
Net realized gain or (loss) on investments	—	—	—	—
Student aid from foundations and agencies	—	9,960	9,960	1,100
Government support for construction	—	—	—	—
Dining and Housing	—	8,643	8,643	—
M.I.T. Press	—	4,613	4,613	—
Gifts, grants and bequests	3,407	8,263	11,670	163
Patent royalties received net of cost	756	140	896	—
Borrowings	—	—	—	6,050
Total revenues, other additions and borrowings	<u>98,022</u>	<u>266,683</u>	<u>364,705</u>	<u>8,333</u>
EXPENDITURES, OTHER DEDUCTIONS AND REPAYMENT OF BORROWINGS:				
Operating expenses (Schedule A)	96,714	260,695	357,409	—
Other deductions	20	2,861	2,881	97
Repayment of borrowings	—	—	—	5,496
Total expenditures, other deductions and repayment of borrowings	<u>96,734</u>	<u>263,556</u>	<u>360,290</u>	<u>5,593</u>
Net increase (decrease) before appropriations	<u>1,288</u>	<u>3,127</u>	<u>4,415</u>	<u>2,740</u>
APPROPRIATIONS AMONG FUNDS:				
Fund balances to unrestricted (Schedule A)	—	—	—	—
Funds functioning as endowment to unrestricted (Schedule A)	—	—	—	—
Appropriations for buildings added to educational plant	(403)	(145)	(548)	—
Expendable funds used to support related expenses	—	3,477	3,477	(1,116)
Other appropriations	(829)	(8,313)	(9,142)	(225)
Total appropriations among funds	<u>(1,232)</u>	<u>(4,981)</u>	<u>(6,213)</u>	<u>(1,341)</u>
NET INCREASE (DECREASE) FOR THE YEAR	<u>56</u>	<u>(1,854)</u>	<u>(1,798)</u>	<u>1,399</u>
BALANCES, END OF YEAR	<u>\$ 124</u>	<u>\$ 56,104</u>	<u>\$ 56,228</u>	<u>\$ 27,787</u>
BALANCES, END OF YEAR INCLUDE:				
Fund balances	\$ 124	\$ 56,104	\$ 56,228	\$ 21,245
Outstanding borrowings	—	—	—	6,542
Total	<u>\$ 124</u>	<u>\$ 56,104</u>	<u>\$ 56,228</u>	<u>\$ 27,787</u>

<i>Endowment and Similar Funds</i>	<i>Educational Plant</i>			<i>Total 1979</i>	<i>Total 1978</i>
	<i>Unexpended Funds</i>	<i>Used for Educational Plant</i>	<i>Life Income and Agency Funds</i>		
\$273,881	\$ 19,784	\$201,055	\$ 7,030	\$586,164	\$566,698
—	—	—	—	45,028	41,366
—	—	—	—	249,666	221,550
415	34	670	233	11,646	12,272
—	1,145	—	481	26,581	22,441
5,420	(10)	—	(41)	5,369	(3,908)
—	—	—	—	11,060	9,228
—	774	—	—	774	64
—	—	—	—	8,643	8,073
—	—	—	—	4,613	4,278
8,354	6,065	—	4,328	30,580	28,236
6	—	—	2	904	828
2,556	—	—	—	8,606	1,100
<u>16,751</u>	<u>8,008</u>	<u>670</u>	<u>5,003</u>	<u>403,470</u>	<u>345,528</u>
—	—	—	—	357,409	319,356
—	—	—	448	3,426	5,106
—	—	686	—	6,182	1,600
—	—	686	448	367,017	326,062
<u>16,751</u>	<u>8,008</u>	<u>(16)</u>	<u>4,555</u>	<u>36,453</u>	<u>19,466</u>
—	—	—	—	—	—
—	—	—	—	—	—
—	(1,371)	1,919	—	—	—
—	(2,328)	—	(33)	—	—
12,187	(2,645)	—	(175)	—	—
<u>12,187</u>	<u>(6,344)</u>	<u>1,919</u>	<u>(208)</u>	<u>—</u>	<u>—</u>
28,938	1,664	1,903	4,347	36,453	19,466
\$302,819	\$ 21,448	\$202,958	\$ 11,377	\$622,617	\$586,164
\$300,263	\$ 21,448	\$172,444	\$ 11,377	\$583,005	\$548,976
2,556	—	30,514	—	39,612	37,188
\$302,819	\$ 21,448	\$202,958	\$ 11,377	\$622,617	\$586,164

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SUMMARY OF CHANGES IN INVESTED FUND BALANCES*

for the ten years ended June 30, 1979

(in thousands of dollars)

Schedule E

	1979	1978	1977	1976
Fund balances at beginning of year	\$379,121	\$359,356	\$349,643	\$344,907
Sources of funds:				
Gifts and bequests (Note A)	\$ 30,580	\$ 28,236	\$ 23,044	\$ 18,528
Investment income (Note C)	26,581	22,441	19,783	18,532
Net gain or (loss) on sales or exchanges of investments	5,369	(3,908)	(4,872)	(2,610)
Royalties received net of related costs	904	828	663	459
Receipts from foundations and agencies for student aid	9,960	8,021	4,733	5,315
Appropriations from research contract allowances	1,799	1,768	1,648	1,830
Government construction grants	774	64	218	—
Government grant for student loans	1,100	1,207	1,226	1,173
Fees, services and other receipts	12,634	14,105	9,535	9,884
	<u>\$ 89,701</u>	<u>\$ 72,762</u>	<u>\$ 55,978</u>	<u>\$ 53,111</u>
Use of funds:				
Used to meet expenses of current operation:				
Endowment investment income (Note C)	\$ 11,654	\$ 11,261	\$ 10,873	10,301
Gifts, investment income and other receipts	29,415	24,975	21,293	21,503
Scholarship and fellowship awards for tuition and stipends	11,962	10,615	9,580	8,550
Additions to educational plant	1,919	1,307	1,179	3,729
Operating expenses recorded in direct expenses of the Office of Sponsored Programs	474	230	399	1,093
Other charges to funds not related to current operation	2,837	4,609	2,941	3,199
	<u>58,261</u>	<u>52,997</u>	<u>46,265</u>	<u>48,375</u>
Net increase in funds	<u>31,440</u>	<u>19,765</u>	<u>9,713</u>	<u>4,736</u>
Fund balances at end of year	410,561	379,121	359,356	349,643
Less gifts and other receipts available for current expenses	11,883	11,400	11,134	10,454
Total invested funds	<u>\$398,678</u>	<u>\$367,721</u>	<u>\$348,222</u>	<u>\$339,189</u>

*This schedule has not been revised to correspond to Schedules A through D-I, however, the data is comparable for the years presented.

<i>1975</i>	<i>1974</i>	<i>1973</i>	<i>1972</i>	<i>1971</i>	<i>1970</i>
\$343,964	\$342,058	\$335,318	\$328,247	\$302,901	\$290,598
\$ 16,782	\$ 18,215	\$ 16,919	\$ 17,081	\$ 34,186	\$ 14,230
18,332	19,099	18,321	16,942	15,498	15,523
443	712	2,429	1,931	7,598	6,768
455	953	1,310	978	1,058	963
5,252	4,321	3,999	4,280	4,787	4,441
1,465	1,426	1,457	1,383	1,209	1,698
499	3,024	651	776	—	92
975	946	816	923	874	556
<u>6,636</u>	<u>3,666</u>	<u>3,978</u>	<u>4,137</u>	<u>4,186</u>	<u>4,789</u>
\$ 50,839	\$ 52,362	\$ 49,880	\$ 48,431	\$ 69,396	\$ 49,060
\$ 10,506	\$ 9,681	\$ 9,794	\$ 9,602	\$ 8,435	\$ 7,354
18,602	17,357	9,193	9,471	14,529	13,704
8,285	7,711	7,965	8,162	7,999	7,533
5,867	10,129	11,969	9,151	6,513	4,283
673	983	1,640	2,246	2,869	2,627
<u>5,963</u>	<u>4,595</u>	<u>2,579</u>	<u>2,728</u>	<u>3,705</u>	<u>1,256</u>
<u>49,896</u>	<u>50,456</u>	<u>43,140</u>	<u>41,360</u>	<u>44,050</u>	<u>36,757</u>
<u>943</u>	<u>1,906</u>	<u>6,740</u>	<u>7,071</u>	<u>25,346</u>	<u>12,303</u>
344,907	343,964	342,058	335,318	328,247	302,901
<u>10,743</u>	<u>9,660</u>	<u>8,927</u>	<u>7,680</u>	<u>6,893</u>	<u>8,900</u>
\$334,164	\$334,304	\$333,131	\$327,638	\$321,354	\$294,001

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

HIGHLIGHTS: A DECADE IN REVIEW*

(in thousands of dollars)

Schedule F

	1979	1978	1977	1976
Total Operating Expenses	\$357,409	\$319,356	\$276,912	\$269,250
Instruction and Un-sponsored				
Research Expenses	53,381	47,245	43,311	40,112
Direct Costs of Sponsored Research	209,800	186,331	158,307	157,433
Expenses Jointly Applicable to both				
Instruction and Research	61,907	57,172	50,291	48,169
Scholarships and Fellowships	12,329	11,085	9,843	8,847
Research Revenues	\$249,666	\$221,549	\$189,639	\$186,637
Tuition and Other Related Income	45,028	41,366	37,939	34,473
Investment Income	\$ 26,581	\$ 22,441	\$ 19,783	\$ 18,532
Total Gifts, Grants and Bequests	\$ 30,580	\$ 28,236	\$ 23,044	\$ 18,528
For Endowment	8,354	6,420	7,137	5,502
For Buildings	6,065	8,918	4,855	3,196
Total Fund Balances	\$583,005	\$548,976	\$529,010	\$517,458
Endowment and Similar Funds	300,263	273,881	269,656	241,192
Current Funds	56,228	58,026	52,055	75,566
Book Value of Educational Plant	208,195	205,992	203,340	201,823
Investments, at Cost	387,209	348,481	332,706	319,878
Investments, at Market	467,094	409,528	401,096	401,006
Borrowings by M.I.T.	39,612	37,188	37,688	30,520
Undergraduate Students ***	4,539	4,506	4,422	4,358
Graduate Students ***	3,944	3,824	3,774	3,603
Library, printed volumes and microforms (thousands of volumes)	2,613	2,492	2,376	2,236
Tuition Rate (in dollars)	\$ 4,700	\$ 4,350	\$ 4,000	\$ 3,700

* Where appropriate the data for the years 1969-1975 have been reclassified for comparison purposes.

** Draper Laboratory divested as of July 1, 1973

*** Full time enrollment

1975	1974**	1973	1972	1971	1970
\$247,441	\$233,442	\$279,061	\$245,127	\$223,222	\$225,169
37,591	33,711	29,449	26,976	27,918	25,134
142,824	139,980	192,849	161,630	140,386	149,292
45,163	39,747	37,745	37,835	36,751	33,917
8,513	7,912	8,108	8,344	8,074	7,582
\$169,757	\$162,372	\$219,447	\$187,715	\$163,429	\$171,294
29,950	27,004	24,571	22,512	21,548	19,036
\$ 18,332	\$ 19,099	\$ 18,321	\$ 16,942	\$ 15,498	\$ 15,523
\$ 16,782	\$ 18,215	\$ 16,919	\$ 17,081	\$ 34,186	\$ 14,230
3,634	3,904	2,127	2,680	3,863	1,853
4,703	5,553	5,450	2,415	2,514	3,918
\$508,329	\$500,925	\$488,240	\$469,050	\$452,558	\$420,305
239,248	234,551	229,327	221,827	216,364	189,901
76,097	81,476	84,693	85,341	80,505	85,352
197,513	190,029	182,063	157,651	143,120	136,926
313,624	318,321	318,513	312,288	303,287	278,454
376,061	365,631	420,104	425,402	382,539	308,091
30,122	29,369	30,782	20,720	17,408	14,501
4,048	4,018	4,105	4,054	4,058	4,002
3,468	3,358	3,328	3,250	3,296	3,395
2,109	1,995	1,879	1,733	1,566	1,437
\$ 3,350	\$ 3,100	\$ 2,900	\$ 2,650	\$ 2,500	\$ 2,150

NOTES TO FINANCIAL STATEMENTS

A. ACCOUNTING POLICIES

BASIS OF PRESENTATION

The accompanying financial statements have been prepared on the accrual basis. In order to ensure observance of limitations and restrictions placed on the use of the resources available to the Institute, the accounts of the Institute have been maintained in accordance with the principles of "fund accounting". This is the procedure by which resources for various purposes are classified for accounting and reporting purposes into funds that are in accordance with activities or objectives specified.

SPONSORED RESEARCH

Revenue associated with contracts and grants is recognized as related costs are incurred. Grants and contracts normally provide for a use allowance, in lieu of depreciation, which is reflected as unrestricted revenue. The Institute has recorded reimbursement of indirect costs relating to Government contracts and grants at the authorized billing rates for the fiscal years ended June 30, 1979, and 1978, which are subject to final negotiation after Government audit.

LAND, BUILDINGS, AND EQUIPMENT

Land, Buildings and Equipment, are shown at cost. As is customary for educational institutions, depreciation has not been recorded on buildings and equipment. When expended, costs associated with the construction of new educational facilities are shown as construction in progress until such projects are completed.

GIFTS

Gifts are recognized upon receipt. Gifts other than cash are recorded at their fair market value when such values are determinable as of the date of contribution.

VACATIONS

The Institute accrues vacation expense earned by certain research related employees. Other vacations are expensed as taken.

INTERFUND BORROWINGS

Interfund borrowings by Educational Plant Funds include short-term advances of \$192,000 as well as \$5,045,000 of borrowings from current invested funds (at 6% and 8% interest) related to the temporary funding of certain buildings.

B. INVESTMENTS

Total market value of investments approximated \$467,094,000 and \$409,603,000 at June 30, 1979 and 1978 respectively. Such amounts include market values of certain real estate which were determined by professional appraisers. The Institute records bond interest as received and does not accrue discount. See the schedule of investments which appears on page 8 of the Treasurer's Report for further details.

C. INVESTMENT INCOME FOR DISTRIBUTION TO FUNDS

At June 30, 1979 and 1978, the Institute had reserved \$23,578,000 and \$20,710,000 (captioned "Investment Income for Distribution to Funds") representing fund income in excess of amounts distributed to funds in prior years. This reserve was increased by \$2,868,000 in 1979 and by \$1,128,000 in 1978 as a result of the difference between income earned and income distributed to funds (see Schedule B).

D. STUDENT LOAN FUNDS

National Direct Student Loan Funds of \$13,141,000 and \$12,420,000 at June 30, 1979 and 1978 respectively, are ultimately refundable to the United States Government.

E. BORROWINGS — MORTGAGE BONDS AND NOTES PAYABLE

Borrowings — Mortgage Bonds and Notes Payable consist of the following at June 30, 1979 and 1978:

	1979	1978
M.I.T. Construction and Consolidation Bonds of 1968:		
Series A, 3 ½%, due 1979-2003	\$ 4,493,000	\$ 4,618,000
Series B, 3 ¾%, due 1979-2015	3,566,000	3,611,000
Series C, 3%, due 1979-2018	<u>1,530,000</u>	<u>1,550,000</u>
	\$ 9,589,000	\$ 9,779,000
Dining facilities bonds, 3 ¼%, due 1979-1999	276,000	285,000
Mortgage notes payable, 5 ¼%, due 1979	—	59,000
Mortgage notes payable, 5 ¼%, due 1979-1981	151,000	226,000
Residential facility lease purchase obligation (note F)	4,993,000**	5,075,000**
Mortgage notes payable, 5-6 ½%, due 1979-2003	9,450,000	9,630,000
Mortgage notes payable, 5-7%, due 1979-2006	<u>6,055,000</u>	<u>6,145,000</u>
Total related to educational plant	\$30,514,000*	\$31,199,000*
Notes payable 6%, due 1979-1988	1,904,000	—
Notes payable 13%, due 1979-1982	400,000	—
Notes payable 9 ½%, due 1979-1989	128,000	—
Notes payable 8 ½%, due 1979-1999	<u>124,000</u>	<u>—</u>
Total related to investment real estate	2,556,000	—
Notes payable SLMA, variable %, due 1983		
for student loans	2,000,000	—
Notes payable to bank, 10%-11 ¾% due 1979 for student loans	3,750,000	5,250,000
Notes payable to bank, 11 ¾%, due 1980 for		
Faculty and Staff Educational Loan Fund	300,000	200,000
Notes payable to U.S. Government, 6 ½%-8 ½%, due 1979-1992,		
for student loans	<u>492,000</u>	<u>539,000</u>
Total	\$39,612,000	\$37,188,000

*At June 30, 1979 the Institute had pledged securities with a market value of \$10,955,000 annual unrestricted operating revenue of \$2,120,000, and certain other project revenue to comply with the terms of the bond indentures.

**The Institute receives interest supplements from the Department of Housing and Urban Development with respect to these issues.

F. COMMITMENTS

1. Annual payments under a 30-year residential facility lease purchase obligation payable to the Massachusetts Health and Educational Facilities Authority approximate \$350,000. Annual rentals for Utility Facilities, which are being leased for their estimated 25-year useful lives from the Massachusetts Health and Educational Facilities Authority, approximate \$400,000 and are being charged to plant operations as incurred.
2. The Institute is committed under real estate leases to a gross annual payment of \$971,000 in 1980. Certain leases expiring in 1979 are subject to renewal or may be renewed.
3. The Institute is committed under a lease for certain computer equipment to a gross annual payment of \$922,000 in fiscal 1980 and \$692,000 in fiscal 1981. Upon its expiration in 1981, the lease is subject to renewal at a rate of \$143,000 annually.

G. RETIREMENT FUNDS

The Institute's retirement plans, which cover substantially all employees, are under the supervision of trustees. Plan assets are not included in the Institute's financial statements. Current service costs of the plans are funded as incurred. Pension expense charged to operations was \$11,622,000 and \$10,103,000 in fiscal 1979 and 1978 respectively. As of July 1, 1978, a change in actuarial methods and assumptions resulted in an unfunded past service liability of \$3,825,000 which is being amortized over thirteen years. The retirement plans have been operated in conformity with the Employee Retirement Income Security Act of 1974 since January 1, 1976, and have received notification of continued qualification from the Internal Revenue Service.

AUDITOR'S REPORT

TO THE AUDITING COMMITTEE OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY:

We have examined the following financial statements of Massachusetts Institute of Technology:

Schedule A—Statement of Revenues and Funds Used to Meet Expenses of Current Operations for the Year Ended June 30, 1979 with Comparative Totals for 1978.

Schedule B—Investment Income for Distribution to Funds for the Year Ended June 30, 1979 with Comparative Totals for 1978.

Schedule C—Balance Sheet as of June 30, 1979 with Comparative Totals for 1978.

Schedule D—Condensed Statement of Changes in Financial Position for the Year Ended June 30, 1979 with Comparative Totals for 1978.

Schedule D-1—Statement of Changes in Financial Position for the Year Ended June 30, 1979 with Comparative Totals for 1978.

Schedule E—Summary of Changes in Invested Fund Balances for the Ten Years Ended June 30, 1979.

Our examination was made in accordance with generally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. We previously examined and reported upon the financial statements of the Institute for the year ended June 30, 1978.

In our opinion, the financial statements referred to above present fairly the financial position of Massachusetts Institute of Technology at June 30, 1979, the revenues and funds used to meet expenses of current operations and the changes in financial position for the year then ended, and the summarized changes in invested fund balances for the ten years ended June 30, 1979 in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

Coopers & Lybrand

Boston, Massachusetts, September 7, 1979

GLOSSARY FOR FINANCIAL STATEMENTS

Agency Funds — funds held as custodian or fiscal agent for affiliates such as alumni and student organizations.

Appropriations Among Funds — authorized transfer of resources between fund groups.

Auxiliary Activities — refers to the operations of Dining and Housing and MIT Press.

Borrowings — represent mortgage bonds and notes payable to external agencies, institutions and others.

Current Invested Funds — expendable resources which have been invested to produce income.

Current Operating Funds — uninvested resources held for meeting current restricted or unrestricted expenses.

Endowment and Similar Funds — encompasses both endowment funds and funds functioning as endowment. Endowment funds are gifts and bequests where the donor has stipulated, as a condition of the gift, that the principal is to remain inviolate in perpetuity and is to be invested for the purpose of producing present and future income. Funds functioning as endowment are gifts, bequests and other receipts which had no restrictions as to the expenditure of principal which the Institute elected to add to endowment funds.

Educational Plant Funds — funds invested (expended) and those available for investment (unexpended) in educational plant, as well as applicable mortgage bonds and notes payable.

Fund — an entity consisting of assets, liabilities and fund balance. The assets and income must be invested or spent in accordance with the designated purpose of the fund.

General Investments — assets of funds which have been pooled for investment purposes.

Life Income Funds — gifts for investment with income payable to one or more beneficiaries during their lives. Upon the termination of life interests, the principal becomes available for Institute purposes which may be designated by the donor.

Permanent Funds — funds designated by the donor or the Institute as unexpendable.

Plant Funds — see Educational Plant Funds.

Quasi Endowment Funds — see funds functioning as endowment in Endowment and Similar Funds.

Restricted — resources, the use of which have been designated (restricted) by a donor or the Institute.

Separately Invested Funds — funds held by the Institute and maintained in separate portfolios for investment purposes.

Student Loan Funds — resources loaned to students or available for such loans.

Unrestricted — resources which are available for the general purposes of the Institute, and are not restricted as to use.

Use of Facilities Allowances — represents the portion of sponsored research program revenues received in lieu of depreciation on facilities used for such programs.

UNIVERSITY FUND ACCOUNTING

University finances, not unlike the rest of the world in which we live, have grown more complex as the organizations themselves have grown. At the same time, the demands for more and better information from both inside and outside the institutions have increased, often with differing objectives. Colleges and universities have tried to be responsive to these demands by improving financial reports, but there are two basic differences between corporate accounting and university finances which make it difficult to understand the financial statements of an educational institution.

What follows is a brief explanation of these two basic differences — the fund accounting concept and the availed of method of accounting:

- a) The concept of **fund** accounting, and the commonly used terms such as **restricted, unrestricted, general, designated, true endowment, funds functioning as endowment, and permanent funds** which all sound like very sharp and distinct categories in which funds are recorded, are often misunderstood. In addition, the use of funds can differ substantially from the narrow definition implied by the name given to a particular category. For example, a **restricted** fund may be drawn upon to support an activity which had been budgeted for **unrestricted** support in the Institute's annual budget process if the activity being supported qualifies under the restriction which governs the use of that particular fund. Used in that way, a restricted fund can fulfill a need for unrestricted funds.
- b) The **availed of** method of accounting makes a distinction between the recording of new resources such as investment income or gifts at the time they are added to funds, and the subsequent use of these funds when applied to meet expenditures. The following description of fund accounting and the availed of method of accounting is taken from the 1973 M.I.T. *Report of the Treasurer*.

"M.I.T., in common with other educational institutions, reports its operations and financial conditions using fund accounting, with the financial resources of the Institute called 'funds.' An accounting standards committee has defined a fund as 'a sum of money or other resources segregated for the purposes of carrying on specific activities or obtaining certain objectives in accordance with special regulations, restrictions and limitations.' Accounting for the funds of the Institute provides information on the assets, liabilities, revenues and expenses of each fund and defined group of funds, and for the funds of the Institute in total. The fund itself, however, in all of its parts including income and principal, remains a definite unit with its use for designated objectives or general Institute purposes.

"Unrestricted funds are resources received by M.I.T. for its general purposes but are not restricted as to their use. By action of the President and Executive Committee of the Corporation, they can be applied to support operating expenses, student aid, plant construction, or to the creation of endowment. Restricted resources are contributed by donors or provided by outside sponsors for defined purposes such as scholarships, professorships, plant construction, or for specific research or educational programs.

"The flow of revenues and funds reflects the 'availed of' method of accounting. Funds accumulated from prior years as well as revenues or funds received within a fiscal year may be used for operations in that year, or set aside as endowment or for other purposes in that year, or deferred for some operating or other use in a subsequent fiscal period. Tuition revenues, net research revenues, and most of the income from investments are used within the year received, but gifts, grants, bequests and other receipts of a given year are often expended later. Current expendable restricted gifts or grants are frequently received in one year but expended over more than one fiscal period, and only the amount 'availed of' in any given year is reported as revenue."

Secretary of the Institute

The Officers and Committees of the Corporation rely upon the Secretary of the Institute to provide a range of support for the operation of the Corporation and its Committees. This report summarizes the work of the Institute's governing body under the chairmanship of Howard W. Johnson.

CORPORATION MEMBERSHIP

At the year's end the record total of 95 Members of the Corporation included 75 Active Members, 19 Life Members Emeriti, and one Member-Elect due to assume office at the October 5, 1979 Annual Meeting of the Corporation. There were 27 individuals whose membership status changed during 1978-79 in an unusually active year for the Membership Committee.

In one important area of membership, Edward J. King succeeded the Honorable Michael S. Dukakis as an ex-officio Representative of the Commonwealth by virtue of his election in the fall of 1978 as Governor of Massachusetts. Governor King attended and spoke at the December 1978 and March 1979 Meetings of the Corporation and was a guest of honor at the June 4, 1979 Commencement Exercises in Killian Court.

The Corporation lost through death on March 17, 1979 its distinguished Member, Henry A. Hill, at the age of 63, Founder and President of Riverside Research Laboratory and former President of the American Chemical Society, who had served for three years. A memorial service was held at the M.I.T. Chapel on March 24, 1979 for family and friends. Dr. Hill made a lasting contribution to M.I.T. through his efforts to enlarge educational opportunities and to encourage minorities in science and engineering over the years since 1942, when he received his M.I.T. doctoral degree in Chemistry. He will be sorely missed.

At its June 4, 1979 Meeting, the Corporation set a precedent by electing two women to Life Membership, effective June 4: Ida M. Green, the 1979 co-recipient of the Public Welfare Medal of the National Academy of Sciences, and Helen F. Whitaker, trustee of the Whitaker Health Sciences Fund. Mrs. Whitaker was first elected to the Corporation in 1976. Mrs. Green transferred to Life Member Emerita and became the first woman to join the group of Life Members Emeriti.

At its June 1979 Meeting, the Corporation further elected the following Members to five-year terms, effective July 1, 1979: Herman R. Branson, President, Lincoln University; Frank T. Cary, Chairman and Chief Executive Officer, IBM Corporation; Edward E. David, Jr., Class of 1947, President, Exxon Research and Engineering Company; S. James Goldstein, Class of 1947, Founder and Managing Partner, James Goldstein and Partners; Maurice F. Granville, Class of 1939, Chairman and Chief Executive Officer, Texaco, Inc.; Edward R. Kane, Class of 1943, President, E.I. duPont de Nemours & Company; Joe F. Moore, Class of 1952, Co-Founder and President, Bonner & Moore Associates, Inc.; J. Paul Sticht, Chairman and Chief Executive Officer, R.J. Reynolds Industries, Inc.; Emily V. Wade, Class of 1945, trustee of conservation programs and institutions in the Boston area; and Thornton A. Wilson, Class of 1953, Chairman and Chief Executive Officer, The Boeing Company. Paulette Coleman, Class of 1977, Assistant Professor in the Department of Community and Regional Planning and the African and Afro-American Studies and Research Center, University of Texas at Austin, was elected a Member at the same Meeting to a five-year term, effective October 5, 1979.

In addition, Claude W. Brenner, Class of 1947, Vice President-Operations, Northern Energy Corporation, assumed an ex-officio position on the Corporation by virtue of his election as the 1979-80 President of the Alumni Association. In that position, he succeeded Joe F. Moore, effective July 1, 1979.

In addition to Mrs. Green's transfer, The Honorable Luis A. Ferre, Class of 1924, President of the Senate of Puerto Rico, transferred to Emeritus status during the year. Governor Ferre continues as Chairman of the Council for the Arts at M.I.T. and as a member of the Leadership Campaign Steering Committee and the Arts Visiting Committee. He has served with distinction as a Member of the Corporation since 1962 and as a Life Member since 1967.

At the June 4, 1979 Meeting the Corporation observed the July 24, 1979 transfer of James R. Killian, Jr., Class of 1926, Honorary Chairman of the Corporation, to Life Member Emeritus. Dr. Johnson presented Dr. Killian with a leather bound and embossed book of letters of appreciation from 140 Members and Former Members of the Corporation, representing more than 1,000 years of trusteeship at M.I.T.

At the same Meeting, a bronze casting of Dr. Killian's head was uncovered. The casting was made from a plaster sculpture done in the early 1970s by the late Beatrice Paipert Finn, Class of 1951. Dr. Killian's transfer to Emeritus status will include his relinquishing the post of Honorary Chairman of the Corporation at his own request. In the 34 years he has served as an Officer of the Corporation and Life Member, Dr. Killian has served concurrently with roughly half of the more than 500 individuals who have served as Members of the Institute's governing body since M.I.T. was founded in 1861. The following resolution was adopted by the Corporation on June 4, 1979:

"Resolved: That the Corporation is deeply appreciative of the enduring and incomparable service to the Institute and to the Corporation of its retiring Life Member, President Emeritus, and Honorary Chairman of the Corporation, James Rhyne Killian, Jr., on the occasion of his transfer to Life Member Emeritus. His true joy in life has been to devote his whole being to a purpose recognized by himself to be a mighty one."

Expiration of term membership has cost the Corporation the formal services of Thomas F. Creamer, Class of 1940, Vice Chairman, Economic Development Council of New York City, Inc.; Paul F. Hellmuth, Class of 1947, Corporate Director and Trustee; Jerome H. Holland, Corporate and Foundation Director and Trustee and newly elected Chairman of the American Red Cross; Wilfred D. MacDonnell, Class of 1934, retired Chairman, Kelsey-Hayes Company; Charles E. Reed, Class of 1937, retired Senior Vice President, General Electric Company; Cecily C. Selby, Class of 1950, Corporate Director and Consultant; Jephtha H. Wade, Class of 1945, Partner, Choate, Hall & Stewart; and Katrina M. Wootton, Class of 1977, graduating from the School of Organization and Management, Yale University. These retiring Corporation Members continue their association with the Corporation in many ways as members of various Corporation and Institute committees.

Under the Bylaws of the Boston Museum of Fine Arts, the President of M.I.T. annually appoints a representative from M.I.T. to serve on the MFA Board of Trustees. During the past year the Institute's representative has been Professor Phyllis A. Wallace of the Sloan School of Management. Several Corporation Members also serve as MFA Trustees. Dr. Johnson continued his service as President of the Museum of Fine Arts.

CORPORATION COMMITTEE ON THE PRESIDENCY

At the December 1978 Meeting, Dr. Johnson announced the membership of the Corporation Committee on the Presidency (C.C.O.P.) under the Chairmanship of Carl M. Mueller, Class of 1941, Vice Chairman, Bankers Trust Company. At the same Meeting, the Chairman of the Faculty was asked to form a Faculty Advisory Committee to C.C.O.P., and the Corporation Joint Advisory Committee on Institute-Wide Affairs (C.J.A.C.) under the Chairmanship of Gregory Smith, was asked to work with C.C.O.P. in a similar advisory role. Subsequently, the Faculty Advisory Committee was formed, under the Chairmanship of Professor John Waugh of the Department of Chemistry.

Secretary of the Institute

The following Corporation Members were appointed to the C.C.O.P. and confirmed by the Corporation: W. Gerald Austen, James B. Fisk, Shirley A. Jackson, Ralph Landau, Norman B. Leventhal, Gregory Smith, Mary Frances Wagley, and Carl M. Mueller, Chairman. In addition, Drs. Killian and Stratton were named consultants to the Committee.

The process of internal and external consultation on the structure of the Executive Office, desired characteristics of the Institute's Chief Executive Officer, and the names of potential candidates has included the solicitation of suggestions from alumni and the several internal constituencies within the M.I.T. community. The C.C.O.P. and its advisory committees have worked hard during the past six months to keep channels of communication open and to be receptive to the ideas and opinions of a wide cross-section of students, faculty, staff, alumni, and friends of the Institute on these issues. Special thanks are due to the chairmen of these committees and to Walter L. Milne, who serves as Secretary of the Corporation Committee on the Presidency. The individual members of the two Corporation Committees and the Faculty Advisory Committee have given unstintingly of their time and creative energies to enhance the selection process and to increase its credibility and openness.

C.J.A.C. devoted virtually the entire year to a study of the Institute's top-level organization and discussions of potential candidates. C.J.A.C. met biweekly and monthly during the first semester and weekly during the second semester. Several meetings were held with officers of the Institute and deans to develop a consensus about the presidency. President Jerome Wiesner's March 1979 Corporation Luncheon speech on "M.I.T. Education for the Future" was particularly helpful in focusing attention on the central issues for the Institute in the years ahead. Student and faculty representatives on C.J.A.C. have given a monumental total of hours and evenings to this effort. Their exceptional dedication to the task at hand has been a source of strength throughout the year. The writer wishes to acknowledge the leadership of Gregory Smith and the voluntary assistance given to C.J.A.C. by Martha L. Bertrand, who served as Secretary of C.J.A.C. during a year of extraordinary exertion by the Committee. Her cheerful helpfulness has greatly lightened the work required to support the Committee.

DEDICATIONS AND SPECIAL FUNCTIONS

The Corporation continued to carry prime responsibility for dedications of major facilities and special functions. Notable ceremonies this year included a symposium in Huntington Hall, Room 10-250, on October 6, 1978, in honor of faculty members who hold named and endowed professorships and institute professorships. Provost Walter A. Rosenblith served as Convenor of a group of faculty members who hold named and endowed professorships, and he spoke at the symposium.

The faculty members included Professors David Baltimore, Mildred S. Dresselhaus, Arthur P. Mattuck, and Elting E. Morison. Former Members of the Corporation were invited to attend the Annual Meeting of the Corporation on October 6 and the subsequent events of the day. Embossed citations were presented to the former Corporation Members who participated.

At the December 1, 1978 Corporation Luncheon, Corporate Leadership Awards were presented to 12 people -- the third annual group of alumni to receive this distinguished Award. Dr. Johnson presided at the Luncheon and Dr. Edward E. David, Jr., President, Exxon Research and Engineering Company spoke about his impressions of the Peoples Republic of China following his recent tour to that country as President of the American Association for the Advancement of Science.

Following the March 2, 1979 Meeting of the Corporation, the Corporation and the President were afternoon hosts at the dedication of a plaque in memory of the late John Ely Burchard, Class of 1923, first Dean of the School of Humanities and Social Science (1950-64). Dr. Johnson presided at the meeting in the Boston Stein Club Map Room in the Hayden Memorial Library. The other speakers were Dr. Killian and Professor Robert L. Bishop of the Department of Economics. The memorial plaque, designed by Professor Emeritus Lawrence B. Anderson, was uncovered by Mrs. Burchard in the Hayden walkway following the speaking program.

Following the June 4, 1979 Commencement Exercises, the Corporation and the President were hosts at the formal groundbreaking ceremony for the Whitaker College of Health Sciences, Technology, and Management and the Medical Department Building. The afternoon ceremony, which was held in the garden of the President's House, included a visit to the nearby construction site on Carleton Street. Dr. Johnson presided at the speaking program. The speakers included Mrs. Helen F. Whitaker; President Wiesner; Mr. Robert I. Smith, President, Glenmede Trust Company, representing the Pew Memorial Trust; Professor Rosenblith; Dr. Irving M. London, Director of Whitaker College and the Harvard-M.I.T. Health Sciences and Technology Division; and Dr. Melvin H. Rodman, M.I.T. Medical Director. Some 250 guests attended.

In an extraordinary event during the year, Mr. and Mrs. Green were honored on November 9, 1978 at the National Academy of Sciences by a group of presidents and chancellors of some 30 colleges, universities, hospitals, academies, and scientific associations in Australia, Canada, England, and the United States. A black tie reception and dinner in honor of Mr. and Mrs. Green were followed by a speaking program in the auditorium of the Academy. The evening was entitled "An International Tribute to Cecil and Ida Green." President Wiesner served as Convenor at this function, and he chaired a planning committee of sister institutions which planned the events during the preceding six months, with the aid of the presidents and chancellors of the participating institutions and their various offices. Among the 200 guests present on November 9, M.I.T. was represented by its senior officers and the Green Professors and their spouses.

The presidents and chancellors of the participating institutions were magnificent in their response to this planning effort. Individuals and their staffs spent hours and days providing ideas and information to the planning process. The National Academy of Sciences, TAGER educational television network in Dallas, and M.I.T. provided the principal staff support for this function. On behalf of the planning committee, the writer wishes to express heartfelt thanks to the offices of the presidents and chancellors of the participating institutions and to a phalanx of offices and individuals in NAS, TAGER, and M.I.T. for their enthusiastic help in an extraordinarily complex task of orchestrating a unique tribute to Mr. and Mrs. Green. To sense the magnitude and importance of Mr. and Mrs. Green's personal involvement with each institution and their example to private philanthropy on a global basis was an unforgettable experience.

In April 1979, the Greens became the first co-recipients of the Public Welfare Medal of the National Academy of Sciences. The institutions which participated in "An International Tribute to Cecil and Ida Green" included the following: American Association for the Advancement of Science; American Association of University Women; Austin College; Bishop College; California Institute of Technology; Colorado School of Mines; Jarvis Christian College; M.I.T.; National Jewish Hospital and Research Center; US Office of Science and Technology Policy; Oxford University; representatives from the National Academies and Smithsonian Institution; St. Mark's School of Texas; Scripps Clinic and Research Foundation; Southern Methodist University; Stanford University; Suffolk University; the Association for Graduate Education and Research of North Texas (TAGER); Texas Christian University; Texas Instruments Foundation; University of British Columbia; University of California at San Diego; University of Dallas; University of Sydney; University of Texas System; University of Texas at Austin; University of Texas at Dallas; University of Texas Health Science Center at Dallas; University of Texas Medical Branch at Galveston; and Woods Hole Oceanographic Institution.

Speakers for the evening included: an invocation by the Reverend Milton K. Curry, Jr., President of Bishop College, and a toast in the form of an original poem by Dr. Guy T. McBride, President, Colorado School of Mines at the dinner. The auditorium speakers were: Dr. Wiesner, presiding; welcoming remarks by Dr. Philip Handler, President, National Academy of Sciences; and greetings by Dr. Frank Press, Director, US Office of Science and Technology Policy; the Honorable Allan Shivers, Chairman, Board of Regents, University of Texas System; Dr. Peter S. Bing, President, Board of Trustees, Stanford University; Dr. Marjorie Bell Chambers, President, American Association of University Women; Dr. Harry Messel, Head, School of Physics, University of Sydney; Dr. Charles A. LeMaistre, President, University of Texas System Cancer Center, who presented an inscribed silver tray on behalf of the participating institutions to the honorees; and Mr. and Mrs. Green. Dr. Wiesner presented additional greetings from Prime Minister Pierre Trudeau of Canada and President Jimmy Carter. The program included videotaped messages from friends and associates of Mr. and Mrs. Green in Dallas who were unable to attend. Guests for the evening remarked that they could not recall a comparable experience in the annals of American philanthropy.

Another happy event for the entire M.I.T. community was the dedication of new furnishings and plantings for the Rogers Lobby lounge area. James L. Bidigare, Jr., President of the Class of 1978, which made this gift to the Institute, presented the Class gift to President Wiesner on May 7, 1979.

Two additional events related to the Department of Chemistry are worth noting for the record: the November 17, 1978 75th anniversary convocation to mark the founding of the Research Laboratory of Physical Chemistry; and the April 19, 1979 dinner at the President's House to mark the establishment of the Dewey-Haslam Professorship of Chemistry. This distinguished chair honors two deceased Members of the Corporation, Bradley Dewey, Class of 1909, and Robert T. Haslam, Class of 1911. Both men were longtime leaders in the chemical and process industries, and both served as directors and advisors to W.R. Grace & Company, the donor of the professorship in their memory.

M.I.T. LEADERSHIP CAMPAIGN

The beginning of the fifth and final year of the M.I.T. Leadership Campaign on April 22, 1979 was observed on Friday, April 27 with a status report by Chairman Howard W. Johnson to the Alumni Advisory Council. At the 90 percent mark in the completion of the Campaign, Dr. Johnson called upon the Institute's alumni leaders to exert every effort to help the Campaign through its last difficult phase. Although the Campaign announcement to the Alumni Advisory Council four years earlier had been made with \$43 million, or only 19 percent of the Campaign goal in hand, the rise to 90 percent -- ahead of schedule on the Fourth Anniversary of the Campaign -- had required a prodigious effort. The final 10 percent would not be easy, Dr. Johnson warned.

By the June 4, 1979 Meeting of the Corporation, the reported total of gifts, grants, and pledges to the M.I.T. Leadership Campaign rose to \$211 million -- close to \$50 million more than the comparable figure of \$164.5 million reported at the June 1978 Meeting. Compared with the \$225 million, five-year Campaign goal, nearly 94 percent of the total sought was then in hand or pledged.

The pattern of positive responses from individuals, corporations, and foundations in the fourth public year of the Campaign was a source of very great encouragement to the Campaign Steering Committee. With the total amount approaching the 94 percent point of the \$225 million Campaign, at the June 4, 1979 Meeting, Dr. Johnson announced that our Life Member, Robert C. Gunness, and John S. Reed, Executive Vice President, Citicorp/Citibank N.A. had agreed to serve as Co-chairmen of the Campaign, joining Paul F. Hellmuth, J. Kenneth Jamieson, W.B. Murphy, Edward O. Vetter, and himself in that capacity for the last year of the Campaign. Mr. Gunness has special responsibilities for the Campaign in the Chicago area and Mr. Reed for the New York area, in addition to their shared national responsibilities for the Campaign as Co-chairmen.

Corporation Members serving on the Campaign Steering Committee, in addition to Dr. Killian, President Wiesner, Chancellor Gray, and the Campaign Co-chairmen are: Paul M. Cook, Luis A. Ferre, Cecil H. Green, Breene M. Kerr, Ralph Landau, Carl M. Mueller, Clint W. Murchison, Jr., D. Reid Weedon, Jr., and John J. Wilson. Paul V. Keyser, Class of 1929, is continuing his service in the Campaign Steering Committee following his completion of Membership in the Corporation in 1977.

The report on behalf of the staff organization for the Campaign is included elsewhere. At the same time, no account of trusteeship would be complete without mentioning the crucial Campaign roles the Corporation has assumed as Co-chairmen, members of the Campaign Steering Committee, Area Chairmen, Corporation Development Committee, and Alumni Fund Board. In addition, many Members of the Corporation have headed or are heading National Sponsoring Committees for particular projects and have made historical gifts on their own. To illustrate, Edward O. Vetter continued to head a national committee to emphasize the importance of endowed Professorships to the endowment object of the Campaign. Breene M. Kerr continued as National Chairman of the Sponsoring Committee for the Building 10 drive to fund the renovation of Huntington Hall, Room 10-250, and to fund the new Alumni Center on the first floor of the Building 10 area of the Maclaurin Buildings under the Great Dome. Clint W. Murchison, Jr. continued as Chairman of

Secretary of the Institute

the \$7.5 million drive for a new Athletics and Special Events Center. Further anonymous gifts brought the total raised for the Center within \$2 million of the goal. Richard L. Terrell continued as Chairman of the National Business Committee seeking major grants from US and foreign corporations. Luis A. Ferre continued as Chairman of the Council for the Arts at M.I.T.; Gregory Smith continued as Chairman of the Arts Council's Development Committee; and the Arts Facilities Sponsoring Committee includes a number of Corporation Members as the Council joined in merging its efforts with the Leadership Campaign. In Japan, Yaichi Ayukawa continued to serve as a central figure in organizing support by Japanese industry for the Leadership Campaign.

The formal start of construction of the Whitaker College of Health Sciences, Technology, and Management, an anonymous trust fund of \$4 million given by an alumnus as a professorship and scholarship endowment to be associated with Whitaker College, and an anonymous, unrestricted gift of \$2 million by an alumnus, which can be used for construction of the new undergraduate residence, were high points of the year. Our Life Member, J. Kenneth Jamieson, received the 1978 Marshall B. Dalton Award of the Corporation Development Committee "in recognition of conspicuous and sustained service in the enhancing of M.I.T.'s financial independence."

President Wiesner's unprecedented withdrawal from the day-to-day management and operation of the Institute during the calendar year 1978, in order to devote more of his energies to the Campaign, will stand as one of the major determinants of the success of the Campaign. Closely associated with Dr. Wiesner's personal effort, the remarkable ability of Chancellor Paul E. Gray to carry forward the Institute's momentum on all fronts has been an anchor to windward in moving the Institute through troubled financial times. It is to the clear credit of the Corporation to have had the foresight in 1971 to select a Chancellor to serve as deputy President should the need arise. With his total grasp of the Institute, Chancellor Gray has managed its affairs with consummate skill and grace in 1978, thus contributing in a unique way to the prospect of the Campaign success during its final year.

On a sad note, the death in July 1978 of General James B. Lampert, Class of 1937, Vice President for Resource Development, was a shock to his friends and colleagues and a serious loss to the Institute and to the Campaign. At his death General Lampert was the Staff Director of the Campaign. He had participated in its earliest planning. A group of Corporation Members and Institute staff were present for his funeral service at West Point, where he had earlier in his distinguished military career served as Superintendent and where he is buried. He was succeeded in September 1978 by Dr. Samuel A. Goldblith, Class of 1940, Underwood-Prescott Professor of Food Science in the Department of Nutrition and Food Science and for the past several years also Director of Industrial Liaison. Long an advocate of closer relationships between industry and M.I.T., Dr. Goldblith brings an international reputation as a food scientist and a staunch devotion to the Institute to his task. The Corporation welcomed Dr. Goldblith to its Annual Meeting in October 1978.

Altogether, these leadership responsibilities and actions by the Corporation represent a renewed sense of high purpose. They constitute an unprecedented commitment by the Institute's governing body to secure the necessary resources for M.I.T.'s continued independence and strength. We are deeply grateful to the above named and to the Corporation as a whole.

MEETINGS

As a matter of record, the Corporation held four meetings during the year. At a time of continued financial stringency, Chairman Johnson, President Wiesner, and Chancellor Gray called upon all segments of the Institute community to continue the budget limitations needed to pull together in planning for a future balanced budget. In addition, through its various committees, the Corporation played a key role in communication with students, faculty, alumni, and the general public on the range of questions and issues before M.I.T.

Special thanks are due once again to the Ad Hoc Committee on Shareholder Responsibility, under the chairmanship of D. Reid Weedon, Jr., and to C.J.A.C., under the chairmanship of Gregory Smith, for their continuing assistance to the Executive Committee and to the Corporation respectively. Walter L. Milne, Assistant to the President and the Chairman of the Corporation, served again as Secretary to the Committee on Shareholder Responsibility, in a year in which the Institute's investments in South Africa were the focal issues.

Additional thanks are due the Corporation Screening Committee, under the chairmanship of Shirley A. Jackson and the staff of the Alumni Association for the effort required to conduct the special alumni election needed to fill a vacancy in the category of younger Member of the Corporation.

In a notable action, the Corporation voted to approve a new interdisciplinary graduate degree of Master of Science in Transportation, to be offered by graduate departments in cooperation with the Center for Transportation Studies. The new degree program will be monitored by a standing faculty committee appointed by the Deans of the School of Engineering and the Graduate School and the Director of the Center for Transportation Studies -- all in accordance with recommendations of the faculty.

Under President Wiesner's leadership, discussions continued at the quarterly Meetings of the Corporation and in the meetings of the Executive Committee, the Council on Resources of the Institute (C.R.I.), Corporation Development Committee (C.D.C.), and the M.I.T. Resource Development staff regarding a plan to develop a membership arrangement for non-alumni of the Institute, which would help to augment and strengthen the network of friends at M.I.T.

The year 1979 marked the election of Professor Sheila E. Widnall of the Department of Aeronautics and Astronautics as Chairman of the Faculty effective July 1, 1979, the first woman to hold that post since the founding of the Institute. In looking forward to her participation in the regular Meetings of the Corporation, the Corporation expresses appreciation to her predecessor, Professor Robert I. Hulsizer of the Department of Physics, who has contributed significantly to the discussions in Corporation Meetings during the past two years.

CORPORATION VISITING COMMITTEES

This was a year of level activity for the Corporation Visiting Committees. Compared with 17 of the 29 Committees which met during the 1977-78 year, 16 meetings were scheduled in 1978-79. One of these meetings involved the chairmen of the Visiting Committees for the Departments of the School of Engineering. The Visiting Committees for Sponsored Research and for Political Science, which were earlier cancelled because of the Blizzard of 1978, were rescheduled for the fall of 1978. The formation of the new Visiting Committee for Whitaker College of Health Sciences, Technology, and Management was deferred until 1979-80, pending the start of construction of the new facilities.

These 16 meetings involved roughly half of the total Visiting Committee membership which now exceeds 525 members with the addition of an Athletics Visiting Committee. This actual level of Visiting Committee activity was in keeping with a guideline set by the Corporation during 1975-76 to reduce the frequency of meetings for Visiting Committees. The rationale for fewer meetings continues to be sound in the light of the increased outreach activities of the Institute during the intensive period of off-campus campaigning under the current capital drive. In addition, in a few cases the turnover among department heads has mitigated the demand for meetings somewhat, as Visiting Committee Chairmen have tried to recognize the need of the new department heads for adequate time to develop their plans.

We hope to maintain a level of about 15 or 16 meetings a year, evenly divided between the fall and spring semesters. The calendar for 1979-80 is headed in this direction, with seven of the Visiting Committees already scheduled to meet during the first semester. I want to recognize the dedicated work of Ellen W. Reinhard of this Office in the painstaking task of scheduling and staffing these meetings. She has moved mountains of work for M.I.T.

Several features of the meetings which have proved successful in the past were continued by the Committees this year. All of the 16 meetings, save the one for the School of Engineering Visiting Committee Chairmen, included dinner at which the committee members were brought together informally with members of the faculty and administration and in a few cases with students. Also, the committees made effective use of private sessions with students on their agenda, further formalizing this additional and valuable means of gaining insight into departmental activities. A number of the committees for larger departments included similar separate sessions with junior faculty.

Secretary of the Institute

Discussions with each of the departments had many common interests, including systematic follow-up of previous Committee recommendations and reviews of departmental progress in recruitment of minorities and women as students and faculty members. Several of the departments visited were headed by new department heads, which lent an additional element of importance to those meetings. In the case of Student Affairs, the Visiting Committee meeting served as an important source of advice to a study of the organization of the office of the Dean for Student Affairs, preliminary to a search now under way for a new Dean. Virtually all of the Departments visited continued to show budget strains. Those in the School of Engineering reflected the additional acute problems posed by the dramatic shift of enrollments towards the School of Engineering.

Attendance by members of the Visiting Committees has been outstanding this year. Sixteen meetings had an average of 14 members per meeting. In addition, the participation in this year's series of meetings by the senior officers and deans of the Institute continued at a high level, considering the Leadership Campaign travel demands on them. The presence of these officers at the various meetings enhances the interchange between the Committee and the Department, and often provides a welcome catalytic effect which contributes to the success of the meeting. Warm thanks are due Provost Walter A. Rosenblith for his continued energetic participation both in the meetings and in the selection of new Committee members, and to the more than 300 faculty members who participated in the sessions of the Visiting Committees.

Of the Committees meeting in the 1977-78 year, all but two of the Chairmen have now reported orally to the Corporation, and all have submitted written reports. These reports to the Corporation are important to the successful operation of the Committees, and they provide a broadened forum in which to consider the plans and progress of each department. They are invaluable to the functioning of trusteeship at M.I.T. The Academic Council now systematically receives copies of the written reports when they are approved for distribution by the Executive Committee, and the Council also hears oral reports from the Provost and the responsible dean or vice president as Visiting Committee meetings occur.

We remain handicapped by reduced staffing of the Visiting Committee operation due to budgetary considerations. A four-year search for volunteer assistance with Visiting Committee arrangements has not been successful, but it continues in order to help fill a staff vacancy. In this interval, Jerilyn K. Edmondson, Ellen W. Reinhard, and the writer are sharing the overload.

In conclusion, I wish to thank Dorothy Adler of the M.I.T. Alumni Association for her strong support of the nomination of alumni to the Visiting Committees and for her assistance to the Corporation Screening Committee for younger alumni. The smooth operation of the special election of younger alumni as nominees to the Corporation has been due in no small measure to her dedicated service and cheerful disposition at all times. I also wish to thank Alice W. Tripp of the Office of the Director of Resource Planning who has given voluntarily of her efforts and time to help plan and execute several major functions during the year, superbly.

VINCENT A. FULMER

Alumni Association

In 1978-79 the Alumni volunteers, at all levels, demonstrated a renewed vigor in their commitment to work through the Alumni Association and its staff to meet the needs of the Institute to the mutual benefit of both. One indicator of this commitment is the response of the senior volunteers to the change in the leadership of the resident Alumni Association's staff. Having completed a major revitalization of the Association through a restructuring of the staff and the move into the new Alumni Center in Building 10, the Executive Vice President, James A. Champy, resigned to return to private business. A search committee, chaired by Association Vice President Harl P. Aldrich, completed an extensive screening and interviewing process in time to introduce the new Executive Vice President, Dr. James A. Hester, Jr., to the Board of Directors at the November 30, 1978 meeting. During the transition period, between the resignation of Mr. Champy and Dr. Hester's joining the Association on a full-time basis in January, President Joe F. Moore, Director Marvin C. Grossman, and President-elect Claude W. Brenner, devoted substantial amounts of time and effort from their busy schedules to assist in making this transition as smooth as possible.

In addition to these efforts, the national boards and committees of the Association continued to probe, throughout the year, for ways in which they could be much more effective in coupling with the needs of the Association and the Institute at large. The former Club Advisory Board was restructured into an Alumni Activities Board advising the Secretary of the Association on all alumni activities, particularly those off campus. A special ad hoc committee for the Board of Directors completed its study of *Technology Review*, which reaffirmed the basic editorial purpose of that magazine and provided significant assistance in strengthening the management and financial controls necessary for its future growth.

At the grass roots level of the Association, the results of the revitalization of the club and other field programs continued to be evident by the continued increase in club meetings and attendance. After three years of such growth the Association finally encountered the pleasant dilemma of beginning to be in the position where the new volunteer leadership, being developed through the field organization, has begun to exceed the Association's capacity to absorb, at the upper levels, using the current structure of national boards and committees. The new president of the Association, Claude W. Brenner, comes to his position with the ideal credentials for solving this problem in a creative way. As chairman of the Committee to Strengthen Alumni Involvement with the Institute he has been exploring, for several years, the ways in which new linkages can be established between the alumni and the Institute to the mutual benefit of both.

The Alumni Fund had a good year with total donations exceeding \$5 million for the first time and the number of donors being the second highest in history. However, it's fair to say that some of the longer-term issues raised in last year's report remain unresolved. Specifically, those issues concern the maintenance of the Fund at its current, or higher, level, in the absence of the impetus of the Leadership Campaign, and the merging of the volunteer campaign effort into the Alumni Fund effort, so as to derive a maximum level of annual fund financial support for M.I.T. These issues will obviously be a major focus of the Association staff, its senior volunteers, and the Institute staff in the coming year.

Finally, the past year was a period in which the Association's magazine, *Technology Review*, showed clear signs of having matured to the point of being on the verge of becoming established as a major international publication in its field. The dramatic growth in paid subscriptions from non-alumni, to the point where they approximately equal the number of alumni readers, and in advertising revenue demonstrated clearly the market's perception of the magazine's prominence. The publishing profession's opinion was clearly shown by the award, for the first time since 1943, of the Sibley Magazine of the Year Award from the Council for the Advancement and Support of Education (CASE). The continuing strengthening of both the staff and the structure of the

Alumni Association

magazine, which has occurred during the year, give us great confidence that these recognitions represent milestones along the way for further growth and improvement rather than a peaking of performance.

ALUMNI RELATIONS

This year marked the first full year of occupancy by the Alumni Association in the Building 10 Alumni Center. Approximately 10,000 to 12,000 individuals used the facilities to hold 350 meetings, as the Center continued to act as a catalyst in bringing students, faculty, and alumni together.

Programs involving students and alumni developed significantly during this year. Senior Dinners, designed to acquaint students with the Association by bringing them together with alumni leaders, attracted 478 students and 95 alumni to 15 dinners in the Vannevar Bush Room, nearly double the number of a year ago. A very successful fund-raising telethon in the spring also attracted 350 undergraduates. The Host Family Program, a Subcommittee of the Committee to Strengthen Alumni Involvement with the Institute, headed by Fagi Levinson, served 150 students -- an increase of 25 percent from a year ago. The Association also became more involved in student class activities. Beginning in the fall of 1979, the Alumni Association will provide capital to undergraduate classes for the purpose of organizing class functions, both recreational and fund-raising, as well as providing advice and a minimum of logistical support.

The matching of students to their alumni host families is clearly oriented towards the students' career interests and this same orientation is present in a number of other alumni/student activities such as "Trailblazing," a freshman symposium on choosing career paths. During the Independent Activities Period in January, the Association sponsored three student-oriented programs attended by nearly 200 students. Student meetings with alumni from their home areas and two student panels were featured during the Alumni Officers Conference in the fall. Receptions with students at East Campus and at Ashdown House after Tech Night at the Pops, and a student panel on Friday morning at Technology Day were major attractions at that event in June.

Clubs continued to run meetings over the Christmas holidays, in conjunction with April student acceptances and in the summer for current, potential, and newly accepted students and their parents. In conjunction with the Educational Council, the New York Center supported a program in New York City for potential students and their parents which attracted 500 people. Clubs also supported seven East Coast performances by the Shakespeare Ensemble, a Midwest trip including a visit to Toronto by the Logarithms, an East Coast trip to three cities by the Concert Band, and visits by Undergraduate Research Opportunities Program (UROP) students.

At the recommendation of the Awards Committee, the Board awarded seven Bronze Beaver Citations, the highest award given by the Association to the following alumni for outstanding service: Peter M. Bernays, Class of 1939, Thomas Farquhar, Class of 1960, S. James Goldstein, Class of 1946, Edward Hanley, Class of 1924, Jack Page, Class of 1948, Hugh Parker, Class of 1943, and Jerome B. Wiesner (Honorary) and one Presidential Citation to the Building 10 Sponsoring Committee for their outstanding service in raising approximately \$1.5 million to renovate Huntington Hall and to build the Alumni Center. The Awards Committee also received approval from the Board to establish two new awards: the Harold E. Lobdell, Class of 1917, Distinguished Service Award to recognize valuable service to the Association and the Institute that is of special depth in one activity or, alternatively, service that is substantial and sustained along broad lines and the George B. Morgan, Class of 1920, Award to recognize sustained excellence in all aspects of Educational Council activities.

The Board approved the following recommendations of the Awards Committee for the Harold E. Lobdell, Class of 1917, Distinguished Service Award: Eugene Becken, Class of 1952, Carroll J. Brown, Class of 1946, Vito A. Caravito, Class of 1962, Raymond Danon, Class of 1958, Myron A. Exelbert, Class of 1963, Arnold A. Kramer, Class of 1952, Robert Lindquist, Class of 1951, Joseph P. McBrien, Class of 1931, Terence K. McMahon, Class of 1957, Philip L. Molten, Class of 1955, Gregory L. Schaffer, Class of 1965, Frank R. Shaw, Class of 1924, and the following for the George B. Morgan, Class of 1920, Award: Lewis R. Aldrich, Jr., Class of 1929, Walter L. Helmreich, Class of 1940, Albert L. Kaye, Class of 1931, Paul A. Lux, Class of 1952, Edwin W. Newton, Class

Alumni Association

of 1958, James S. Offutt, Class of 1926, Victor L. Ransom, Class of 1948, Everett P. Weatherly, Jr., Class of 1929, Beaumert Whitton, Class of 1933.

As a result of efforts by the Alumni Council Program and Membership Committee, interest, as demonstrated by attendance at the six Council meetings, increased for the second year. Programs continued to focus on various aspects of the M.I.T. community and their impact on alumni and society in general, starting with a student panel and ending with, "An Insider's View of National Science Policy" given by Dr. Frank Press, Science Advisor to the President. Other programs allowed Drs. Robert C. Seamans, Jr., Dean of the School of Engineering, and Thomas F. Jones, Vice President for Research, to share their views on critical issues in engineering education and research with an informal alumni audience. Kenneth R. Olsen, Class of 1950, President of Digital Equipment Corporation and Professor Francis F. Lee, Class of 1950, explored the appropriate relationships of the entrepreneur and M.I.T., and Professor Frederick Sanders, Class of 1954, presented a look at the future possibilities of weather forecasting.

Attendance at Technology Day, primarily a Class Reunion activity, was up over last year due to an increase in non-reunion attendance. Thirteen quinquennial classes, from the 65th to the 5th, held all or part of their reunions on campus. Attendance at the Alumni Officers Conference was down slightly from the past few years, although the program, which highlighted students, was enthusiastically received. Dean Seamans delivered the second Annual Robert H. Richards Alumni Lecture to a full house in Room 10-250. In its third year, Summer College featured a program entitled "Emerging Technologies: Taking on Tomorrow" under the direction of Professor Ithiel de Sola Pool of the Department of Political Science. For the first time the same program was conducted at both Cambridge and at Aspen.

Club activities continued at slightly above last year's record high. Nearly 250 club mailings to 40,000 alumni communicated a strong M.I.T. presence at the local level and 64 members of the M.I.T. faculty and administration brought M.I.T. to the local communities. Kudos go to President Jerome B. Wiesner, Chancellor Paul E. Gray, Provost Walter A. Rosenblith, and Institute Professor Emeritus Harold E. Edgerton, for speaking to five or more local alumni associations during the year.

<u>EVENT</u>	<u>1978-79</u>	<u>1977-78</u>	<u>1976-77</u>	<u>1975-76</u>	<u>1974-75</u>
Technology Day and Reunions	2,578	2,361	2,801	2,344	1,968
Alumni Officers Conference	580	652	571	590	745
Alumni Council	906	838	492	806	802
Club Programs	16,988	15,816	13,500	10,765	9,800
Conferences and Seminars	700	770	900	1,359	700
Summer College	182	50	212		
Student Programs	1,288	580			
TOTAL	23,222	21,067	18,476	15,864	14,015

The National Selection Committee met on November 14, 1978 to select the Association's Corporation nominees and national officers as follows: for five-year terms on the Corporation, S. James Goldstein, Class of 1946; Joe F. Moore, Class of 1952; and Emily Wade, Class of 1945; for a one-year term as Association President, Claude W. Brenner, Class of 1947; for two-year terms as Vice Presidents of the Association, James K. Littwitz, Class of 1942 and Paul P. Shepard, Class of 1953; for two-year terms as Association Directors, District 3, William A. Bayer, Class

Alumni Association

of 1958; District 6, Norman R. Klivans, Class of 1940; District 7, Marianna P. Slocum, Class of 1955; District 8, Thomas J. Lamphier, Class of 1949; District 9, Otto E. Kirschner, Jr., Class of 1949.

A ballot was sent to all alumni in March containing the names of seven alumni nominated by their clubs to serve three-year terms on the National Selection Committee. Marjorie Pierce, Class of 1922, Weston, Massachusetts; William Richardson, Class of 1944, Cape Elizabeth, Maine; and Eugene D. Becken, Sloan School of Management Class of 1952, Glen Rock, New Jersey, were elected to serve on the Committee.

The Association also supports the election process for membership on the M.I.T. Corporation of a member from the three recent classes, 1977, 1978, and 1979. Paulette Coleman, Ph.D. 1977, Urban Studies and Planning, was nominated from a slate of nine candidates to serve a five-year term on the Corporation.

A total of 64 alumni were nominated by the Association's Committee on Nominations for Corporation Visiting Committees to fill vacancies on the Visiting Committees. Forty-four alumni were appointed by the Board of Directors to fill vacancies on the Association's eight national Boards.

ALUMNI FUND

1978-79 was another extraordinary year for the Alumni Fund. The impressive sum of \$5,160,000 was received from 21,900 donors. This gift total was up \$190,000 from 1977-78 and the number of donors increased by 1,100 or 5 percent. Several areas of the Fund continued to contribute to its success and two new programs -- Student Telethons and Personal Solicitation -- were launched. Alumni Fund volunteers, some 1,500 of them, contacted alumni through a variety of efforts directed at upgrading gifts and increasing participation.

The Young Alumni Program, which began in 1977-78, continued its emphasis on increasing the participation of recent graduates in the Alumni Fund. A special challenge, issued by the Class of 1929 in celebration of their 50th Reunion, matched any increase in an alumnus' gift over his or her last gift and matched first-time gifts dollar for dollar. The increased participation among the classes of 1974 through 1978 accounts, in part, for the Fund's success this year.

A Senior Class Gift Program was undertaken for the second year in a row. The Class of 1979 raised \$1,400 from over 275 class members. This sum was matched by the Class of 1929's special challenge. These funds are designated for improvements in the area at the intersection of Buildings 2 and 6, as well as for the planting of a class tree.

This year the Fund initiated a new program involving students in solicitation efforts by conducting a series of 12 Student Telethons. Over 300 students participated in this effort which resulted in 2,048 pledged and \$71,470. The Student Telethons were organized by living group and provided an opportunity for students to talk with over 5,400 alumni about M.I.T. today. Student callers spoke enthusiastically, emphasizing the need for alumni support of student housing.

While the Student Telethons were aimed at increasing participation, a new pilot program was aimed specifically at upgrading gifts. The new Personal Solicitation Program was designed and tested successfully in eight regions during the spring. The cornerstones of this new program are extensive prospect screening and solicitor training. The solicitor training component was designed especially for the Personal Solicitation Program. It provides the solicitor with the tools and techniques required to make face-to-face solicitations and secure upgraded gifts. This past spring over 50 alumni were trained in solicitation techniques. Next fall the Program will expand to include 10 cities and some 1,200 alumni.

The 25th, 40th, and 50th Reunion Classes of 1954, 1939, and 1929 reported five-year reunion gifts of \$337,618, \$969,693 and \$1,073,606 respectively. Several projects of the Fund were also particularly successful -- the Ellen Swallow Richards Professorship, the Independent Residence Fund, and the Campus Residence Fund.

The 1979 Fund year was an outstanding one thanks to Chairman Thomas H. Farquhar, Class of 1960, who retired in June after four years of service, including two served as Chairman.

TECHNOLOGY REVIEW

By any measure, 1978-79 (Volume 81) was a very good year for *Technology Review*.

The best quantitative indices are those from the marketplace, reflecting the performance of the *Review* as supplied to "paid" subscribers and newsstand readers. By the end of the year, total "paid" subscriptions were approaching 30,000, compared with just over 21,000 at the start of the year. Subscription income for the fiscal year 1979 is estimated at \$338,000, compared with \$258,000 in the previous year. Net advertising income has nearly doubled -- from \$69,000 in 1977-78 to \$118,000 in 1978-79. The renewal rate apparently advanced nearly 60 percent.

To some extent these improved results can be attributed to a renaissance of interest in science which all magazines and media are experiencing. The *New York Times* has responded to this interest with a weekly supplement, "Science Times;" the American Association for the Advancement of Science is inaugurating a new magazine in the fall, and there are persistent rumors of new magazines from Hearst Publishing Corporation and Time, Inc. Science coverage in general magazines is being increased, and new science-oriented programming will appear on network television in September.

But *Technology Review's* improved results are surely also the result of better performance by the magazine in fulfilling its editorial goals. Here the measures are more qualitative -- and to a large extent subjective. We've had a range of timely and outstanding articles, covering such topics as photovoltaics, visual information processing, office automation, Chinese science, tidal power, "stagflation," nuclear proliferation, steelmaking, sail power for cargo ships, innovation, post-modern architecture, and the future of nuclear power. A successful experiment resulted in publication of a dialogue on the future of nuclear power in the light of the accident at Three Mile Island, organized and conducted by Steven J. Marcus, managing editor.

The most reprinted article in many years was "Analyzing the Daily Risks of Life," by Professor Richard Wilson of Harvard University; it appeared in many newspapers and in *Reader's Digest* for June. Wide media attention also came to Lloyd Bergeson's proposal for sail-powered cargo ships.

In all these, and in the preparation of items for "Trend of Affairs," the editors have given constant attention to making our contents both accurate and accessible; responses from readers suggest that these efforts have been successful.

Illustration and design have been subjects of special attention during the year from Nancy Pokross and Kathleen Sayre, Art Director and Production and Design Manager, respectively. As a result, covers and editorial spreads from *Technology Review* have been accepted for annual exhibitions of the Art Directors Club of Boston, the New York Society of Publications, and the Council for the Advancement and Support of Education (CASE).

And, for the first time since 1943, *Technology Review* received the Sibley "magazine of the year" Award of CASE for Volume 81.

As the 1978-79 year began, the Board of Directors of the Alumni Association asked Marvin C. Grossman, Class of 1951, to chair a committee to review editorial and business operations of the *Review* and to counsel the Board on its future expectations. Other members of the committee were Claude W. Brenner, Class of 1947, James A. Champy, Class of 1963, Robert C. Cowen, Class of 1949, Ernest D. Frawley (General Manager of *Harvard Business Review*), Patrick J. McGovern, Jr., Class of 1959, and Charles H. Spaulding, Class of 1951. Working throughout the year, the committee conducted intensive studies of the *Review's* recent policies and operations, the experiences of other college magazines, and the response to *Technology Review* of alumni and non-alumni readers. Readership studies were made possible by funds granted to the committee by the Class of 1917.

Alumni Association

The committee concluded its work by supporting the *Review's* present editorial policies and program, by recommending improvements in design and illustration, by urging further development of the M.I.T. '80 section, and by emphasizing the need for improved management and financial controls. The staff of the *Review* will respond to these recommendations at the first meeting of the Board of Directors for 1979-80 in September 1979.

Sara Jane Neustadt, managing editor, resigned in the fall to join the "Nova" group at WGBH-TV; after an extensive search we asked Steven J. Marcus, who was then vice president of Energy Resources Co., Cambridge, to join the Board of Editors as managing editor. In addition, Richard F. Wright, who had been advertising manager since 1965, left the *Review* to establish his own agency to create and sell advertising services. He was succeeded by Peter Gellatly, who, as the *Review's* business manager, will have major responsibility for responding to the concerns of Mr. Grossman's committee.

ALUMNI RECORDS AND DATA PROCESSING

As of June 30, 1979, the rolls of living alumni included 69,441 names, resulting from the addition of 3,877 names and the removal of 1,078 alumni reported deceased since the last statistics published in our 1976-77 report.

In anticipation of the final development stage of the Alumni records system, a data base manager was added to the staff of the Association in July 1978, and in September the senior systems analyst resigned from the Association staff and continued in a consulting role for the remainder of the year. Alumni Association staff are working with the Business Systems Development group in the final stages of development. The final functional design was completed and approved, data base management system software has been installed, and Alumni records are being maintained in the new data base. The current system continues to operate in parallel with the development of the new data base system. Discussions are in process with other Institute offices to offer access to the data base as a service in the future.

JAMES A. HESTER